WMC-R14

GROUND WATER AND RIVER FLOW ANALYSES APPENDICES

MAY 2001
Revised June 2001

Technical Report Appendices
of the Platte River EIS Team
U.S. Department of the Interior
Bureau of Reclamation
Fish and Wildlife Service

MARCH 3, 1849

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GROUND WATER AND RIVER FLOW ANALYSES APPENDICES

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MAY 2001
Revised June 20001

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APPENDIX A

BANK STORAGE

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.

Appendix -- Bank Storage Equation

The linear partial differential equation for unsteady, one-dimensional flow is:

$$\frac{\partial^2 s}{\partial x^2} = \frac{1}{\alpha}\frac{\partial s}{\partial t} \tag{1}$$

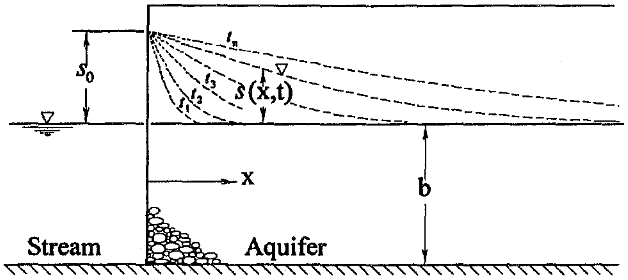
where:

s	is drawdown or buildup,	[L]
x	is horizontal distance,	[L]
t	is time, and	[T]
α	is the hydraulic diffusivity.	$[L^2T^{-1}]$

$\alpha = T/S$, where T is transmissiviy, $[L^2T^{-1}]$, and S is storativity, [dimensionless].
$T = kb$, where k is hydraulic conductivity, $[LT^{-1}]$, and b is saturated thickness, [L].

Strictly adhereing to the mathematics, when water table condition exist, the governing equation is non-linear. However, it has been demonstrated by many (...) that when drawdown, s, is small relative to saturated thickness, b, ($s << b$) linear solution results are very good.

The figure below shows the conceptual model for the case where stream stage is instantaneously stepped up by s_0 at t=0:



The initial and boundary conditions for an instantaneous step change in stream stage are:

Condition	Explanation
$s(x,0) = 0$	drawdown is 0 for all values of x at time = 0
$s(\infty,t) = 0$	drawdown is 0 at x = ∞ for all values of time
$s(0,t) = s_0$	drawdown is s_0 at x = 0 for all values of time

The solution of equation (1) subject to the initial and boundary conditions is:

$$s_{(x,t)} = s_0\left(1 - \frac{2}{\sqrt{\pi}}\int_0^{\frac{x}{\sqrt{4\alpha t}}} e^{-u^2}du\right) \tag{2}$$

where u is a dimensionless dummy variable of integration.

The term inside the parenthesis in equation (2) is know as the "complementary error function" and values are tabulated in mathematical handbooks.

Equation (2) can be written in terms of the complementary error function as:

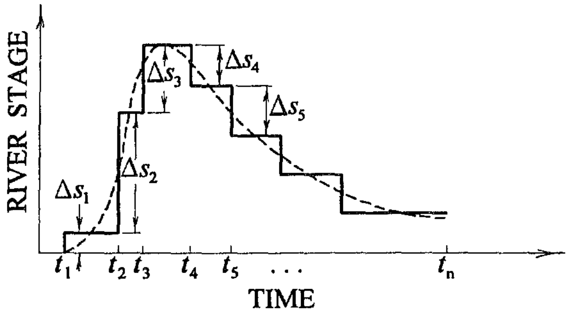
$$s_{(x,t)} = s_0 \, erfc\left(\frac{x}{\sqrt{4\alpha t}}\right) \tag{3}$$

Equation (3) is often referred to as the bank storage equation or, (predominantly within Reclamation) as Glover's equation, however McWhorter's (1977) description -- "flow toward [or from] a plane on which piezometric head is prescribed" -- is the more informative.

Superposition solution

The basic equation has of limited applicability to natural systems. The hydrologist is rarely concerned with the problem of an instantaneous step change of stage that then remains constant for all time thereafter, rather, practical problems involve continuously changing conditions of stage.

The principal of superposition allows basic linear solutions to be combined to form complex solutions. By approximating the continuous hydrograph with a series of steps as shown in the figure below.



Equation (3) can be extended using superposition to obtain equation (4) which has far more practical application to natural processes.

$$s_{(x,t)} = \sum_{i=1}^{n} \Delta s_i \, erfc\left(\frac{x}{\sqrt{4\alpha(t-t_i)}}\right) \; ; \qquad t \geq t_i \tag{4}$$

Units Used

THE FORMULAS to be described and elaborated upon in this monograph apply to certain important cases of ground-water movement. The formulas are expressed in a notation which been selected, on the basis of experience, to ve the needs of this subject. Units are specied in the notation as a means of identifying physical dimensions, but the formulas are written in consistent form and will, therefore, apply in any consistent system of units. A system of units is consistent when no more than one unit of a kind is permitted. In general, these formulas involve only the units of length and time. The use of consistent units secures the advantages of simplicity and flexibility.

An example of a consistent unit system based upon the units of length in feet and time in seconds is:

Length: feet
Time: seconds
Flow: cubic feet per second
Permeability: feet per second
Drawdown: feet
Thickness of aquifer: feet
Radius: feet

This system, for example, would become inconsistent if flow were expressed in gallons per minute, because the gallon unit of volume does not agree with the chosen unit of length and the minute unit does not agree with the chosen unit of time.

Graphs appearing in the text have been prepared by using dimensionless parameters. Such parameters are often composed of a group of quantities which have units but they are so arranged that the parameter, as a whole, has none. Using such parameters is advantageous in that they permit the construction of generalized charts which can be used with any system of consistent units.

Notation and Definition of Terms

The following notation is used throughout the text:

a a well or drain radius (feet)
b an outer radius (feet)

$$c=\frac{\Gamma\left(\frac{7}{6}\right)}{\Gamma\left(\frac{5}{3}\right)\sqrt{\pi}}=0.5798 \text{ (dimensionless)}$$

D the initial saturated thickness of an aquifer (feet)
D_a an average saturated thickness (feet)
d the vertical distance between the centerline of a drain and an impermeable barrier or a saturated thickness below some maintained minimum water level (feet)

$e=2.71828+$. The base of the natural system of logarithms

$$E=\frac{\pi K}{2d\log_e\left(\frac{d}{a}\right)} \qquad \frac{1}{\text{sec}}$$

f	a pumping rate distributed over an area (ft per sec)
F	a flow of ground water through a unit width of aquifer (ft^2 per sec)
F_L	a flow to a drain, per unit length of drain, as limited by a local resistance (ft^2 per sec)
F_0	a value of F at $x=0$ (ft^2 per sec)
$G\left(\frac{\sqrt{4\alpha t}}{a}\right)$	a function of the parameter $\left(\frac{\sqrt{4\alpha t}}{a}\right)$. The discharge of a flowing artesian well is given in terms of this function in the form $Q=2\pi KDs_oG\left(\frac{\sqrt{4\alpha t}}{a}\right)$. The function $G\left(\frac{\sqrt{4\alpha t}}{a}\right)$ is dimensionless
h_r and H_r	transient and maximum amplitudes of reservoir fluctuation (feet)
h	in the Dupuit-Forchheimer idealization, a drainable depth of water in an aquifer (feet). In the Laplace idealization, a pressure in excess of hydrostatic, expressed in terms of the pressure due to a unit depth of water
h_a and h_b	drainable depths as used in the method of Brooks
H	an initial drainable depth (feet)
i	an infiltration rate (ft per sec)
$I_0(x)$	a modified Bessel function of the parameter x of zero order and the first kind
$J_0(x)$, $J_1(x)$	Bessel's functions, of order zero and one, of the parameter x (dimensionless) (Notation of Reference 4)
K	permeability of an aquifer (ft per sec)
KD	the transmissibility of an aquifer (ft^2 per sec)
$K_0(x)$, $K_1(x)$	modified Bessel's functions, of orders zero and one, of the parameter x of the second kind (dimensionless)
L	the distance between parallel drains (feet)
L_c	the length of a leaky canal (feet)
m and n	consecutive whole numbers used in specifying the terms of a series
m	the thickness of a horizontal bed or member which offers a high resistance to the flow of ground water (feet)
p	the permeability of a bed which offers a high resistance to the flow of ground water (ft per sec)
p_1	the part of the drainable water which remains in the aquifer at the time t (dimensionless)
q_d	a portion of the flow of a well which is taken from an identified source (ft^3 per sec)
q_1	a flow per unit length of a line source or a flow to a unit length of a drain (ft^2 per sec)
r	a radius (feet)
R	a total return flow up to a time t per unit width of aquifer (feet^2)
S	an increment of storage capacity contributed by bank storage per unit length of bank (feet^2)
s	drawdown (feet)
s_0	for a flowing artesian well, the initial pressure reduction at the well when flow began, expressed in feet of water
t	time (seconds)
t_c	an equivalent time. See Figure 10 (seconds)
t_1	a time between irrigations (seconds)
t_L	a time during which a flow to a drain is limited by a local resistance (seconds)
T	a period (seconds)
u	a dimensionless variable

$U=\frac{h}{H}$ (dimensionless)

V	voids ratio. The ratio of drainable or fillable voids to the total volume (dimensionless)
W	a factor in the equation $U=WY$ (W is dimensionless)
x and y	rectangular coordinates (ft)
x	a symbol used to indicate a dimensionless parameter
$Y_0(x)$, $Y_1(x)$	Bessel's functions of the zero and first orders of the second kind (Notation of Reference 4)
Y	a factor in the equation $U=WY$ (Y is dimensionless)
y_{c0}, y_{ct}, y_{x0}	drainable depths as used in the drain spacing procedure of Dumm, Tapp, and Moody
y_{c0}	an initial drainable depth midway between drains
y_{ct}	a drainable depth at the point midway between drains at the time t
y_{x0}	an initial drainable depth at the point x
$\alpha=\frac{KD}{V}$	the diffusivity (ft^2 per sec)
β_n	a root of a Bessel's equation, defined where used. The dimensions of β are $\frac{1}{\text{feet}}$

$$\omega=\frac{2\pi}{T}\ \frac{1}{\text{sec}}$$

$$\sigma=\frac{Q}{2\pi KD^2}\ \text{(dimensionless)}$$

$$\eta=\left(\frac{p}{mV}\right)t\ \text{(dimensionless)}$$

$$\eta_1=\left(\frac{KH}{VL^2}\right)t\ \text{(dimensionless)}$$

$$\mu=\frac{s}{\left(\frac{Q}{2\pi KD}\right)}\ \text{(dimensionless)}$$

$$\rho=r\sqrt{\frac{p}{mKD}}\ \text{(dimensionless)}$$

$$\xi=\frac{x}{L}\ \text{(dimensionless)}$$

$$U_0(\beta_n r)=J_0(\beta_n r)Y_0(\beta_n a)-J_0(\beta_n a)Y_0(\beta_n r)$$

$$\pi=3.14159+\ \text{(dimensionless)}$$

$\Gamma(x)$ = a gamma function of the parameter x (dimensionless)

Definitions

Aquifer	A water-bearing bed or stratum.
Diffusivity	A quantity $\alpha=\frac{KD}{V}$ used with the Dupuit-Forchheimer idealization to specify the transient behavior of an aquifer.
Transmissivity	A quantity expressed in the Dupuit-Forchheimer idealization as the product KD. It defines the ability of an aquifer to transmit ground water under the influence of a gradient.
Exponential integral	A tabulated function defined by the integral $\int_x^\infty \frac{e^{-u}}{u}\,du$
Probability integral	A tabulated function defined by the integral $\frac{2}{\sqrt{\pi}}\int_0^x e^{-u^2}du.$

From Table 4

$$\sqrt{\pi}\int_{\frac{r}{\sqrt{4\alpha t}}}^{\infty}\frac{e^{-u^2}}{u^2}\,du=0.02168$$

and

$$h=\frac{q_1x}{2\pi KD}(0.02168)=\frac{(1)(5{,}280)(0.02168)}{(5{,}280)(2)\pi(0.035)}$$

$$=0.098\text{ feet.}$$

This is the rise of the water table 1 mile from the canal if the river is absent.

The values computed in this way represent the heights of the mound if the aquifer extended to great distances on either side of the canal. The presence of the river can be accounted for by the use of an image. In this case it may be idealized as a pumped drain paralleling the river at a distance of 2 miles on the side opposite to the canal and having an inflow rate equal to the seepage rate of the canal. With this arrangement, the level of the water table at the river will be represented as unchanged. This will include in the computations a recognition of the ability of the river to control water-table levels along its course.

The point 1 mile from the canal is 3 miles from the drain. Then for the image, $\frac{x}{\sqrt{4\alpha t}}=(3)(1.46)$ $=4.38$. A reference to Table 4 will show that the effect of the image will be negligibly small at this time. This will be true for the point under the canal also. The estimated heights therefore remain at 5.51 feet and 0.098 foot at the canal and 1 mile from the canal, respectively. The return flow to the river is from Formula (66) on the basis that all of the leakage returns to the river.

$$q=-Q\left[1-\frac{2}{\sqrt{\pi}}\int_0^{\frac{x_1}{\sqrt{4\alpha t}}}e^{-u^2}du\right]$$

$$=-(15)(0.03895)=-0.584\text{ ft}^3/\text{sec.}$$

The minus sign indicates that the flow is toward the river.

Bank Storage

When a reservoir is filled there is a flow of water into the banks and when the reservoir is emptied some of the water stored in the banks returns again to the reservoir. Similar changes accompany rising and falling stream stages.

A solution of Equation (3) subject to the conditions,

when $x=0$ $h=0$ for $t>0$,

when $t=0$ $h=H$ for $x>0$, is

$$h=H\underbrace{\frac{2}{\sqrt{\pi}}\int_0^{\frac{x}{\sqrt{4\alpha t}}}e^{-u^2}du.}_{erf(x/\sqrt{4\alpha t})}\quad [1] \tag{58}$$

The integral which appears here is the tabulated "Probability Integral." The notation is as shown on Figure 13.

The flow F toward the reservoir at x is:

$$F=\frac{2HKD}{\sqrt{\pi}}\frac{e^{-\frac{x^2}{4\alpha t}}}{\sqrt{4\alpha t}}. \tag{59}$$

The flow out of the bank at $x=0$ at the time t is:

$$F_0=\frac{HKD}{\sqrt{\pi\alpha t}}. \tag{60}$$

The total flow from the bank into the reservoir up to the time t is:

$$R=HV\sqrt{\frac{4\alpha t}{\pi}}. \tag{61}$$

When the reservoir goes through a yearly cycle of filling and emptying, there is an amount of water which flows into the banks when the reservoir level is high and returns again when the level is low. If a reservoir goes through a regular cycle of filling and emptying year after year the

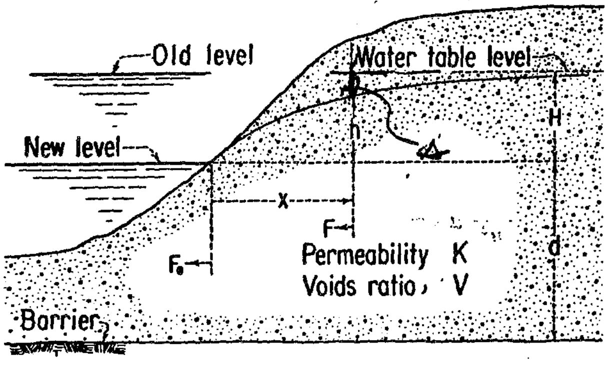


FIGURE 13.—Bank storage conditions.

[1] McWhorter, eq. 5-59, p. 215 is developed for drawdown, Δ, and thus uses the "complimentary-error function", erfc(x). erfc(x) = 1 - erf(x)

$\Delta = H - h$

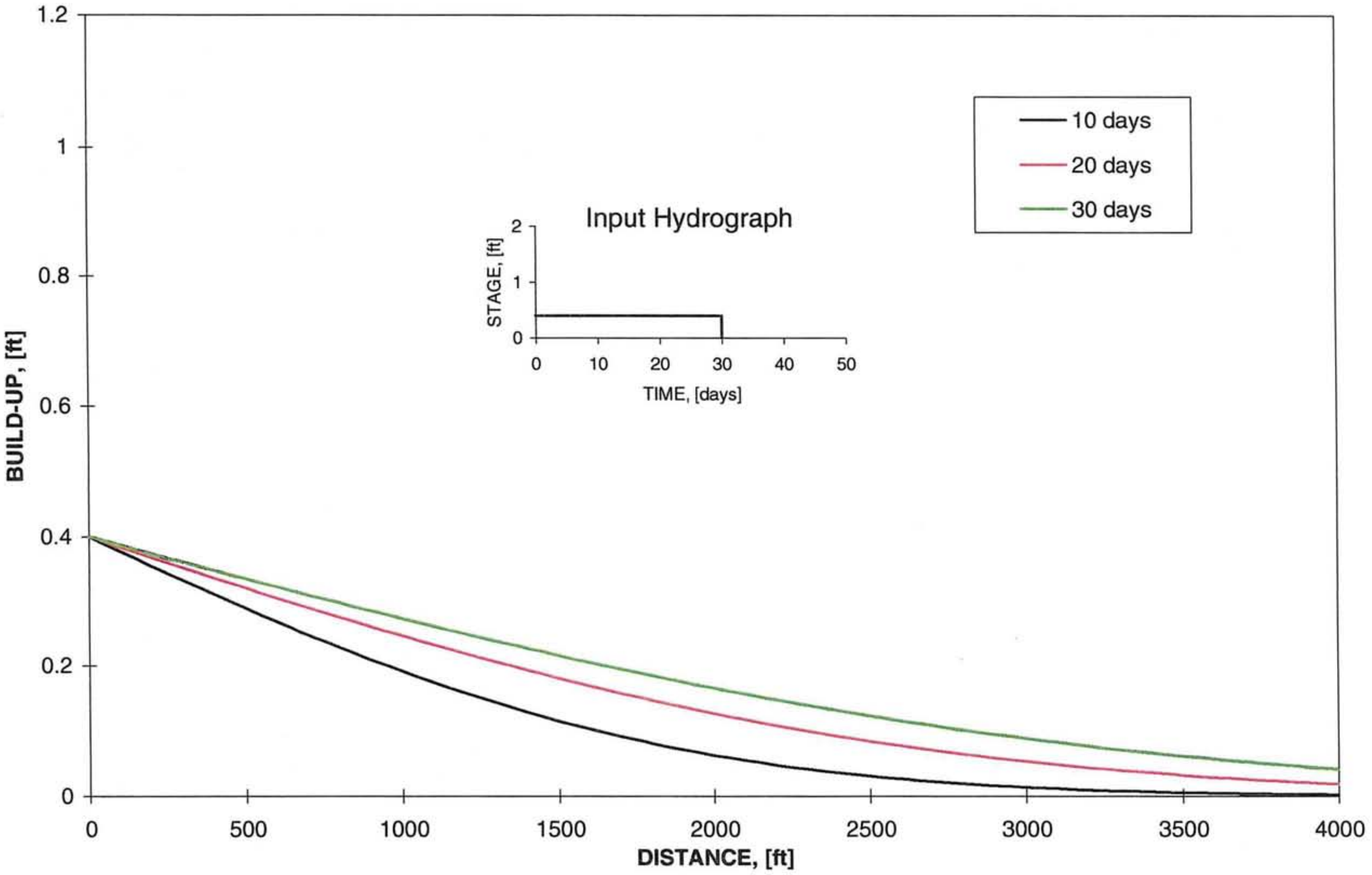
$h = H\,erf(x/\sqrt{\cdots}$

$\Delta = H - H\,erf(x/\sqrt{\cdots}$

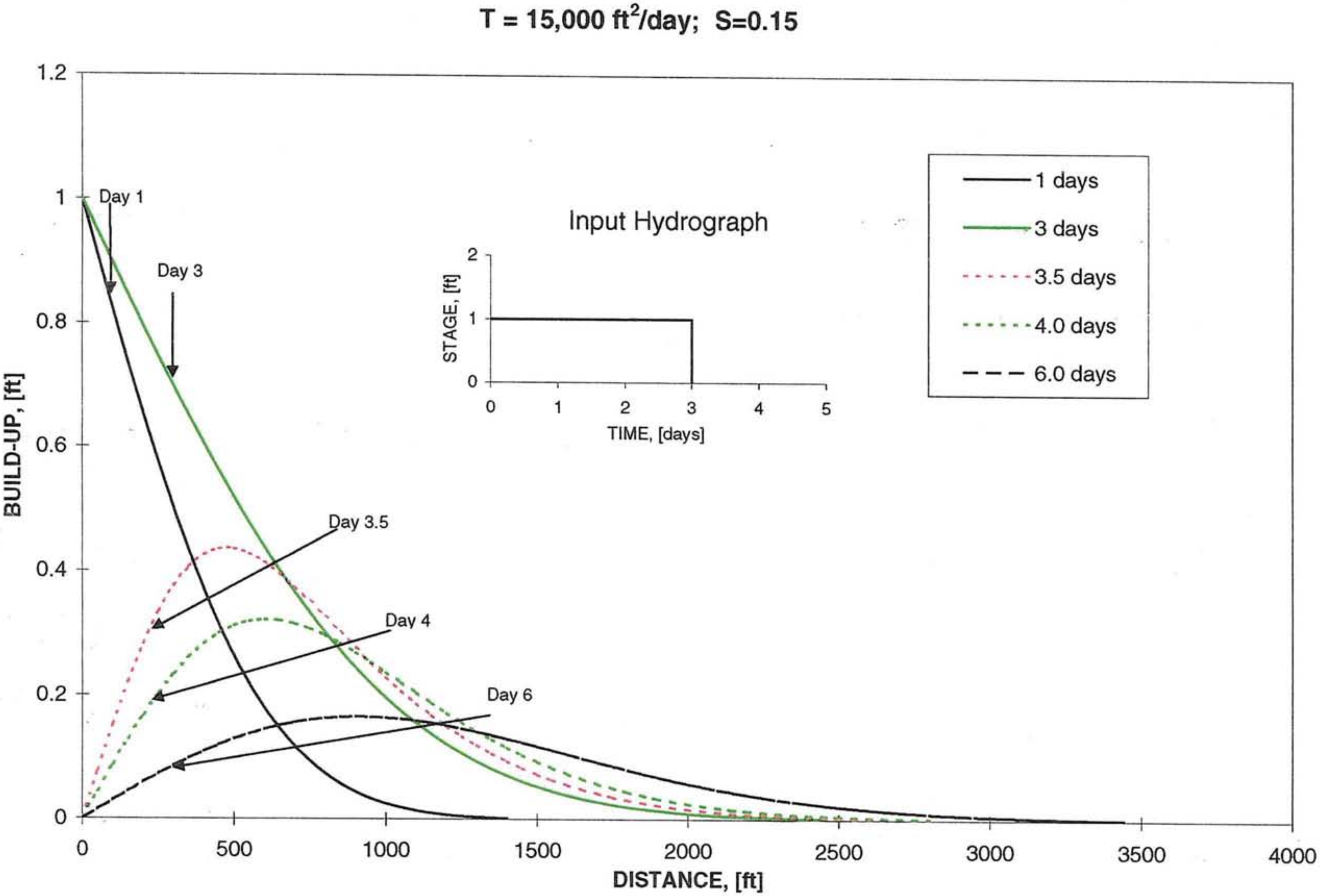
$\Delta = H\,erfc(x/\sqrt{\cdots}$

TABLE 4.—*Values of* $\sqrt{\pi}\int_{\frac{r}{\sqrt{4at}}}^{\infty}\frac{e^{-u^2}}{u^2}\,du$ *for given values of the parameter* $\frac{r}{\sqrt{4at}}$

$\frac{r}{\sqrt{4at}}$	$\sqrt{\pi}\int_{\frac{r}{\sqrt{4at}}}^{\infty}\frac{e^{-u^2}}{u^2}\,du$	$\frac{r}{\sqrt{4at}}$	$\sqrt{\pi}\int_{\frac{r}{\sqrt{4at}}}^{\infty}\frac{e^{-u^2}}{u^2}\,du$	$\frac{r}{\sqrt{4at}}$	$\sqrt{\pi}\int_{\frac{r}{\sqrt{4at}}}^{\infty}\frac{e^{-u^2}}{u^2}\,du$	$\frac{r}{\sqrt{4at}}$	$\sqrt{\pi}\int_{\frac{r}{\sqrt{4at}}}^{\infty}\frac{e^{-u^2}}{u^2}\,du$
0. 00010	17721. 4	0. 00062	2855. 7	0. 00240	735. 39	0. 00760	230. 09
0. 00011	16110. 1	0. 00063	2810. 3	0. 00250	705. 84	0. 00770	227. 06
0. 00012	14767. 3	0. 00064	2766. 3	0. 00260	678. 58	0. 00780	224. 11
0. 00013	13631. 1	0. 00065	2723. 7	0. 00270	653. 33	0. 00790	221. 23
0. 00014	12657. 2	0. 00066	2682. 4	0. 00280	629. 88	0. 00800	218. 43
0. 00015	11813. 2	0. 00067	2642. 3	0. 00290	608. 05	0. 00810	215. 69
0. 00016	11074. 7	0. 00068	2603. 4	0. 00300	587. 68	0. 00820	213. 03
0. 00017	10423. 1	0. 00069	2565. 6	0. 00310	568. 62	0. 00830	210. 42
0. 00018	9843. 8	0. 00070	2528. 9	0. 00320	550. 76	0. 00840	207. 88
0. 00019	9325. 6	0. 00071	2493. 3	0. 00330	533. 97	0. 00850	205. 40
0. 00020	8859. 1	0. 00072	2458. 6	0. 00340	518. 17	0. 00860	202. 97
0. 00021	8437. 1	0. 00073	2424. 9	0. 00350	503. 28	0. 00870	200. 60
0. 00022	8053. 5	0. 00074	2392. 1	0. 00360	489. 21	0. 00880	198. 29
0. 00023	7703. 2	0. 00075	2360. 1	0. 00370	475. 91	0. 00890	196. 03
24	7382. 1	0. 00076	2329. 0	0. 00380	463. 30	0. 00900	193. 81
5	7086. 7	0. 00077	2298. 7	0. 00390	451. 34	0. 00910	191. 65
026	6814. 0	0. 00078	2269. 2	0. 00400	439. 98	0. 00920	189. 53
00027	6561. 5	0. 00079	2240. 5	0. 00410	429. 17	0. 00930	187. 46
0. 00028	6327. 1	0. 00080	2212. 4	0. 00420	418. 88	0. 00940	185. 43
0. 00029	6108. 8	0. 00081	2185. 1	0. 00430	409. 06	0. 00950	183. 45
0. 00030	5905. 0	0. 00082	2158. 4	0. 00440	399. 70	0. 00960	181. 51
0. 00031	5714. 5	0. 00083	2132. 3	0. 00450	390. 75	0. 00970	179. 60
0. 00032	5535. 8	0. 00084	2106. 9	0. 00460	382. 18	0. 00980	177. 74
0. 00033	5367. 9	0. 00085	2082. 1	0. 00470	373. 98	0. 00990	175. 91
0. 00034	5210. 0	0. 00086	2057. 9	0. 00480	366. 13	0. 01000	174. 12
0. 00035	5061. 0	0. 00087	2034. 2	0. 00490	358. 59	0. 01100	158. 010
0. 00036	4920. 3	0. 00088	2011. 0	0. 00500	351. 36	0. 01200	144. 584
0. 00037	4787. 3	0. 00089	1988. 4	0. 00510	344. 41	0. 01300	133. 224
0. 00038	4661. 2	0. 00090	1966. 3	0. 00520	337. 72	0. 01400	123. 487
0. 00039	4541. 6	0. 00091	1944. 6	0. 00530	331. 29	0. 01500	115. 049
0. 00040	4428. 0	0. 00092	1923. 4	0. 00540	325. 10	0. 01600	107. 665
0. 00041	4319. 9	0. 00093	1902. 7	0. 00550	319. 13	0. 01700	101. 151
0. 00042	4217. 0	0. 00094	1882. 4	0. 00560	313. 38	0. 01800	95. 360
0. 00043	4118. 8	0. 00095	1862. 6	0. 00570	307. 83	0. 01900	90. 179
0. 00044	4025. 2	0. 00096	1843. 2	0. 00580	302. 46	0. 02000	85. 517
0. 00045	3935. 6	0. 00097	1824. 1	0. 00590	297. 28	0. 02100	81. 298
0. 00046	3850. 0	0. 00098	1805. 5	0. 00600	292. 28	0. 02200	77. 463
0. 00047	3768. 0	0. 00099	1787. 2	0. 00610	287. 44	0. 02300	73. 962
0. 00048	3689. 5	0. 00100	1769. 3	0. 00620	282. 75	0. 02400	70. 753
0. 00049	3614. 1	0. 00110	1608. 18	0. 00630	278. 21	0. 02500	67. 801
0. 00050	3541. 8	0. 00120	1473. 91	0. 00640	273. 82	0. 02600	65. 076
0. 00051	3472. 3	0. 00130	1360. 29	0. 00650	269. 56	0. 02700	62. 553
0. 00052	3405. 4	0. 00140	1262. 90	0. 00660	265. 42	0. 02800	60. 210
0. 00053	3341. 1	0. 00150	1178. 50	0. 00670	261. 42	0. 02900	58. 029
0. 00054	3279. 2	0. 00160	1104. 64	0. 00680	257. 53	0. 03000	55. 993
55	3219. 5	0. 00170	1039. 48	0. 00690	253. 75	0. 03100	54. 089
56	3162. 0	0. 00180	981. 56	0. 00700	250. 08	0. 03200	52. 304
57	3106. 4	0. 00190	929. 73	0. 00710	246. 51	0. 03300	50. 628
0. 00058	3052. 8	0. 00200	883. 09	0. 00720	243. 05	0. 03400	49. 050
0. 00059	3001. 0	0. 00210	840. 89	0. 00730	239. 67	0. 03500	47. 562
0. 00060	2950. 9	0. 00220	802. 52	0. 00740	236. 39	0. 03600	46. 157
0. 00061	2902. 5	0. 00230	767. 49	0. 00750	233. 20	0. 03700	44. 828



T = 15,000 ft^2/day; S=0.15



T = 15,000 ft²/day; S=0.15
BUILD-UP, [ft]
1.2
1
0.8
0.6
0.4
0.2
0
Day 1
Day 3
Day 3.5
Day 4
Day 6
Input Hydrograph
STAGE, [ft]
2
1
0
0
1
2
3
4
5
TIME, [days]
1 days
3 days
3.5 days
4.0 days
6.0 days
0
500
1000
1500
2000
2500
3000
3500
4000
DISTANCE, [ft]

APPENDIX B

DAILY ANALYSIS OF TRANSECTS

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.

Well 10-10-29DDA

Alda upstream transect - 50 feet northwest of the river.

The correlation factor between the well (Alda U-1) and the river gage near Grand Island for the period March 11 to September 17, 1999 is 0.981 (Appendix F, table 1)

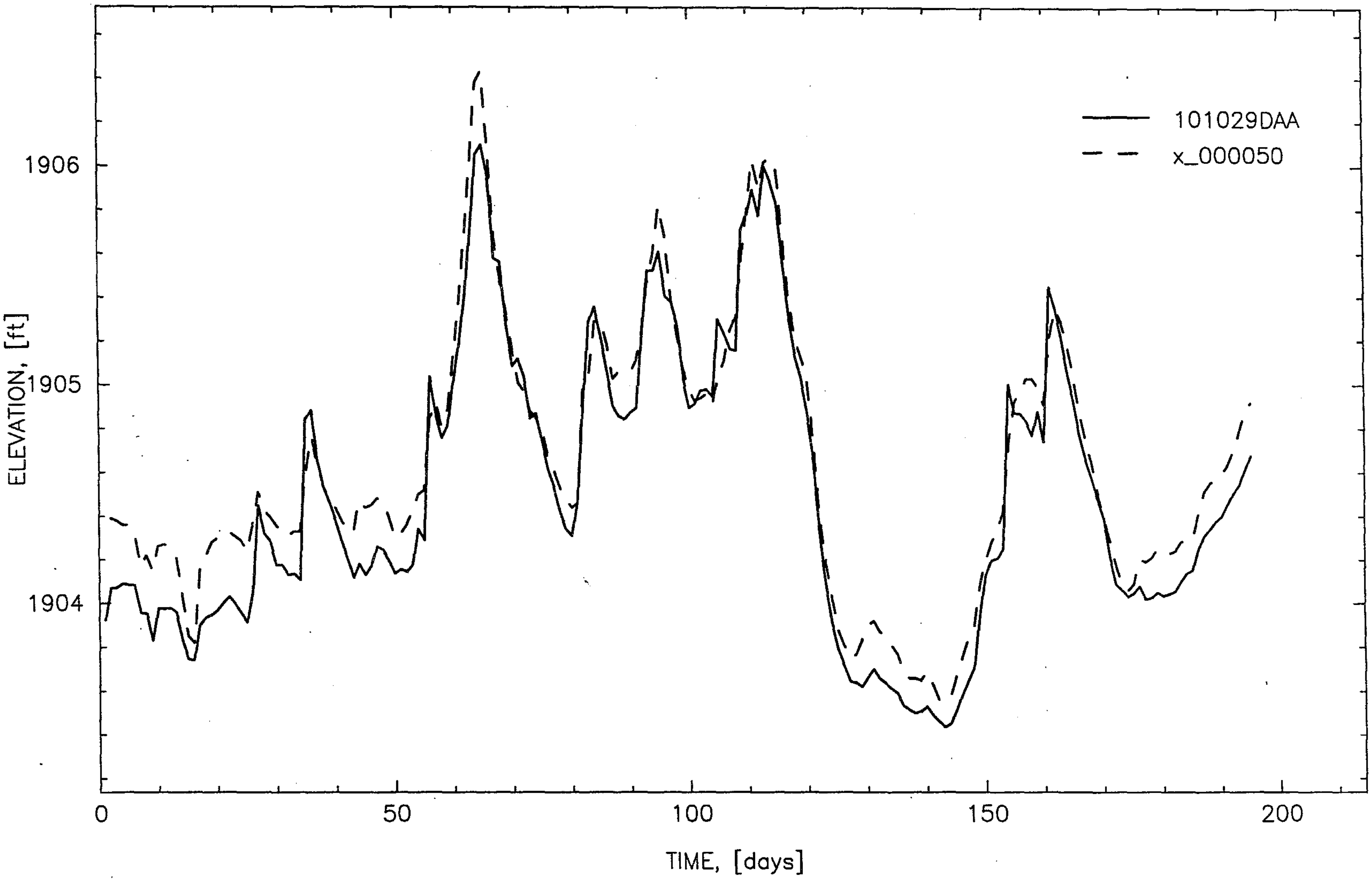
Bank Storage comparison using a transmissivity of 20,000 ft^2/day (the highest plausible aquifer values) shows that the change in water surface at the well would stay within 0.2 feet of the river elevation throughout the period. Actually, the well performed nearly as predicted except that it rose as much as 0.4 feet higher than the river after large rainfalls. The graph on the following page shows the actual well hydrograph as a solid line, and the bank storage simulation as a dashed line.

Indications that the water level in the well responds to river stage include:

1. The well hydrograph traces the river hydrograph except immediately after significant rainfalls.

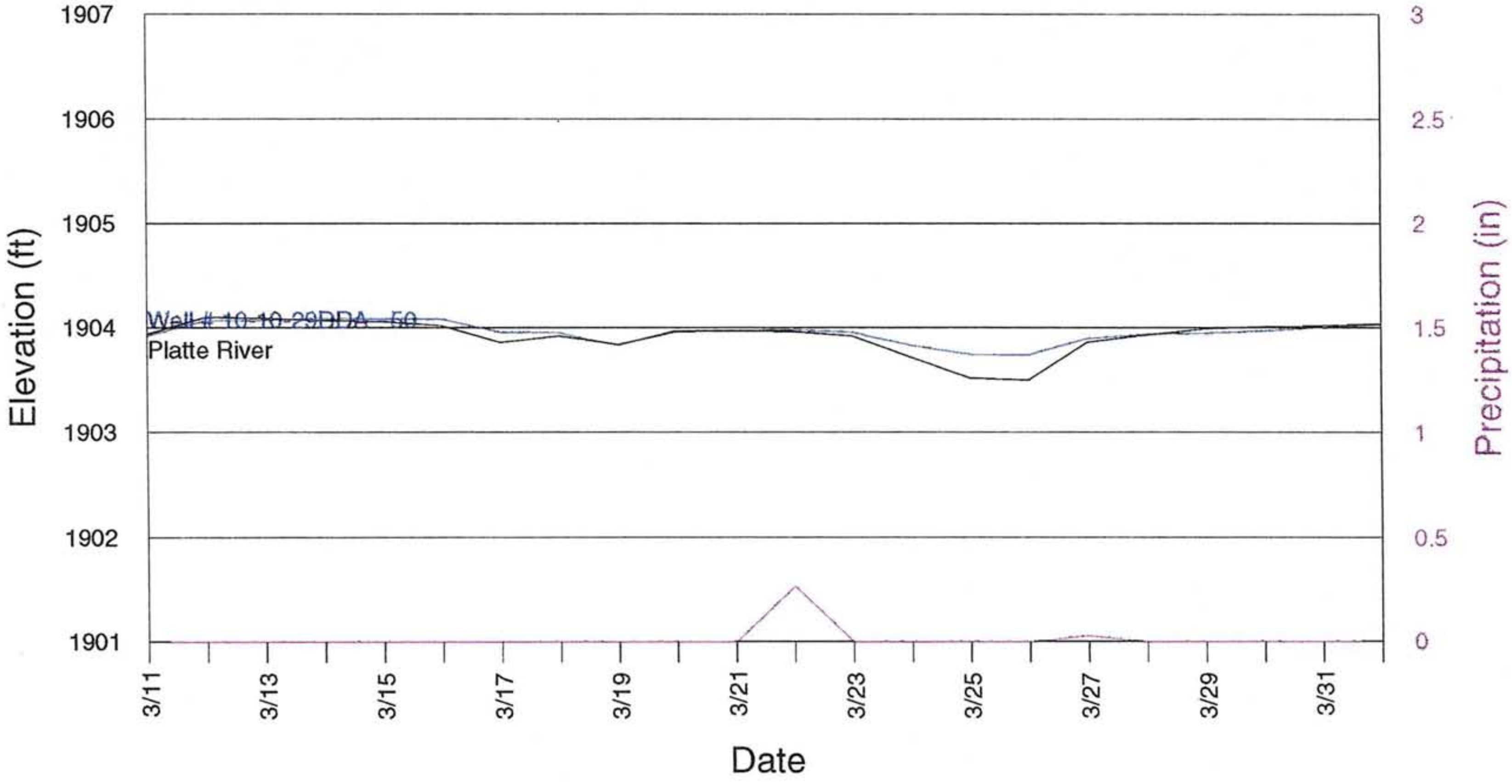
Indications that the well also responds to other factors such as precipitation include:

1. After each significant rainfall, the well rose above the river by as much as 0.4 feet and generally remained higher than the river during the decline in elevations following the rain.


101029DAA
x_000050
1906
1905
1904
ELEVATION, [ft]
0
50
100
150
200
TIME, [days]

Alda Transect Wells (U)

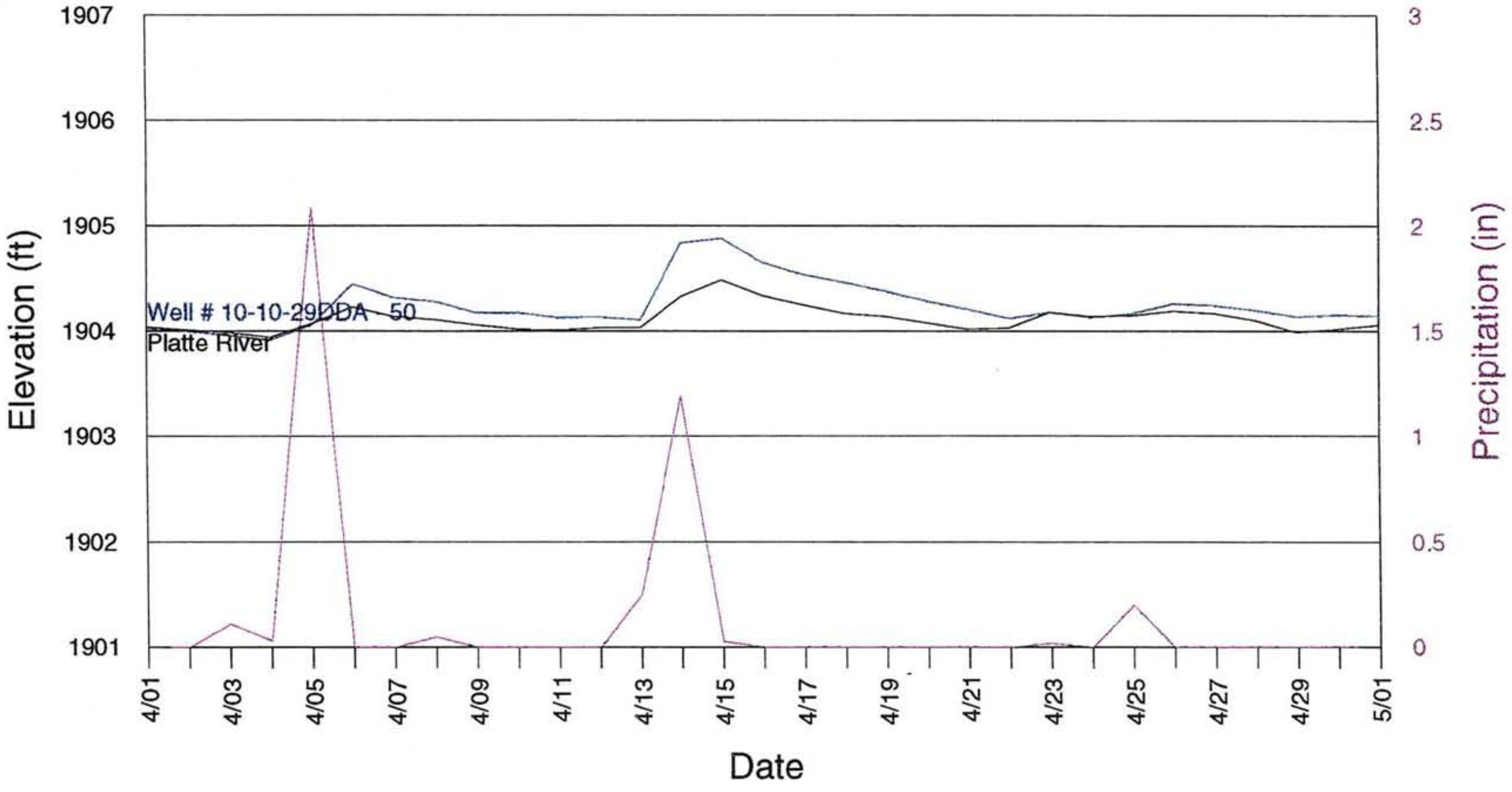
Elevations for March 1999



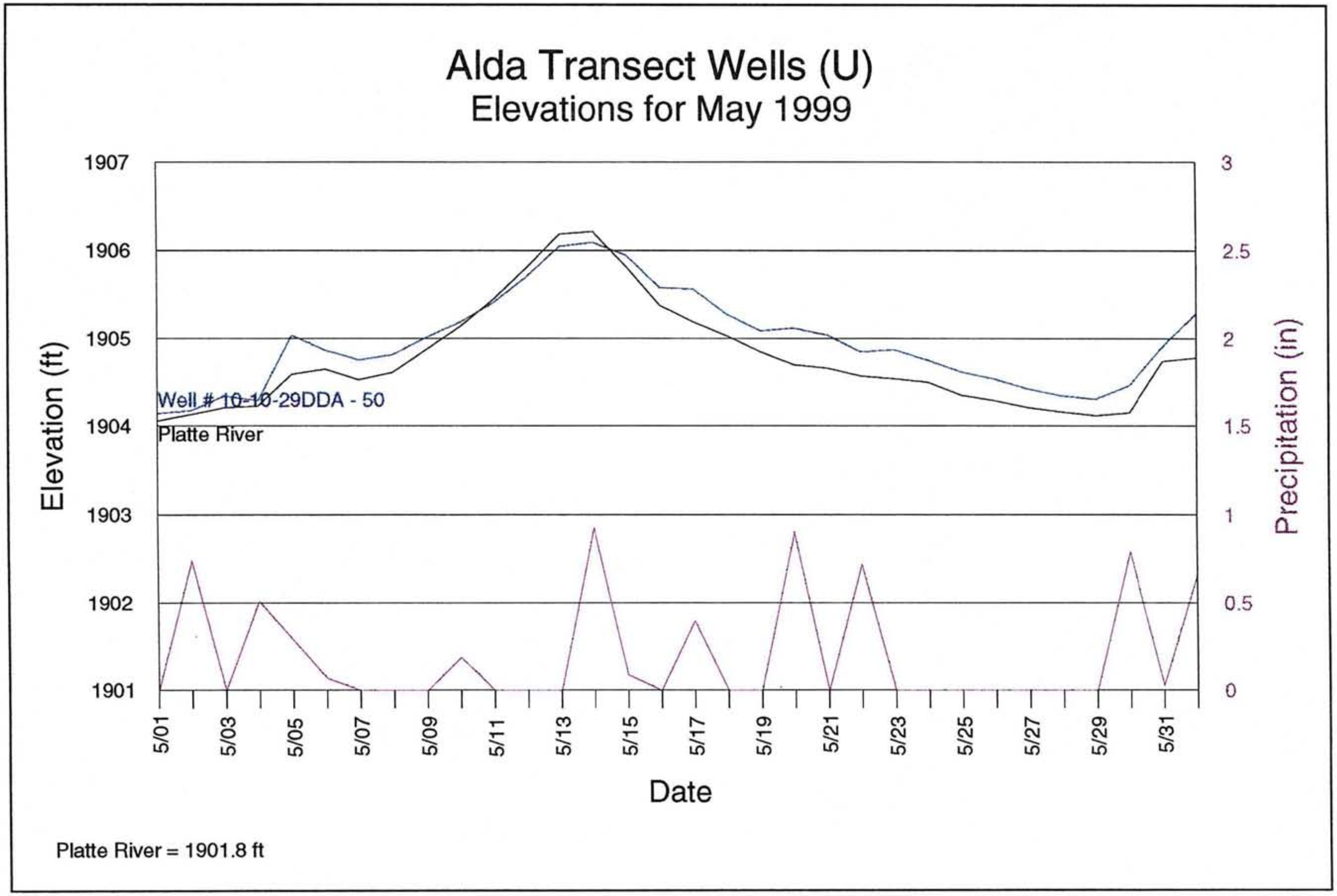
Platte River = 1901.8 ft

Alda Transect Wells (U)

Elevations for April 1999

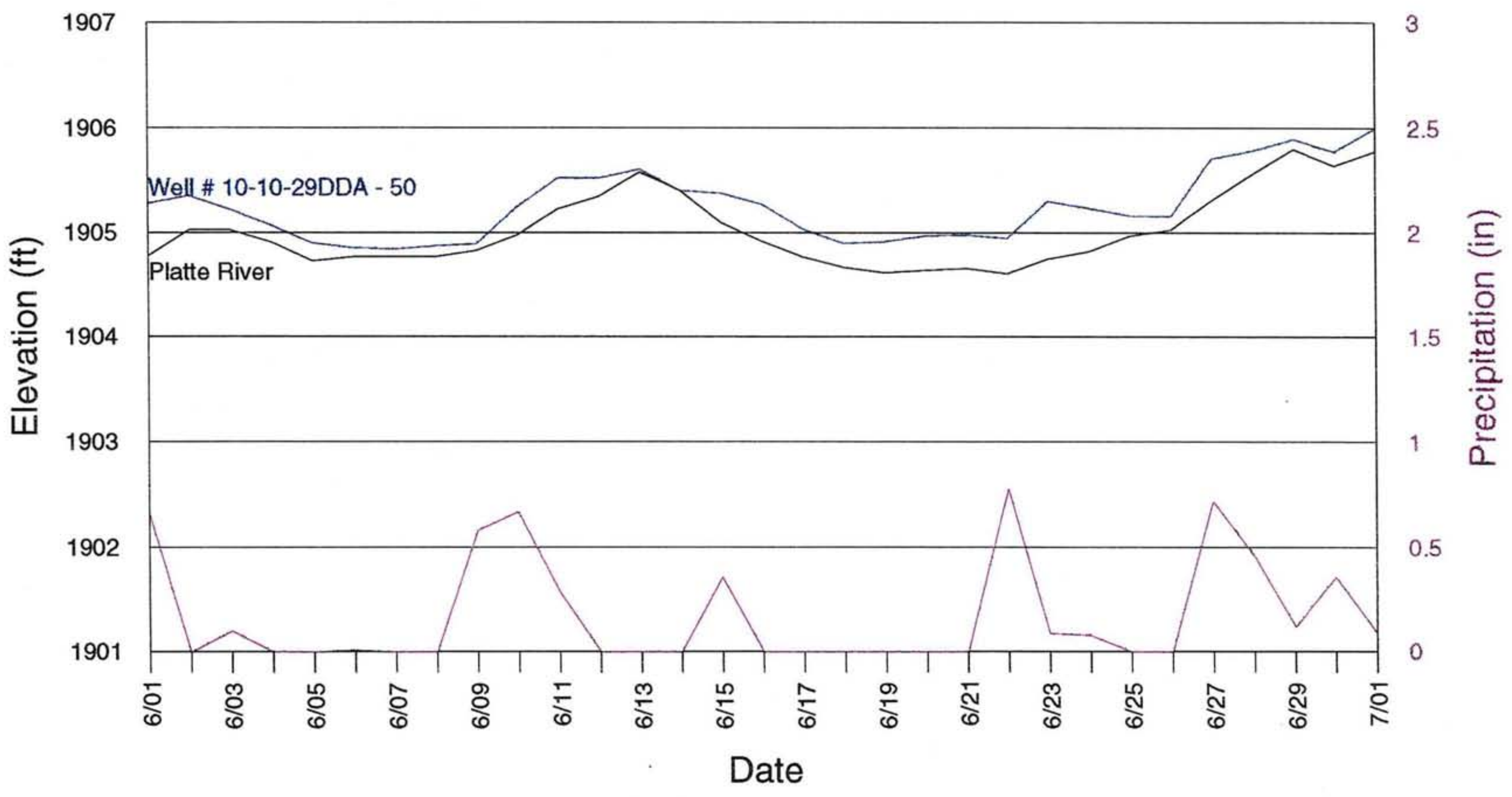


Platte River = 1901.8 ft

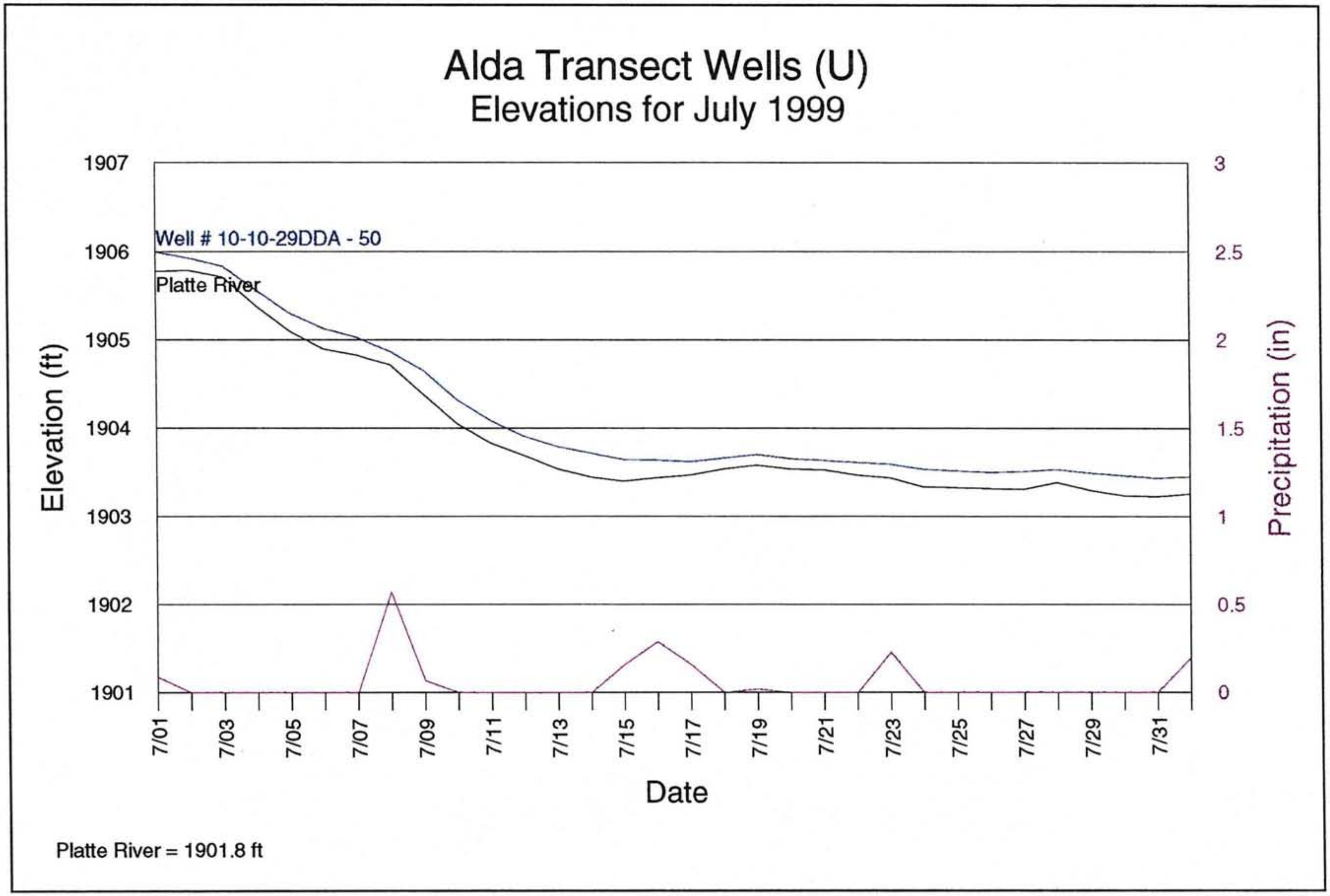


Alda Transect Wells (U)
Elevations for May 1999

Platte River = 1901.8 ft

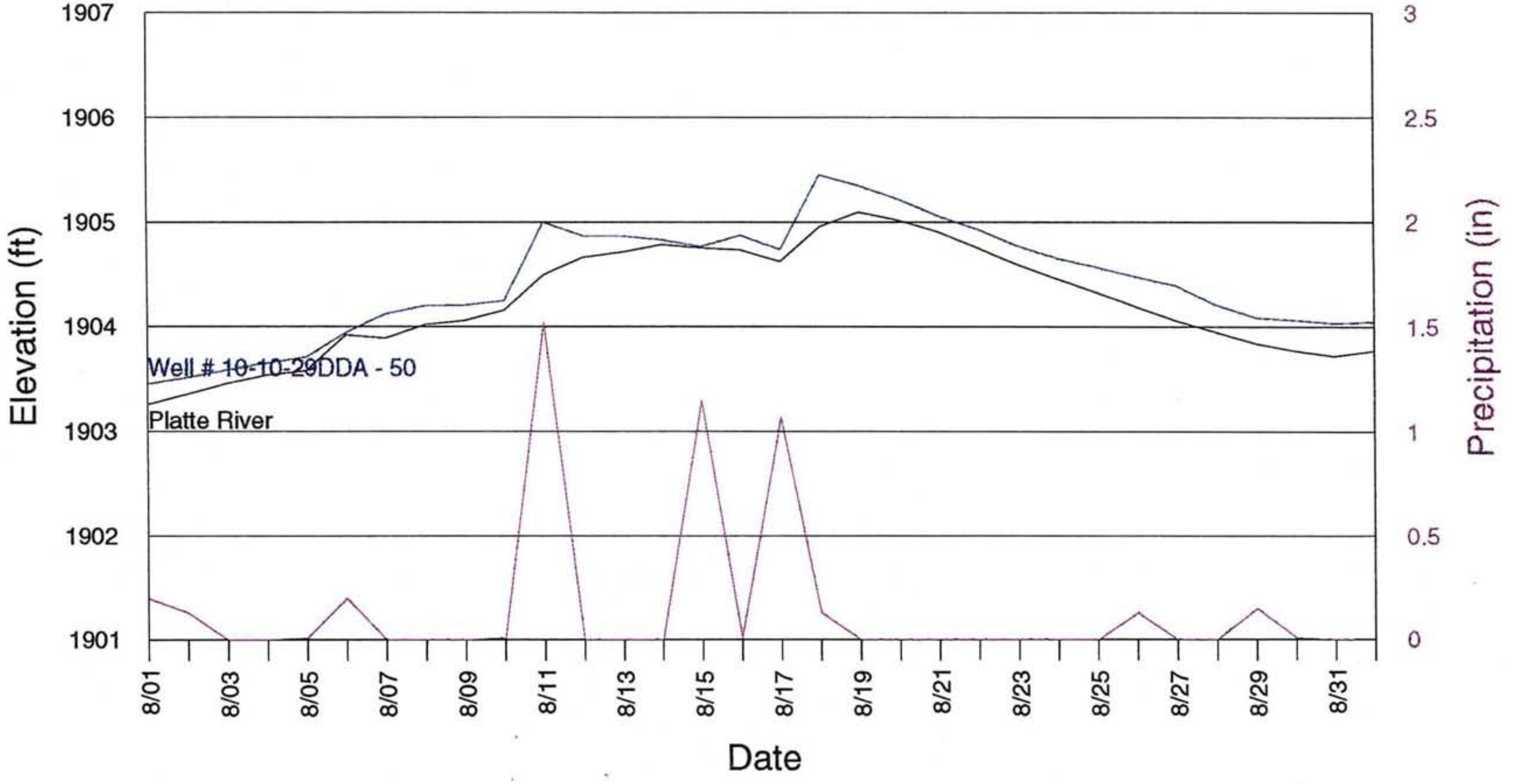


Platte River = 1901.8 ft



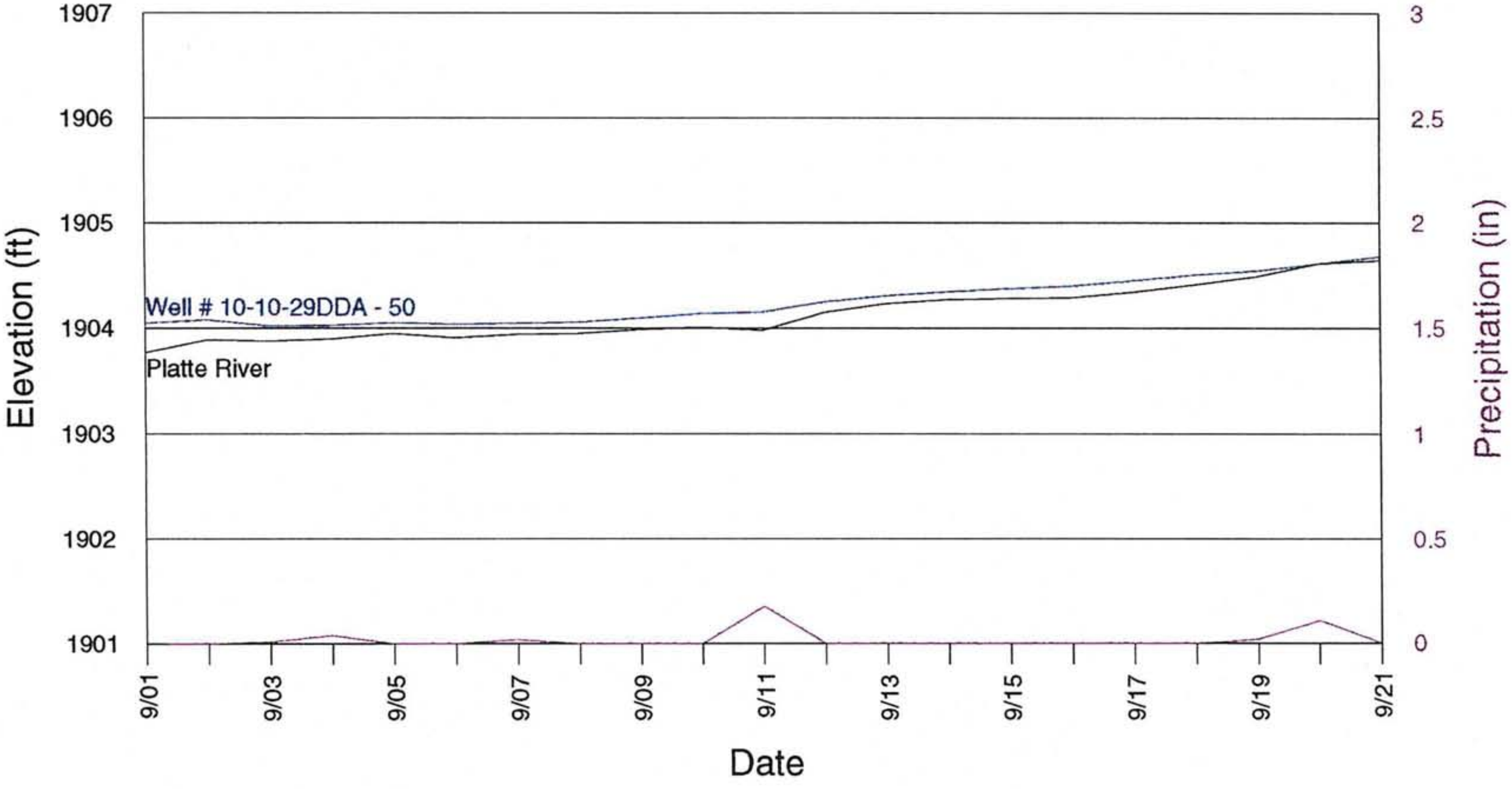
Platte River = 1901.8 ft

Alda Transect Wells (U)
Elevations for August 1999



Platte River = 1901.8 ft

Alda Transect Wells (U)
Elevations for September 1999



Platte River = 1901.8 ft

Well 10-10-22CCB

Alda downstream transect - 1200 (1/4 mile) northwest of the river.

The correlation factor between the well (Alda D-1) and the river gage near Grand Island for the period May 3 to September 21, 1999 is 0.694 (Appendix F, table 1)

Bank Storage comparison using a transmissivity of 20,000 ft^2/day (the highest plausible aquifer values) shows that the change in water surface at the well would rise about 1 foot as a result of the high river elevations that occurred from May 1 to July 15. Actually, the initial reading of the well on May 5 was 2.0 feet above the river elevation and it rose another 1.3 feet between May 5 and July 2, while the river rose 1.6 feet. The graph on the following page shows the actual well hydrograph as a solid line, and the bank storage simulation as a dashed line.

Indications that the water level in the well responds to river stage include:

1. The rise in the river between August 5 and 10 seems to slow and then reverse the decline in the well that had been going on since July 2.

Indications that the well also responds to other factors such as precipitation include:

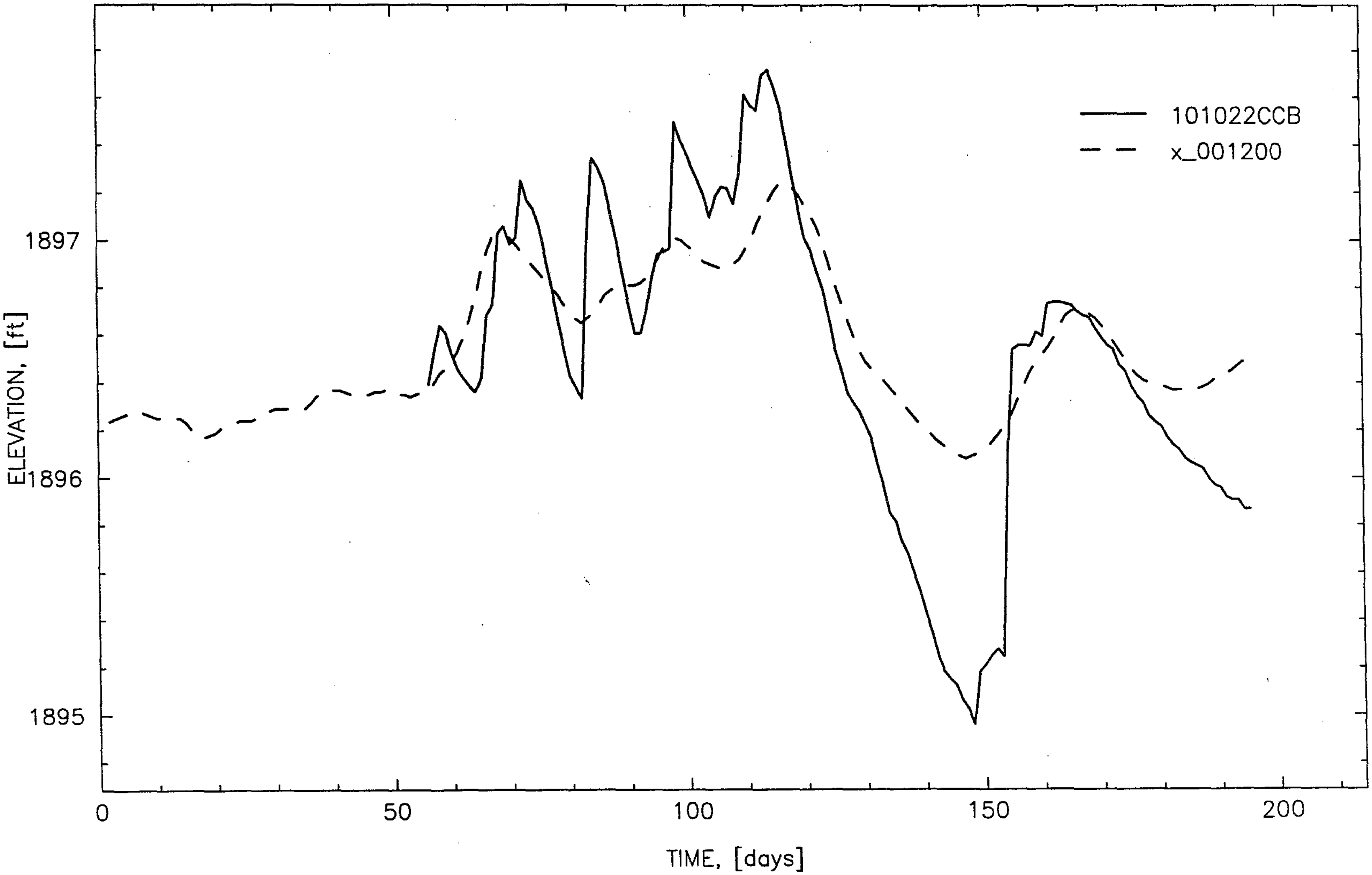
1. Except for a 2 day period May 13 and 14, the well ranges 1 to 2.5 feet higher than the river, meaning that water would move from the well to the river rather than from the river to the well.

2. A steep rise in the river from May 7 to 12 is not reflected in the well. In fact, the well is dropping during most of that period.

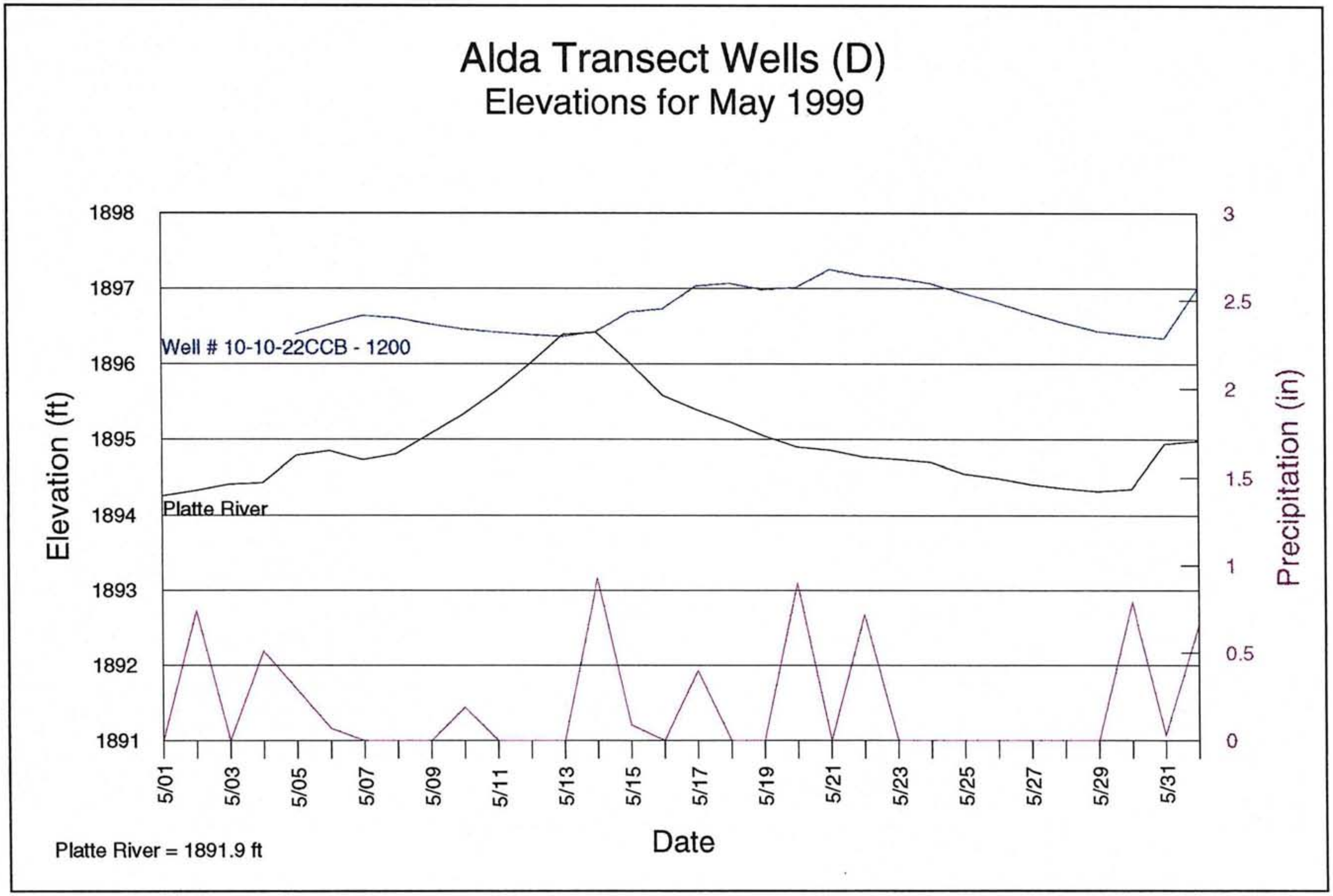
3. The river drops sharply from May 14 to 21, while the well is rising.

4. From June 13 to 16, the well rose 0.6 feet while the river dropped 0.6 feet, even though the well was 1.5 feet higher than the river on June 3.

5. From September 1 to 21, the well dropped steadily while the river rose steadily.



101022CCB
x_001200
ELEVATION, [ft]
1897
1896
1895
0
50
100
150
200
TIME, [days]



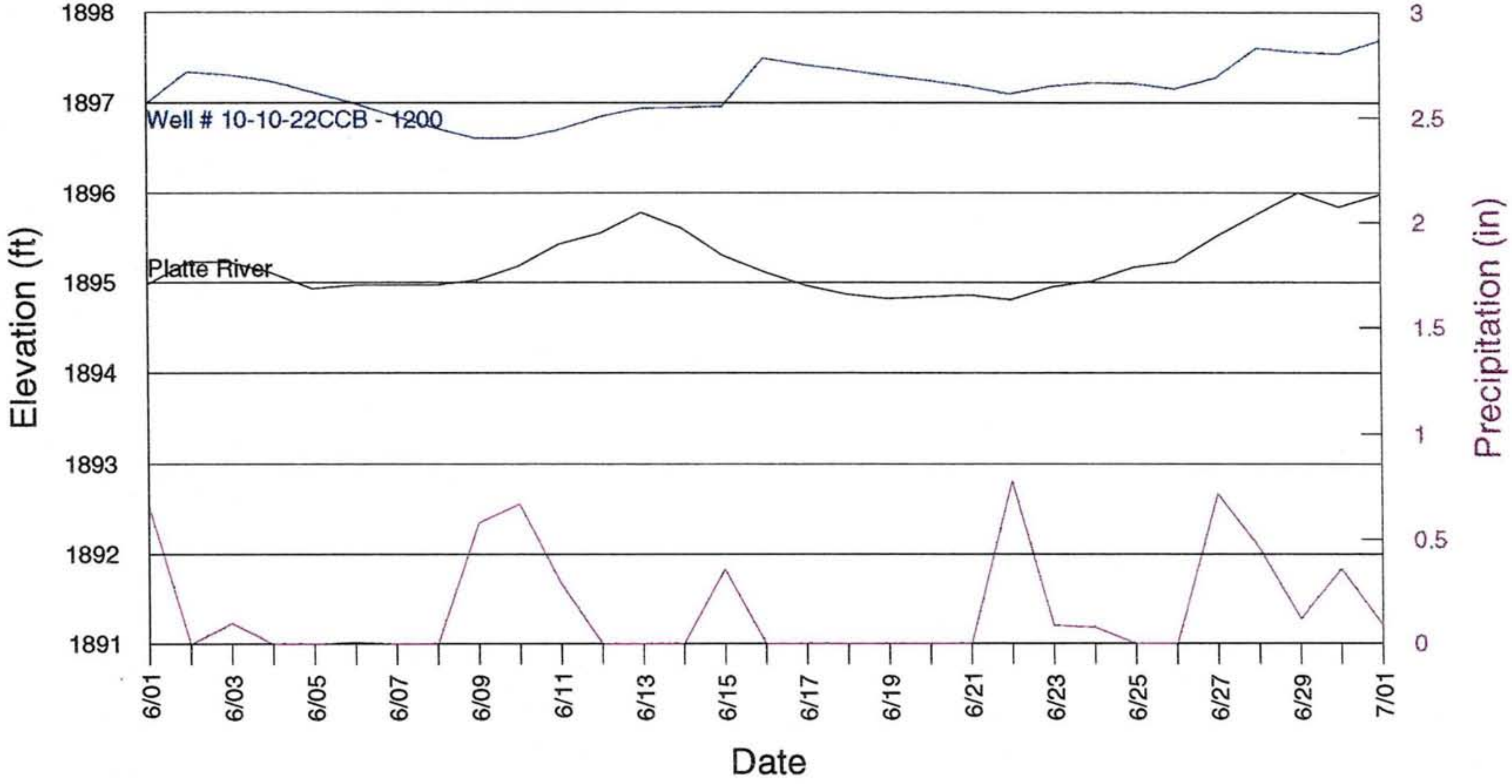
Alda Transect Wells (D)

Elevations for May 1999

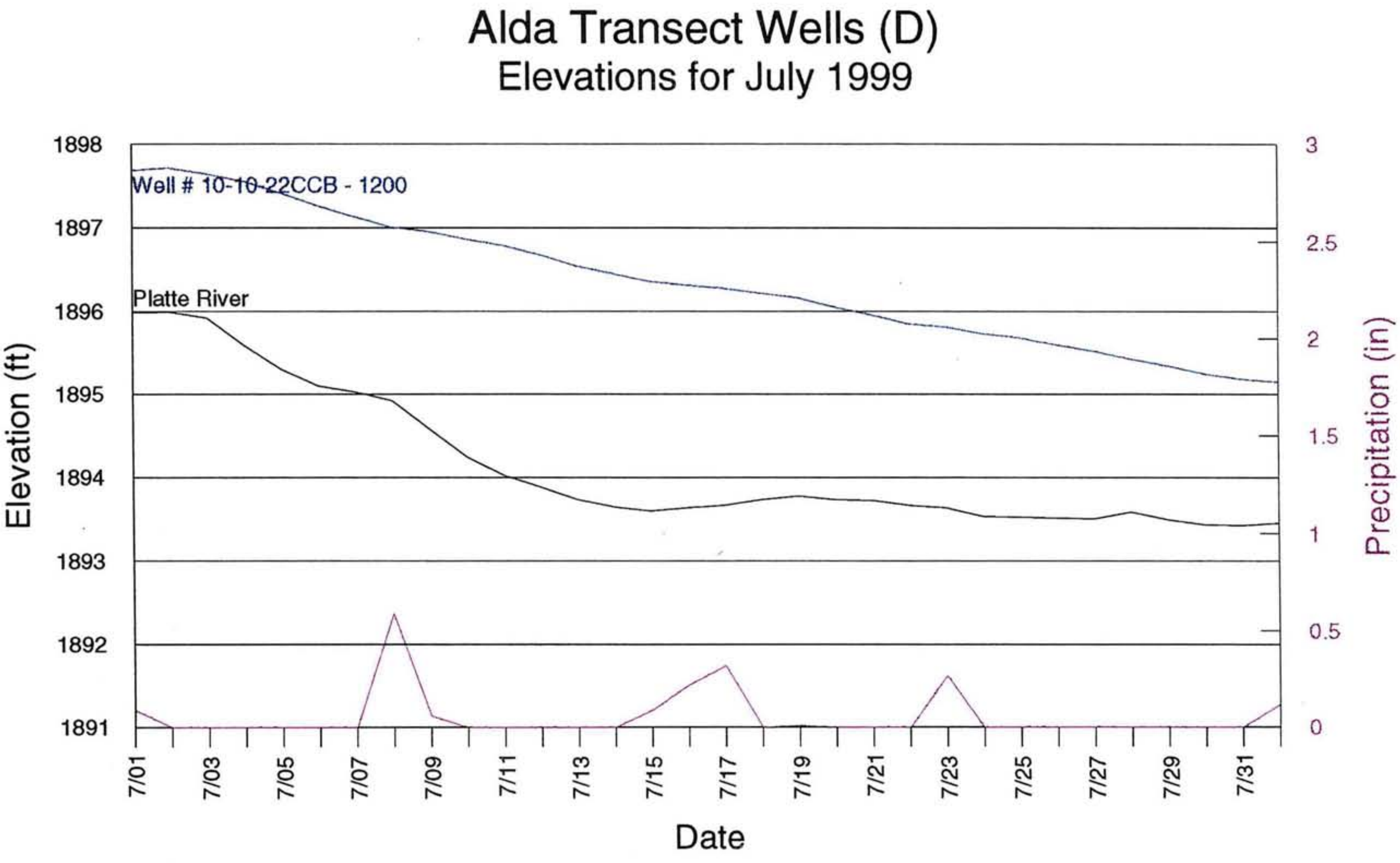
Platte River = 1891.9 ft

Alda Transect Wells (D)

Elevations for June 1999



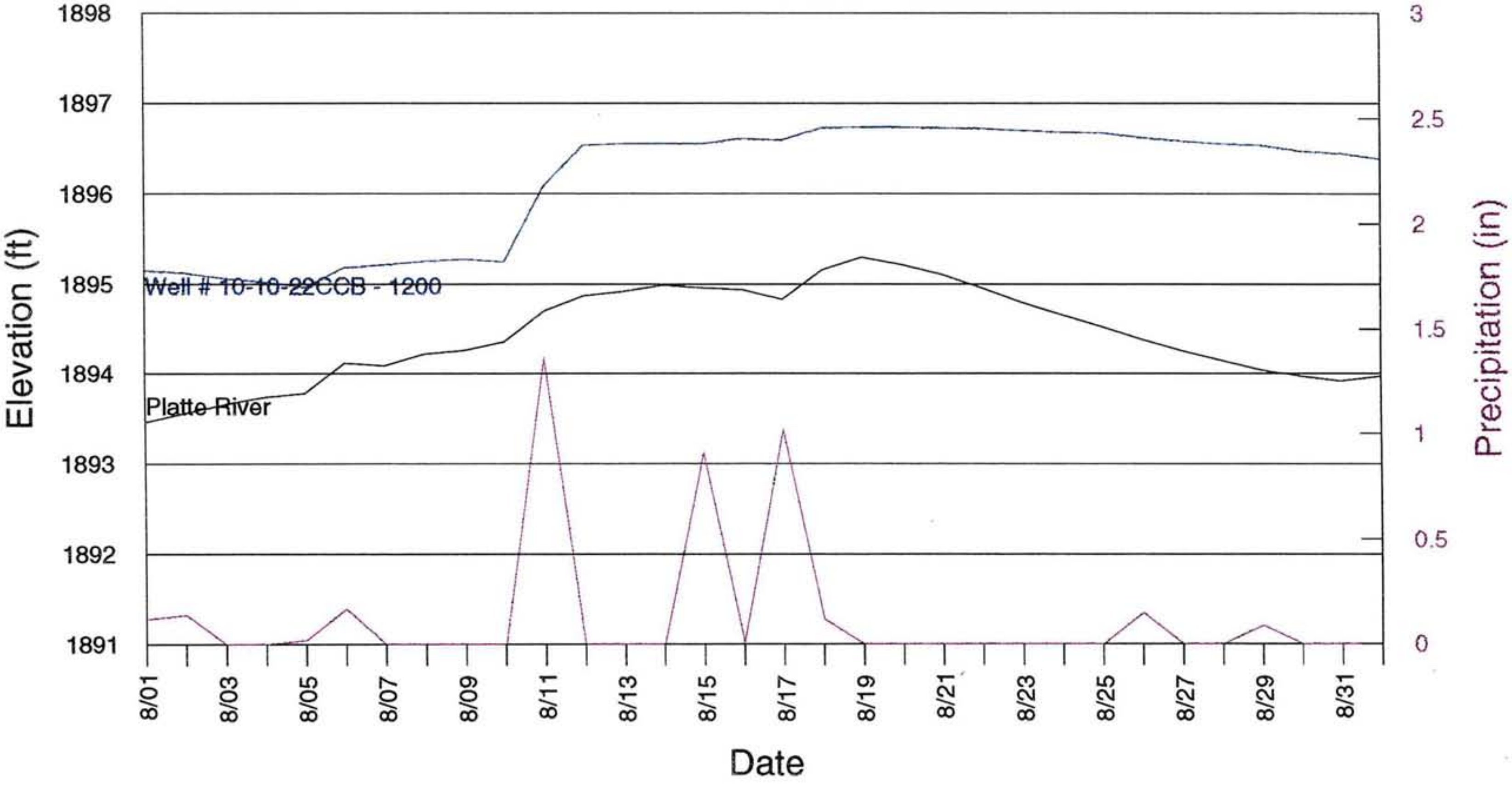
Platte River = 1891.9 ft



Platte River = 1891.9 ft

Alda Transect Wells (D)

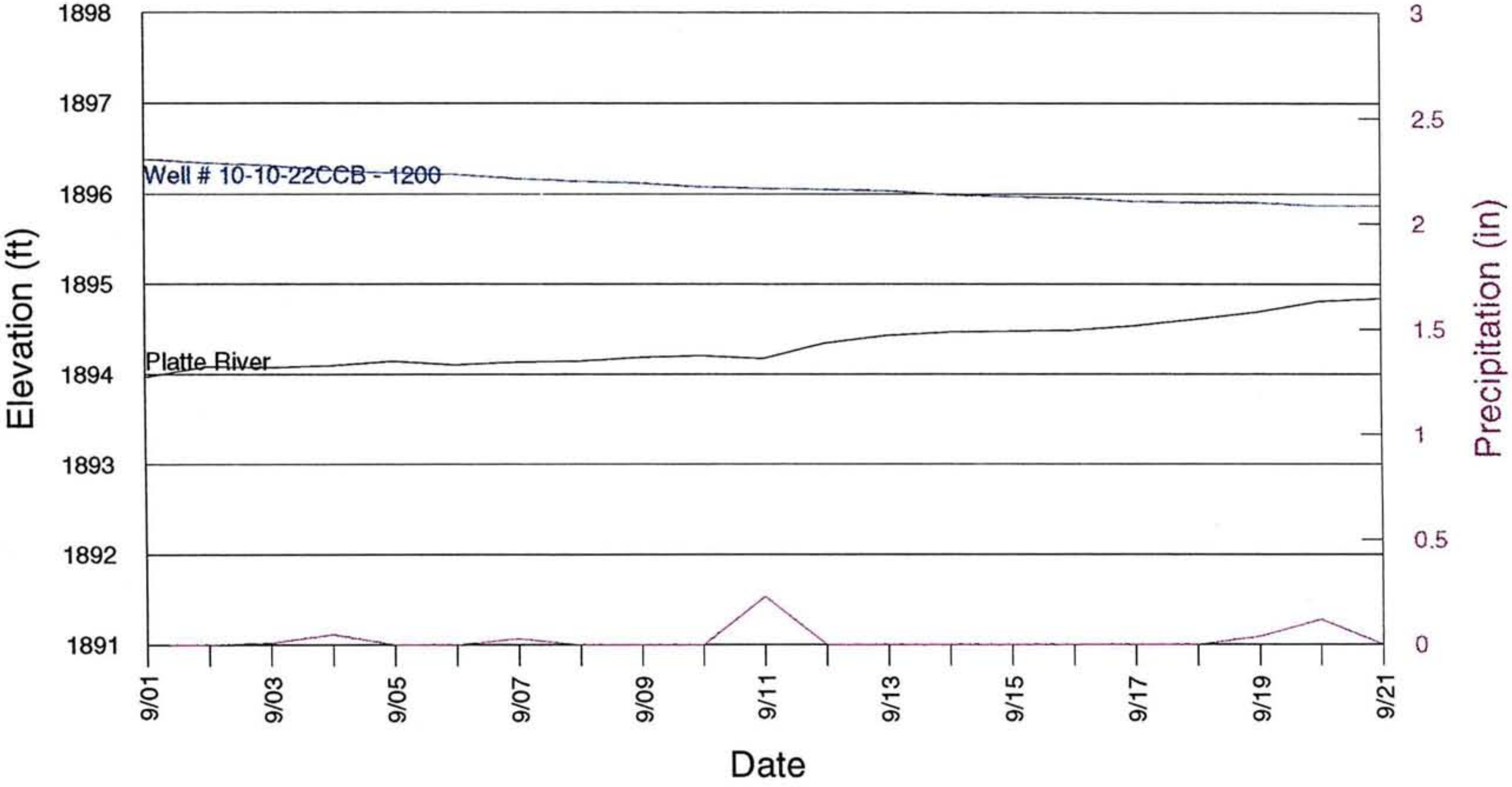
Elevations for August 1999



Platte River = 1891.9 ft

Alda Transect Wells (D)

Elevations for September 1999



Platte River = 1891.9 ft

Well 10-10-28BBC

Alda upstream transect 3,000 feet (½ mile +) northwest of the river.

The correlation factor between the well (Alda U-2) and the river gage near Grand Island for the period March 11 to September 21 was 0.741 (Appendix F, table 1)

Bank Storage comparison using a transmissivity of 20,000 ft^2/day (the highest plausible aquifer values) shows that the ground water surface at the well rise 0.5 feet in response to the high river elevations that occurred from May 1 to July 15. Actually the well fluctuated through a range of 2.6 feet during that period. The graph on the following page shows the actual well hydrograph as a solid line, and the bank storage simulation as a dashed line.

Indications that the water level in the well responds to river stage include:

1. Declines in the river elevation are often, but not always, accompanied by similar declines in the well.

Indications that the well also responds to other factors such as precipitation include:

1. The well rose nearly 2.5 feet from April 3 to 5, while the river rose 0.5 feet. They started from nearly equal elevation.

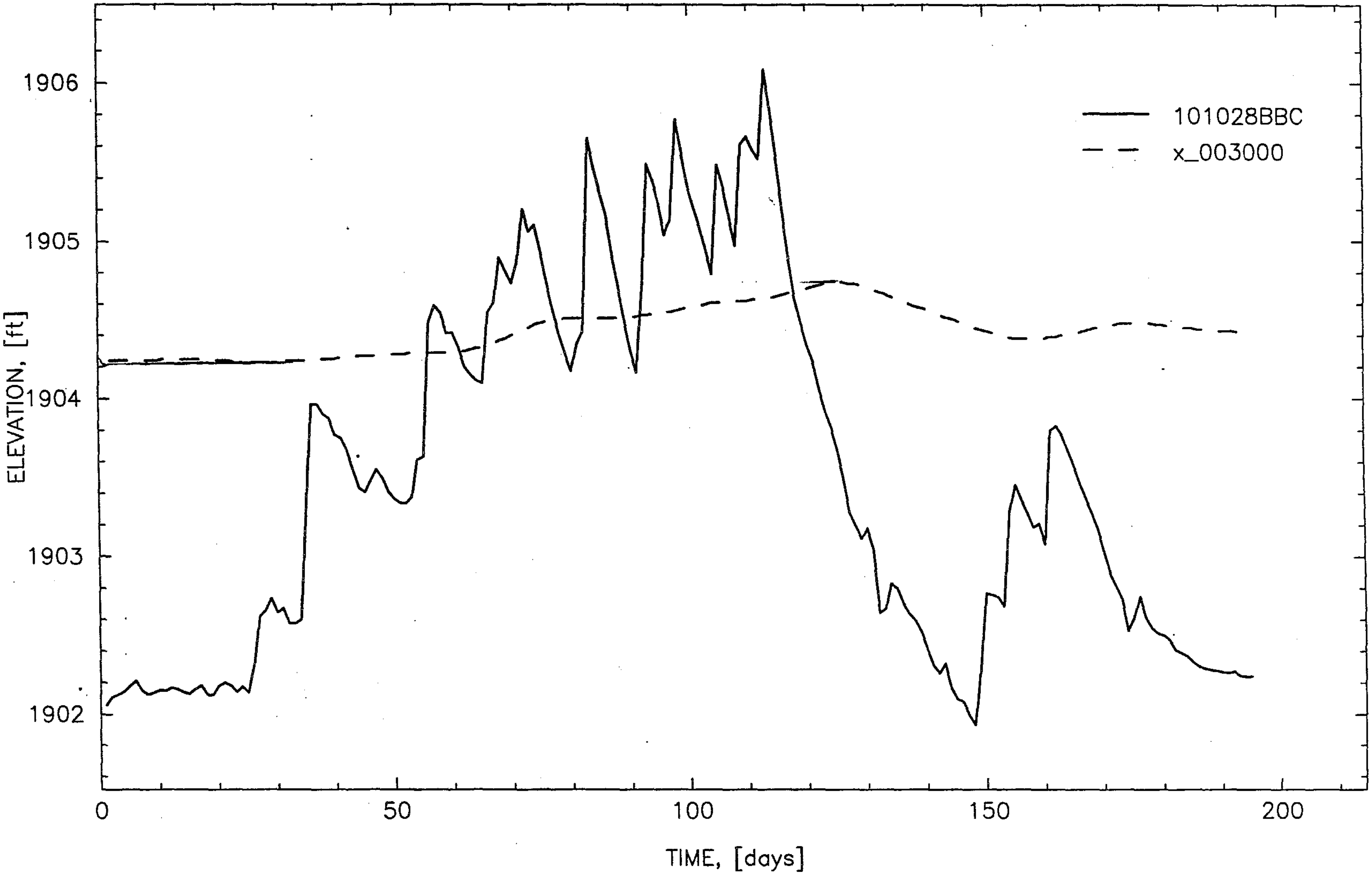
2. From May 6 to 14, the well dropped while the river rose, even after the river reached a higher elevation than the well on May 12.

3. From May 14 to 21, the well rose while the river declined, even after the river dropped below the well on May 15.

4. Through June, the well rises and falls in harmony with precipitation events having 5 separate peaks, while the river hydrograph has only 3 peaks. It appears more likely that the river peaks are due in part to discharge from the aquifer.

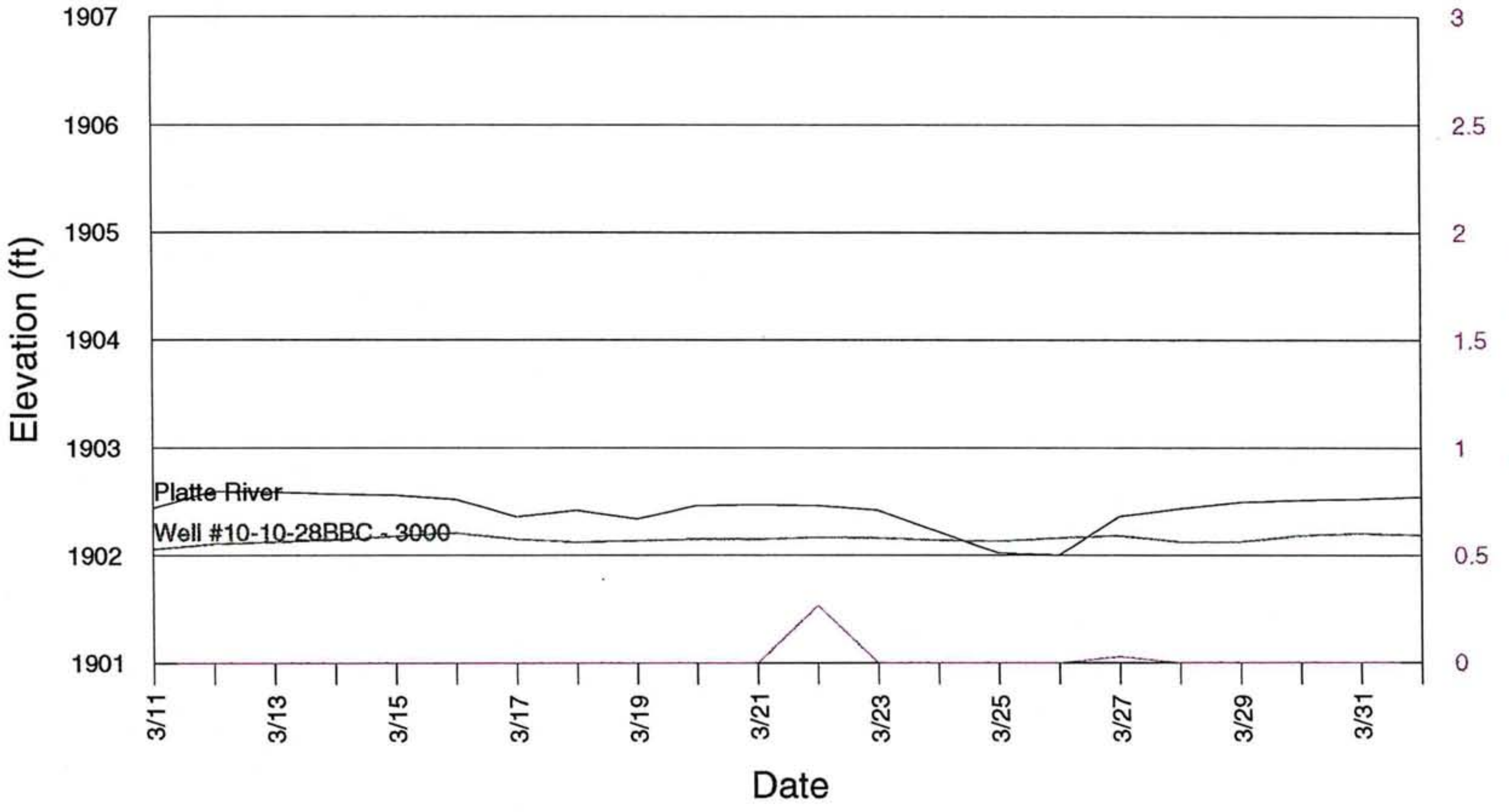
5. From August 1 to 5, the well dropped while the river rose, even as the well dropped lower than the river.

6. From September 2 to 21, the well dropped continuously, while the river rose continuously. The well ended the period nearly 1 foot lower than the river.

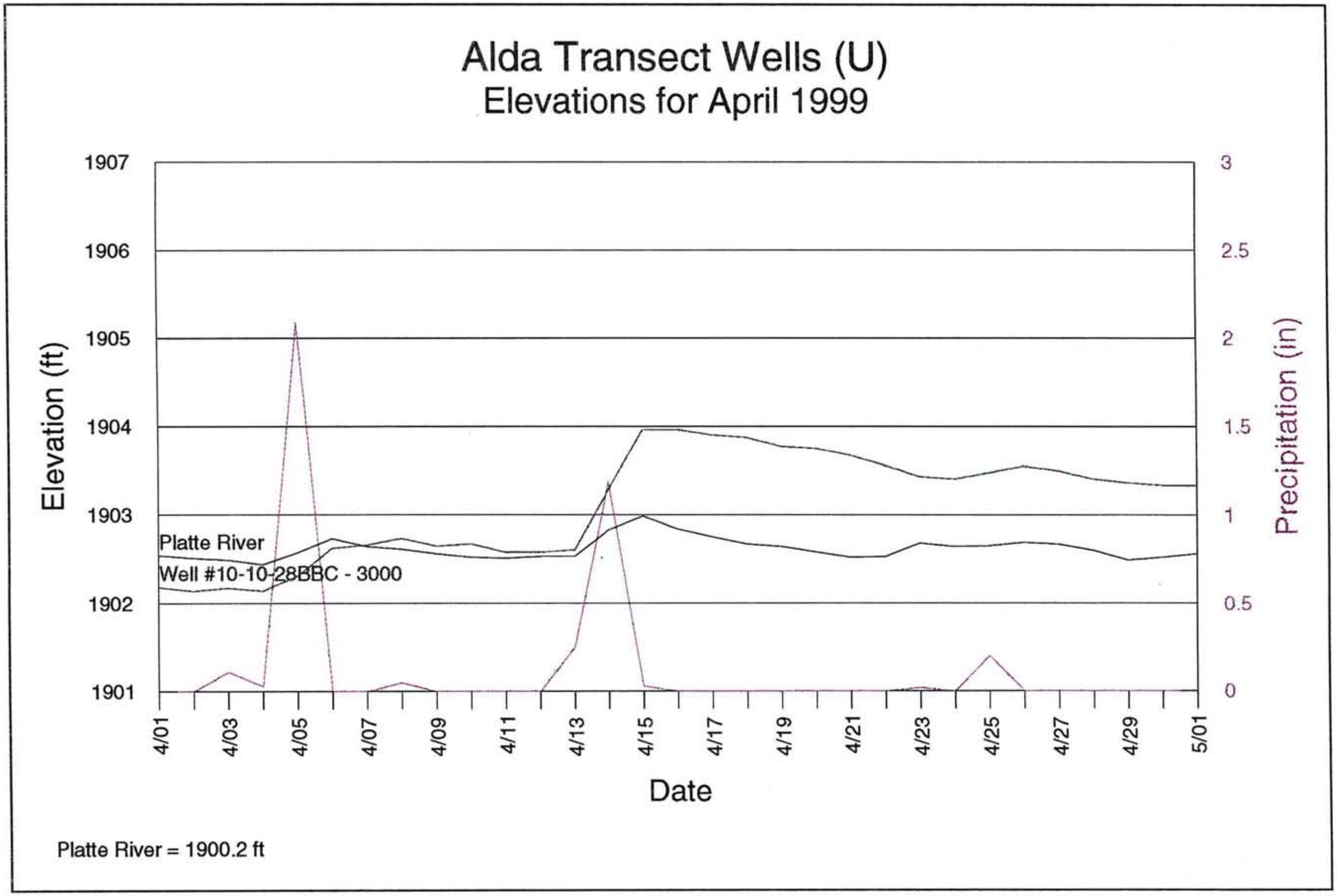


ELEVATION, [ft]
1906
1905
1904
1903
1902
0
50
100
150
200
TIME, [days]
101028BBC
x_003000

Alda Transect Wells (U)
Elevations for March 1999



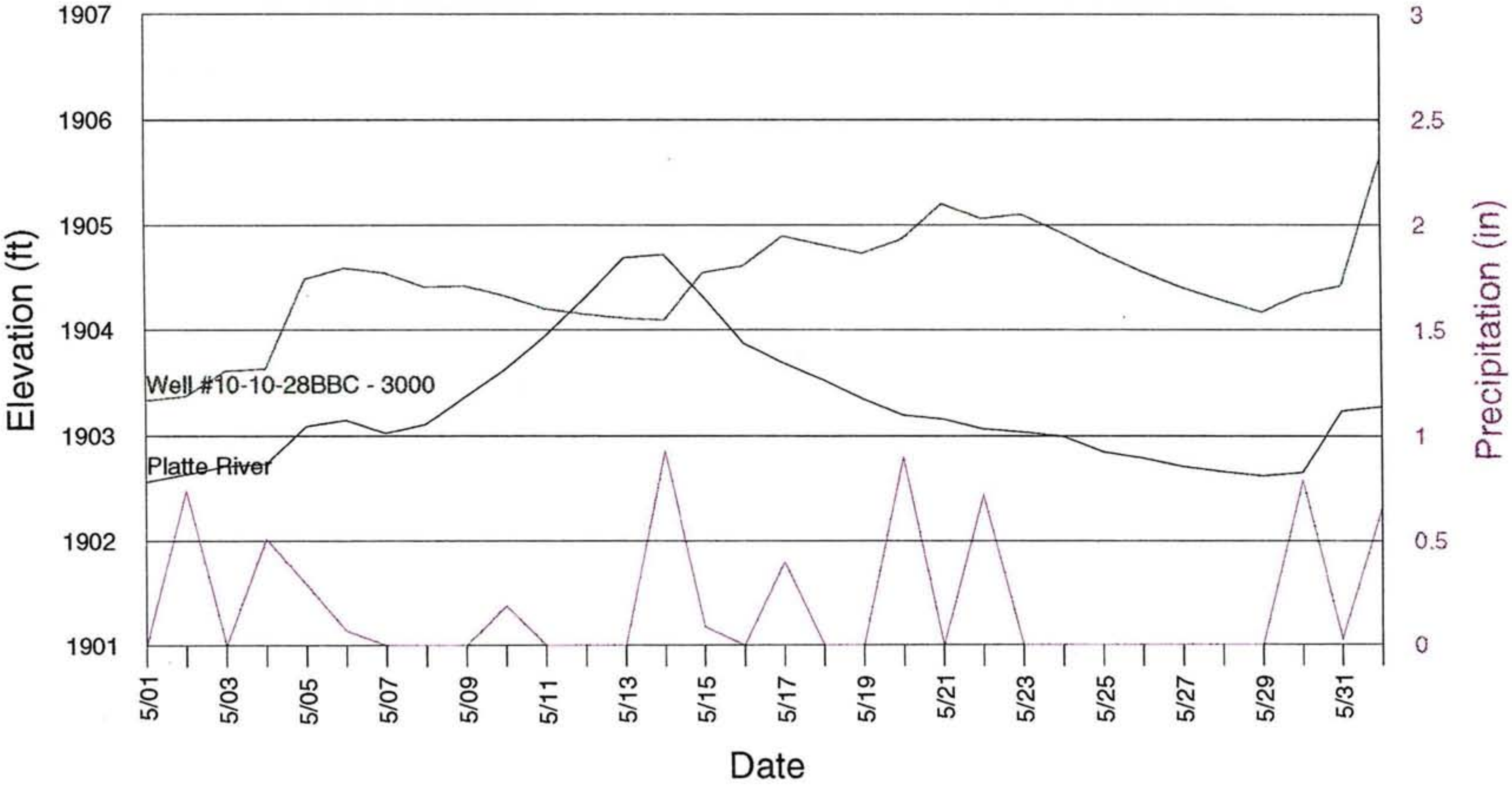
Platte River = 1900.2 ft



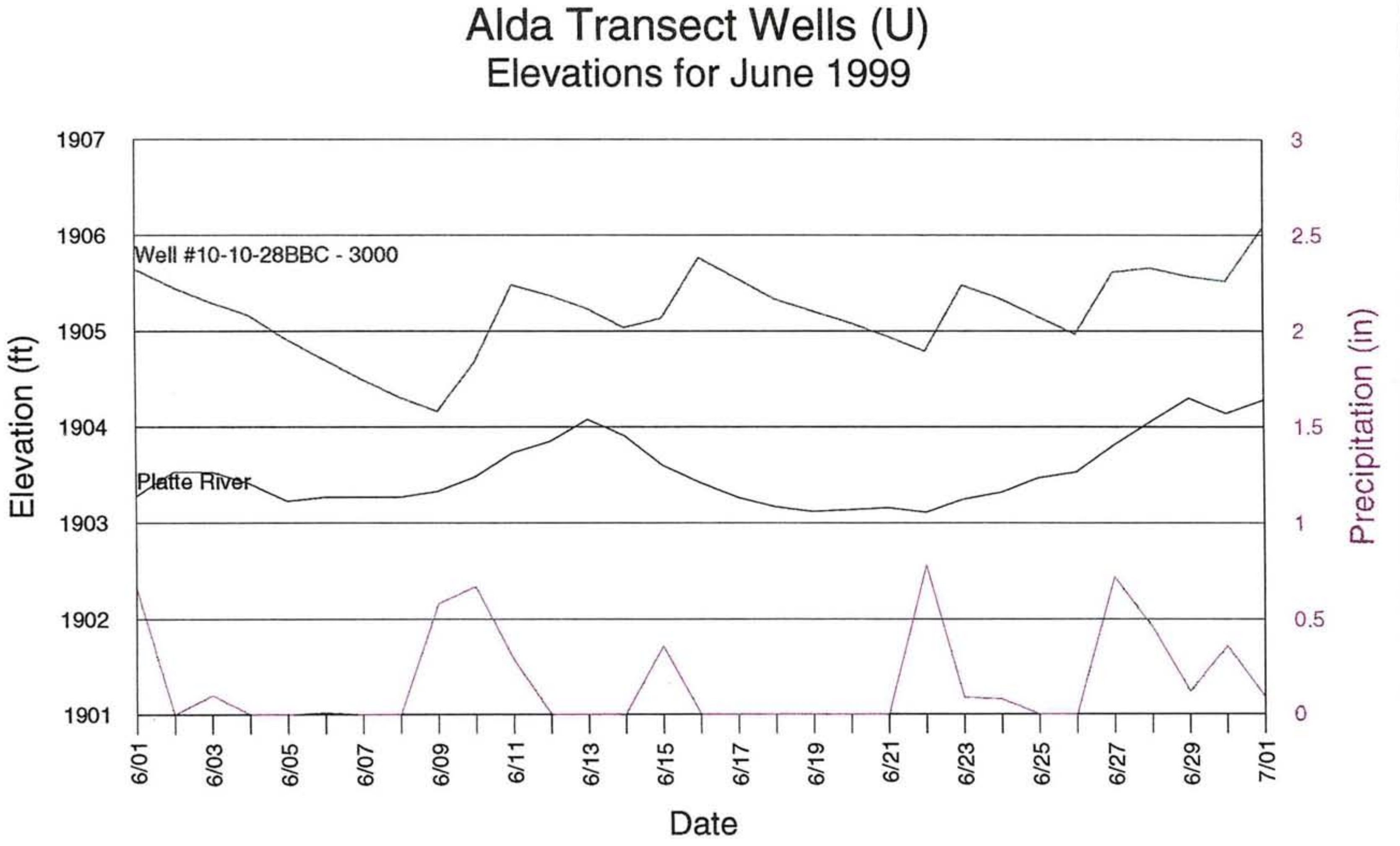
Alda Transect Wells (U)
Elevations for April 1999

Platte River = 1900.2 ft

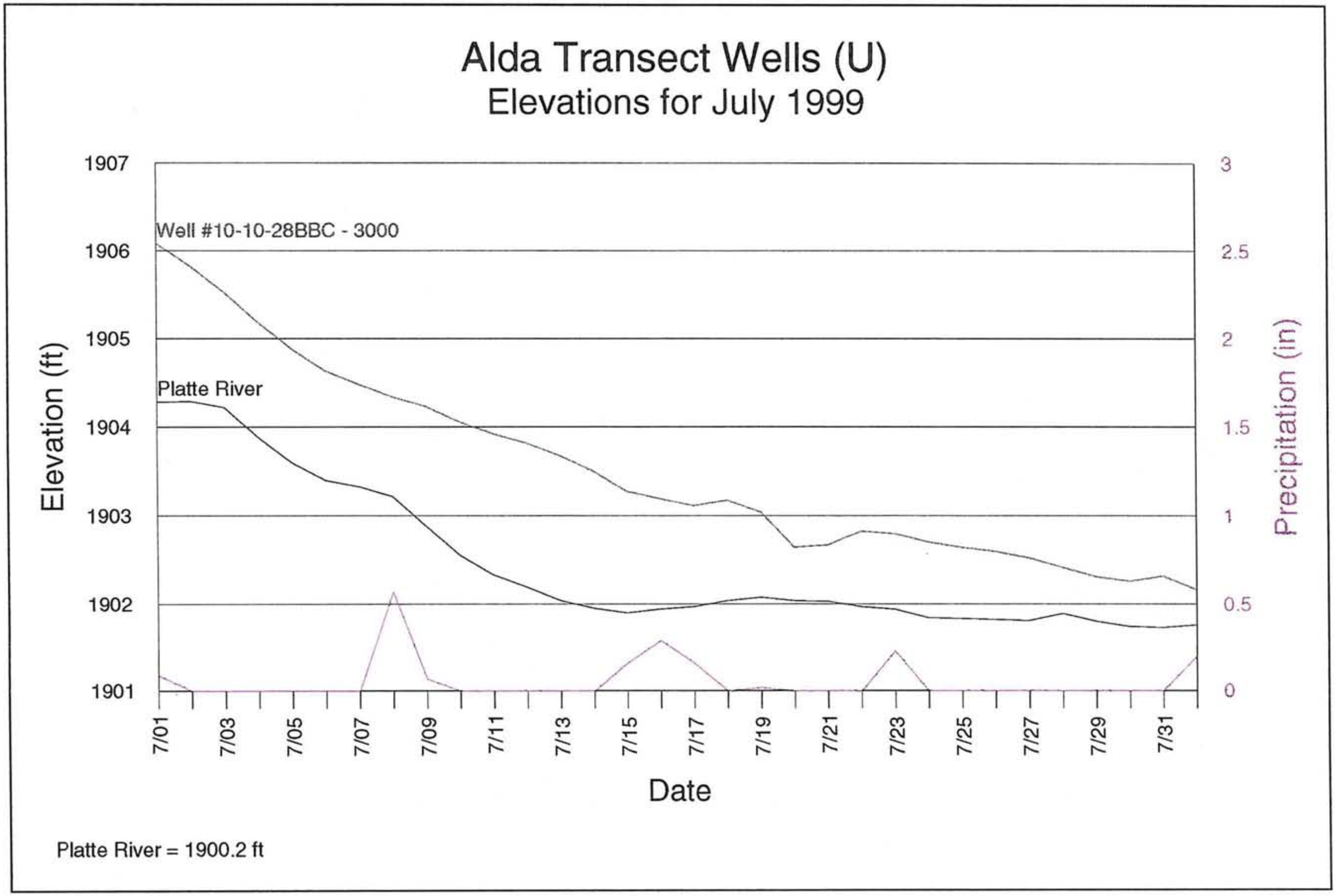
Alda Transect Wells (U)
Elevations for May 1999

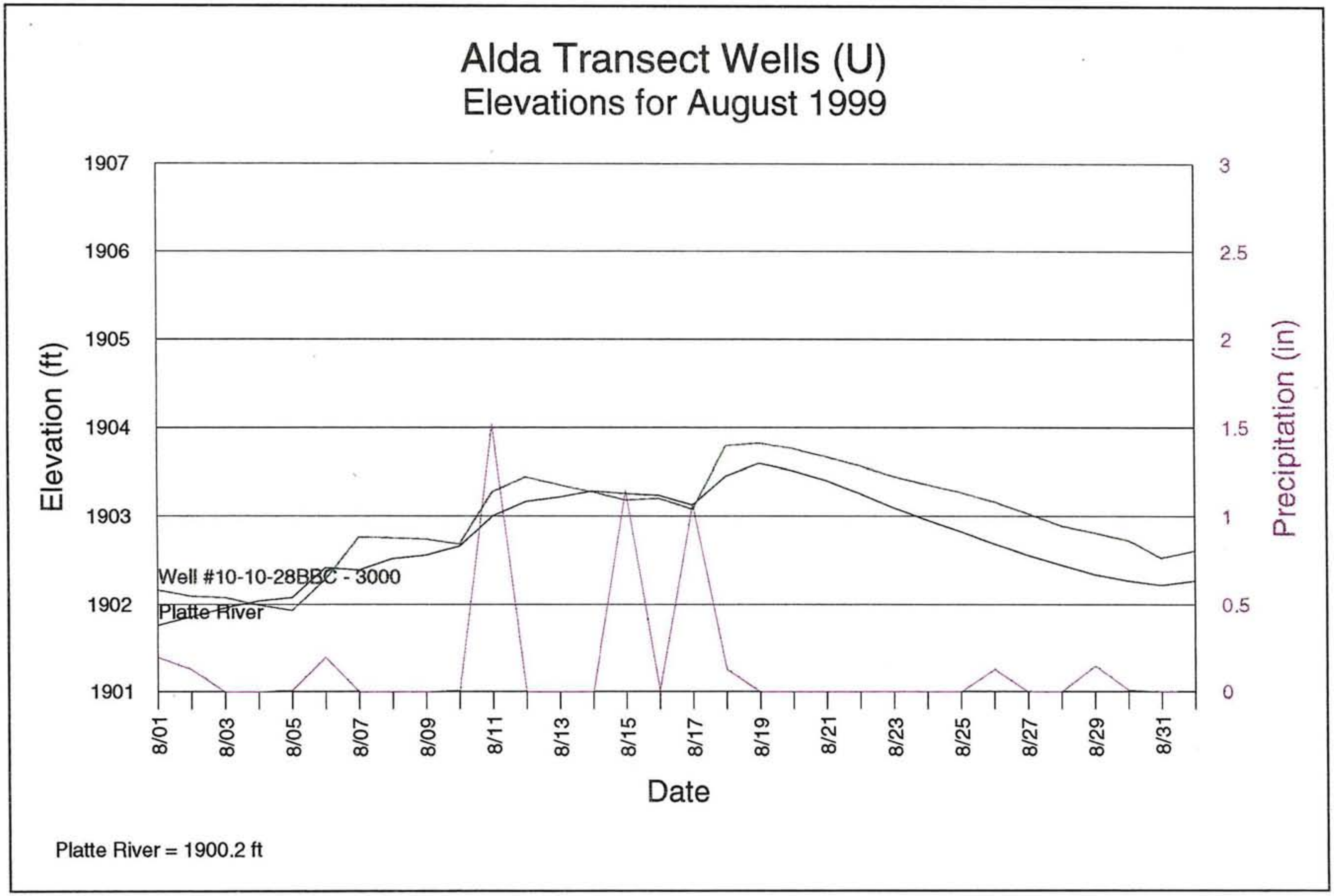


Platte River = 1900.2 ft



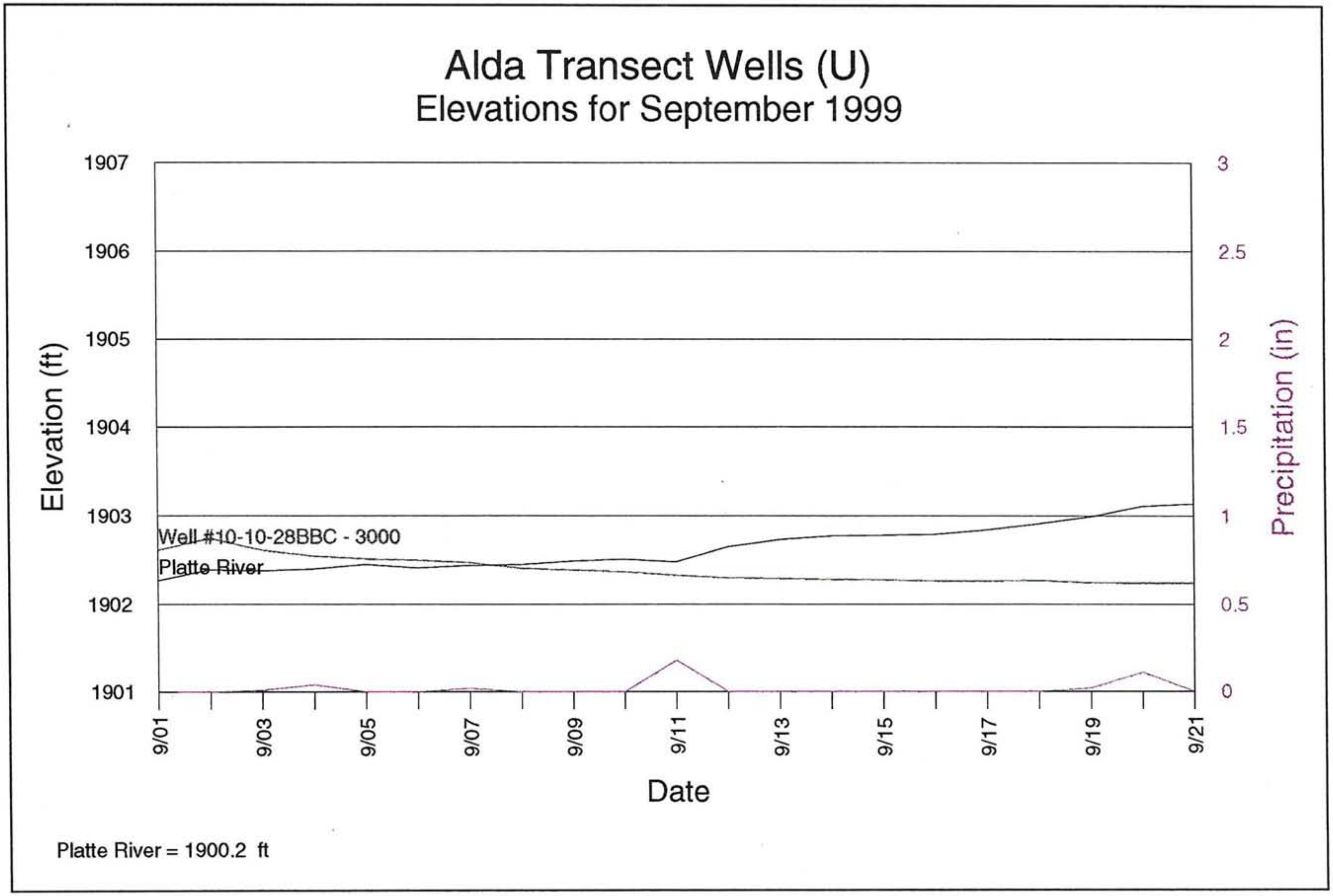
Platte River = 1900.2 ft


Alda Transect Wells (U)
Elevations for July 1999
Elevation (ft)
1907
1906
1905
1904
1903
1902
1901
Well #10-10-28BBC - 3000
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
7/01
7/03
7/05
7/07
7/09
7/11
7/13
7/15
7/17
7/19
7/21
7/23
7/25
7/27
7/29
7/31
Date
Platte River = 1900.2 ft



Alda Transect Wells (U)
Elevations for August 1999

Platte River = 1900.2 ft



Alda Transect Wells (U)
Elevations for September 1999

Platte River = 1900.2 ft

Well 10-10-22BBB

Alda downstream transect 6,500 feet (1-1/4 miles) northwest of the river.

The correlation factor between the well (Alda D-2) and the river gage near Grand Island for the period March 11 through September 21 was 0.621 (Appendix F, table 1)

Bank Storage comparison using a transmissivity of 20,000 ft^2/day (the highest plausible aquifer values) shows that the change in the water surface at the well in response to the high river elevations from May 1 to July 15 would be less than 0.2 feet. Actually the well fluctuated through a range of 2.5 feet. The graph on the following page shows the actual well hydrograph as a solid line, and the bank storage simulation as a dashed line.

Indications that the water level in the well responds to river stage include:

1. Declines in the river elevation are often, but not always, accompanied by similar declines in the well.

Indications that the well also responds to other factors such as precipitation include:

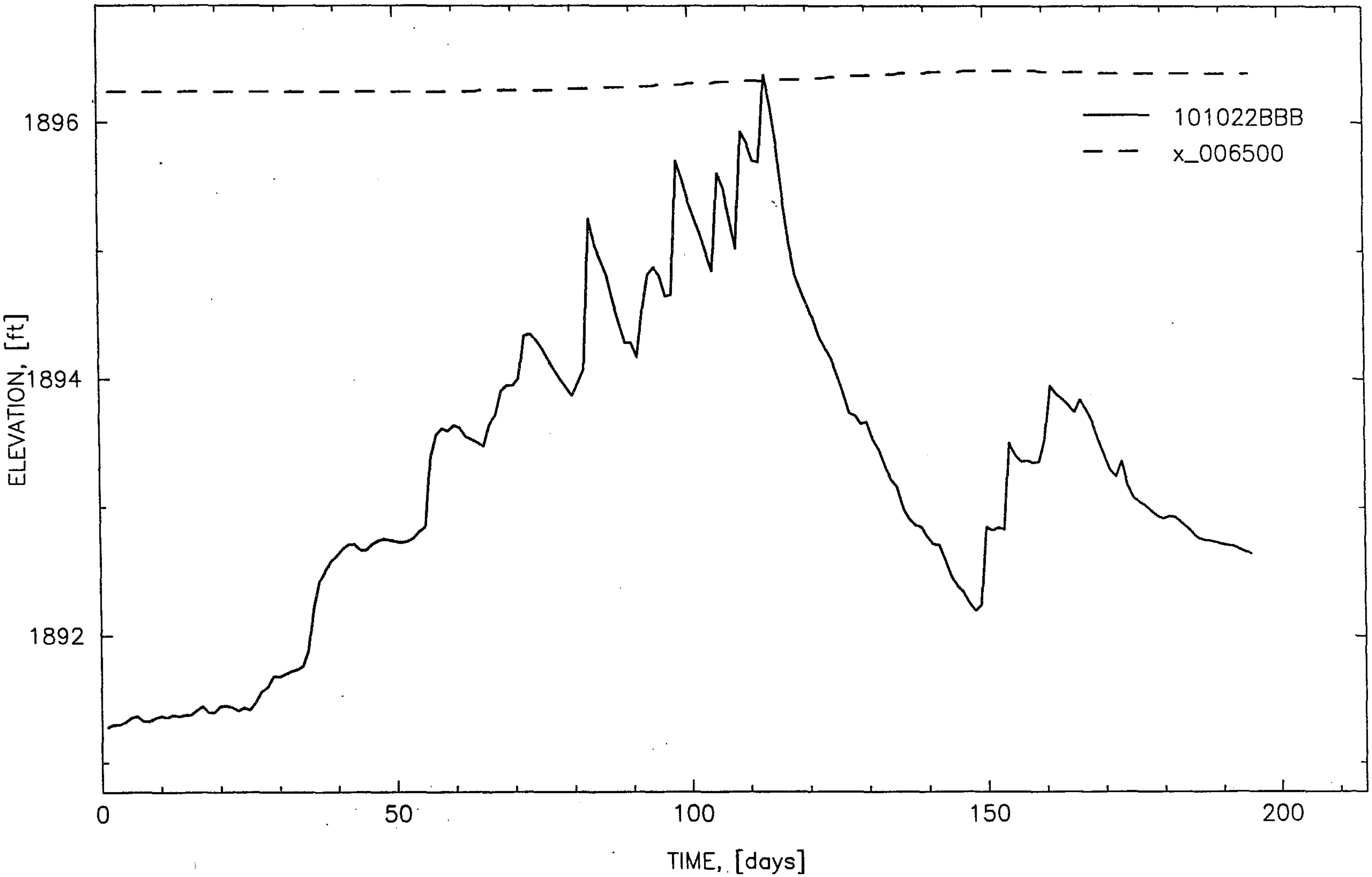
1. From March to April 13, the well was 0.8 to 1.5 feet lower than the river at the point where the well is perpendicular to the river, but the well shows no indication of reacting to this difference.

2. From May 8 to 13, the river rose 1.6 feet and remained at the high elevation for another day. There was no corresponding rise in the well.

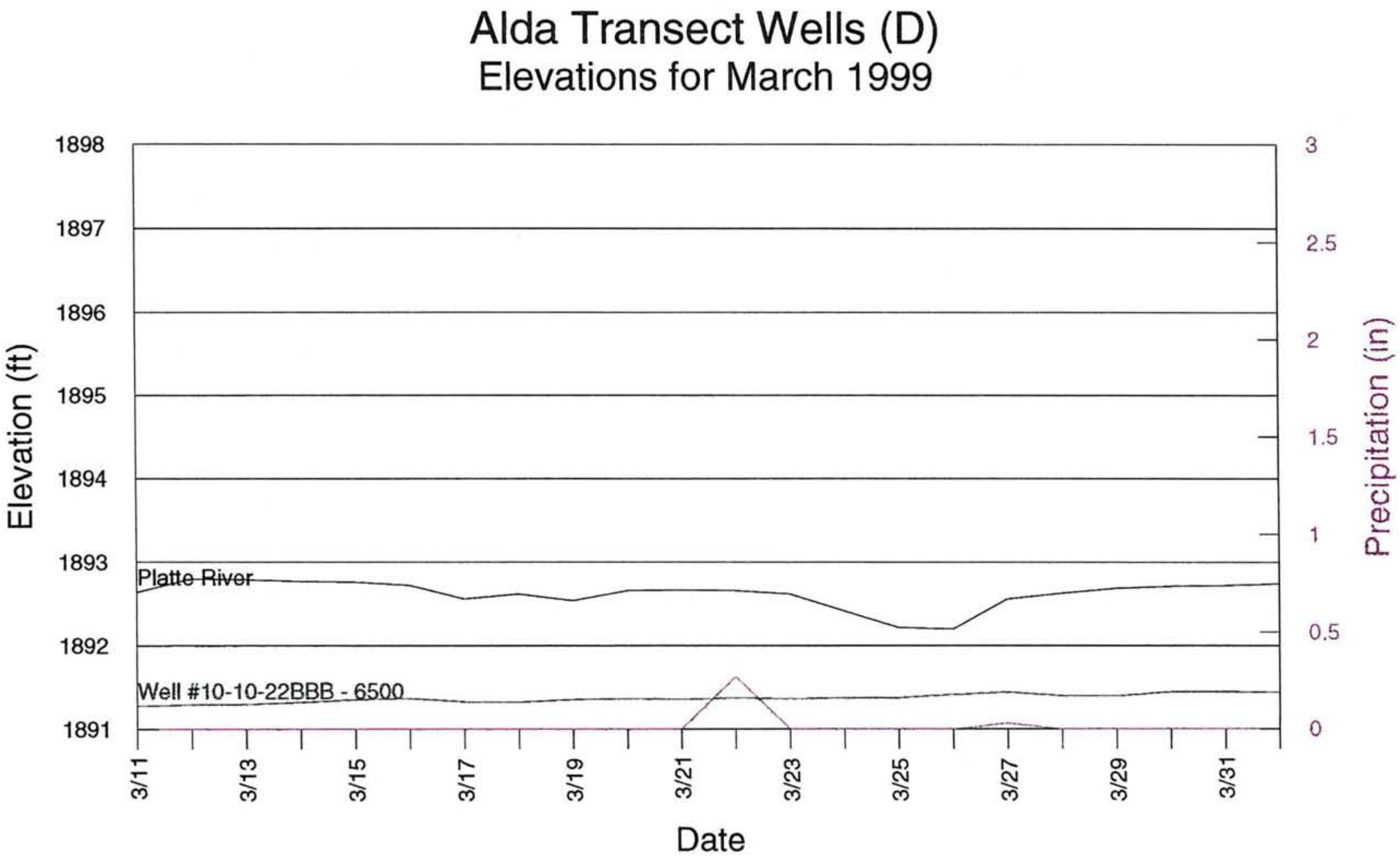
3. From May 14 to 21, the well rose 0.9 feet while the river elevation was declining. On May 17 the well elevation met and exceeded the river elevation and continued to rise for another four days, while the river continued to decline.

4. Through June, there were 5 rainfalls of ½ inch or more, each of which produced a rise in the well of 0.6 to 1.0 feet on the following day. The river response was much more subdued and lagged the well by several days.

5. On September 1 to 21, the well elevation slowly declined while the river slowly rose. The hydrographs cross on September 11 with no apparent reversal of the downward trend in the well. This implies that the concurrent declines — cited as an indication that the well is controlled by the river — are coincidental.

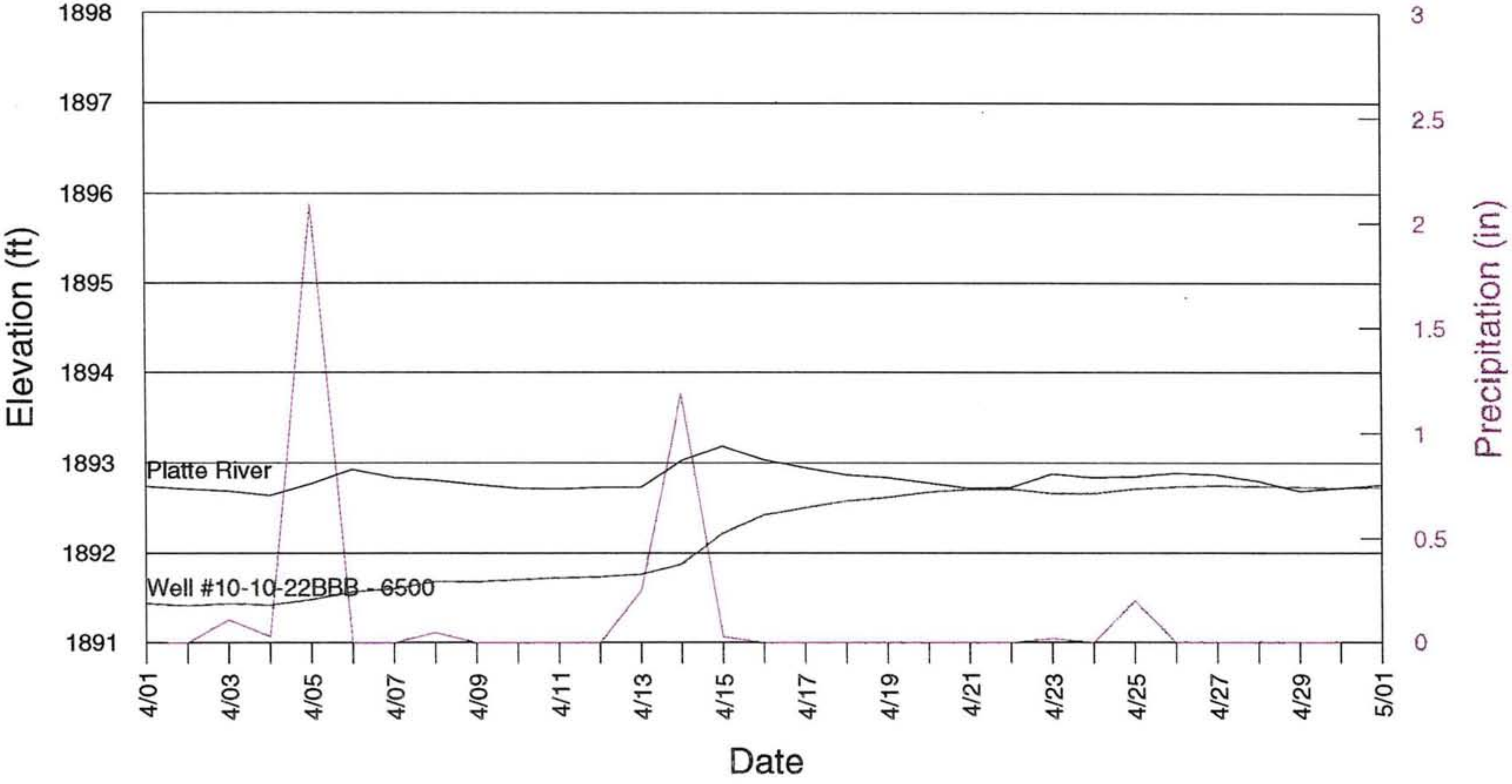


1896
1894
1892
ELEVATION, [ft]
0
50
100
150
200
TIME, [days]
101022BBB
x_006500

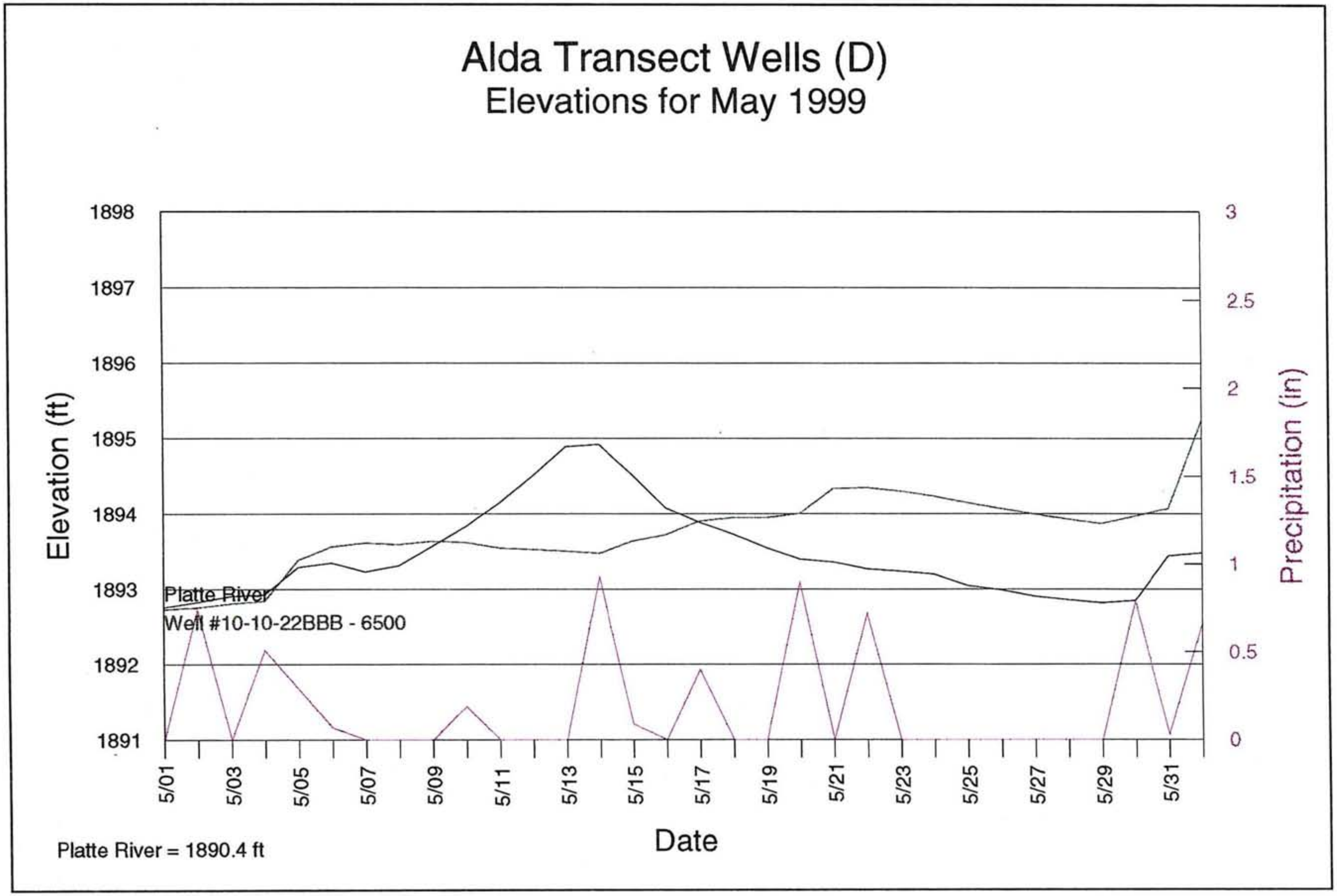


Platte River = 1890.4 ft

Alda Transect Wells (D)
Elevations for April 1999

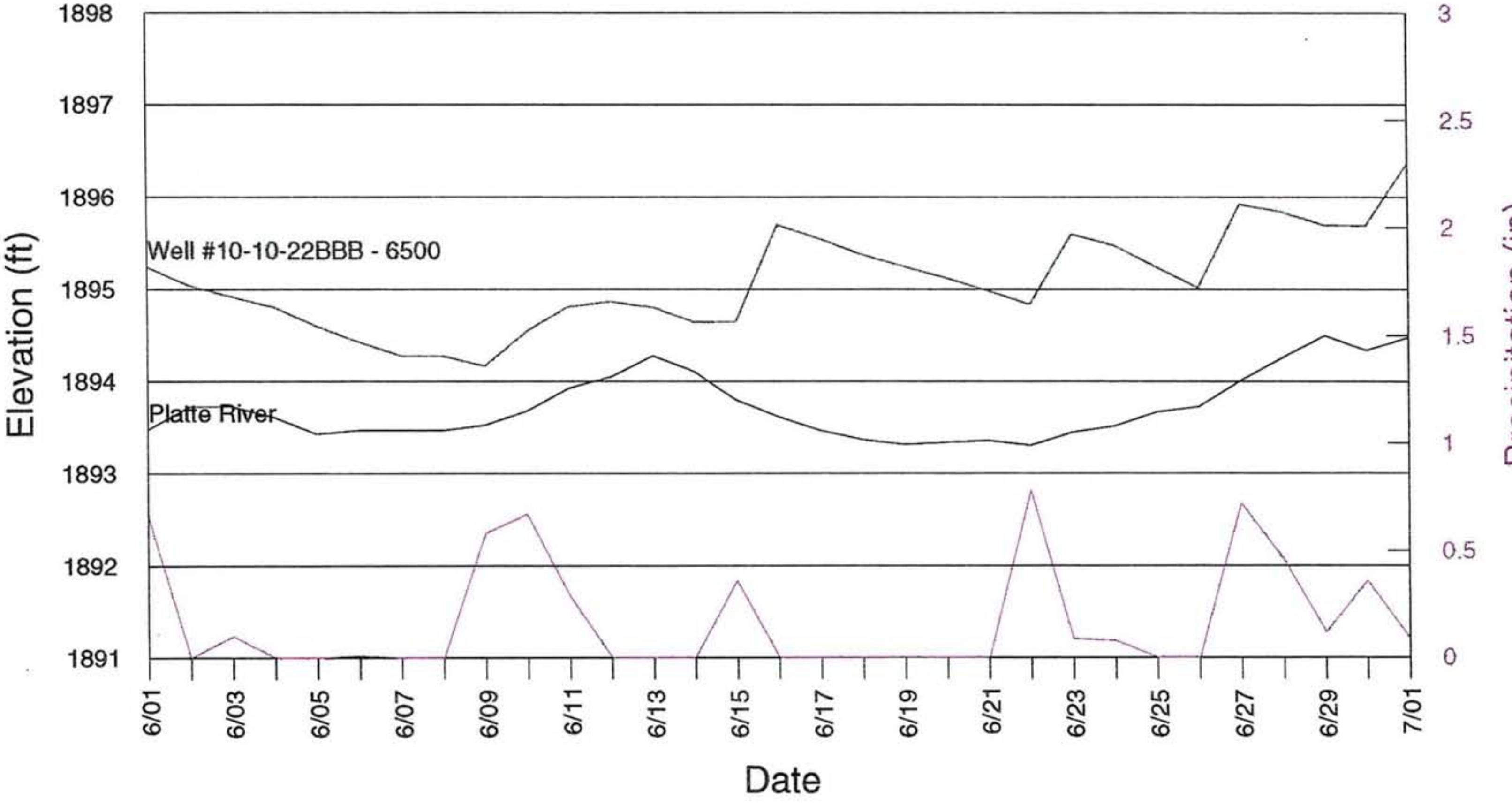


Platte River = 1890.4 ft

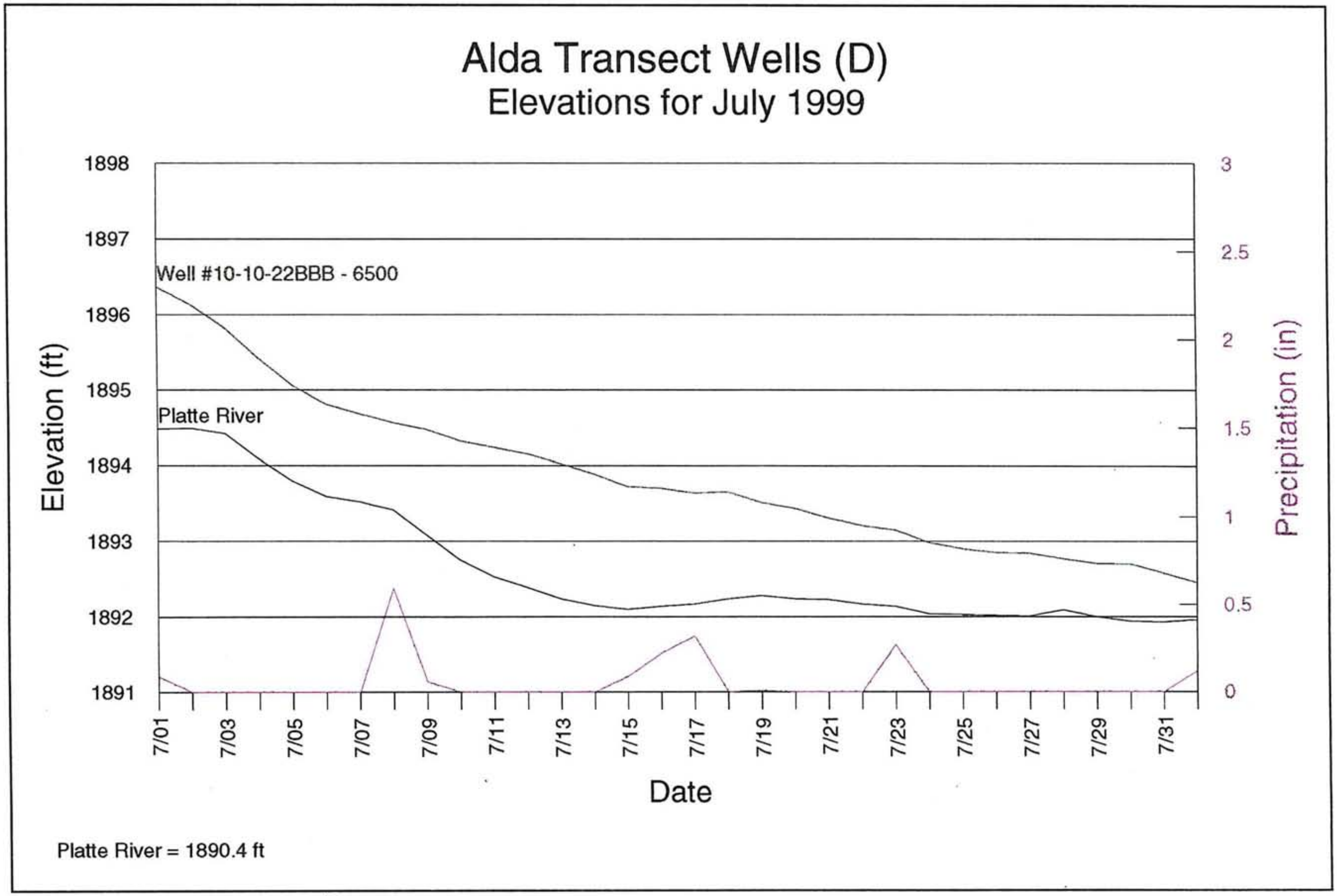

Alda Transect Wells (D)
Elevations for May 1999
Elevation (ft)
1898
1897
1896
1895
1894
1893
1892
1891
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
Platte River
Well #10-10-22BBB - 6500
5/01
5/03
5/05
5/07
5/09
5/11
5/13
5/15
5/17
5/19
5/21
5/23
5/25
5/27
5/29
5/31
Date
Platte River = 1890.4 ft

Alda Transect Wells (D)

Elevations for June 1999



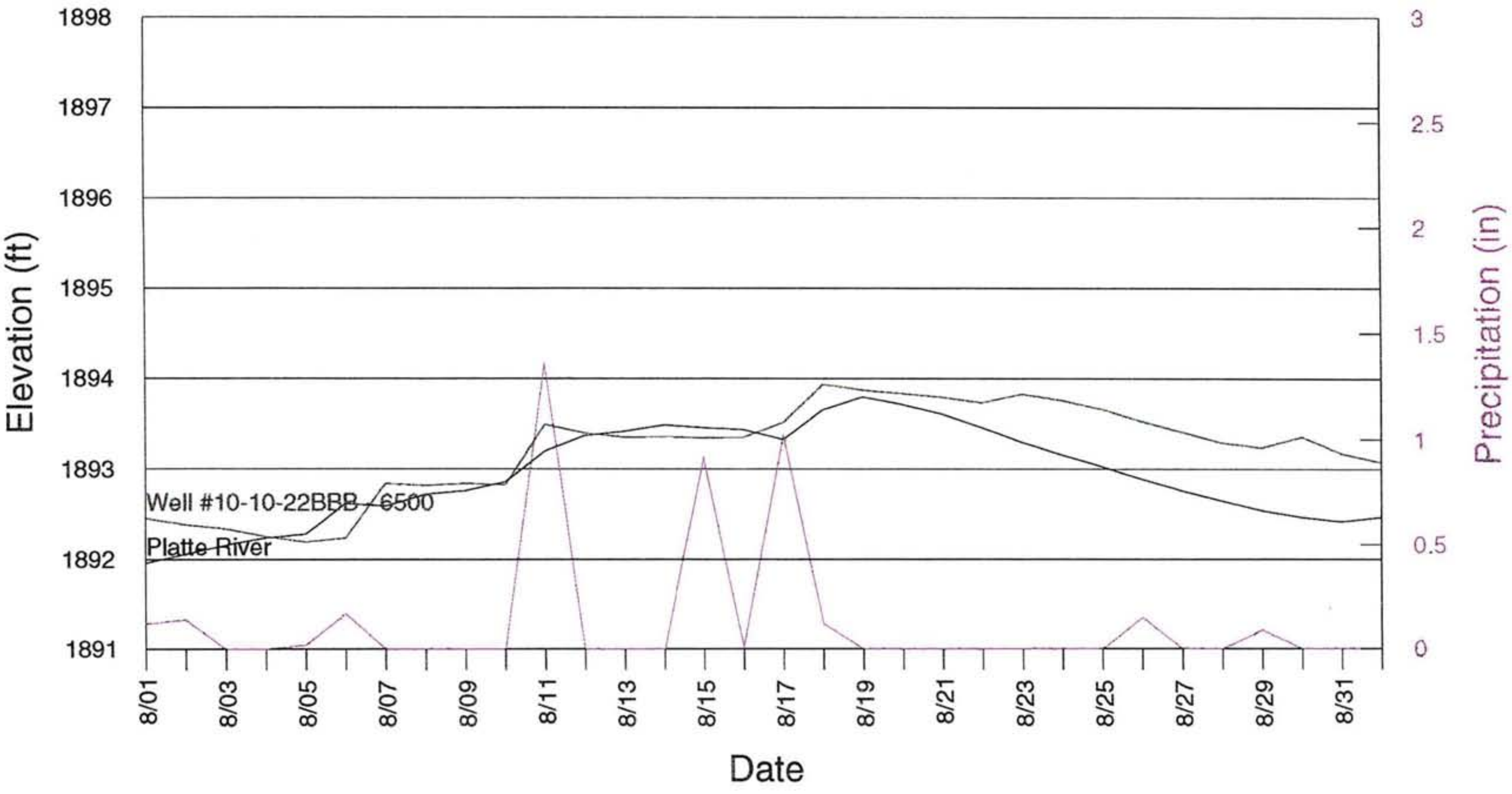
Platte River = 1890.4 ft



Alda Transect Wells (D)
Elevations for July 1999

Platte River = 1890.4 ft

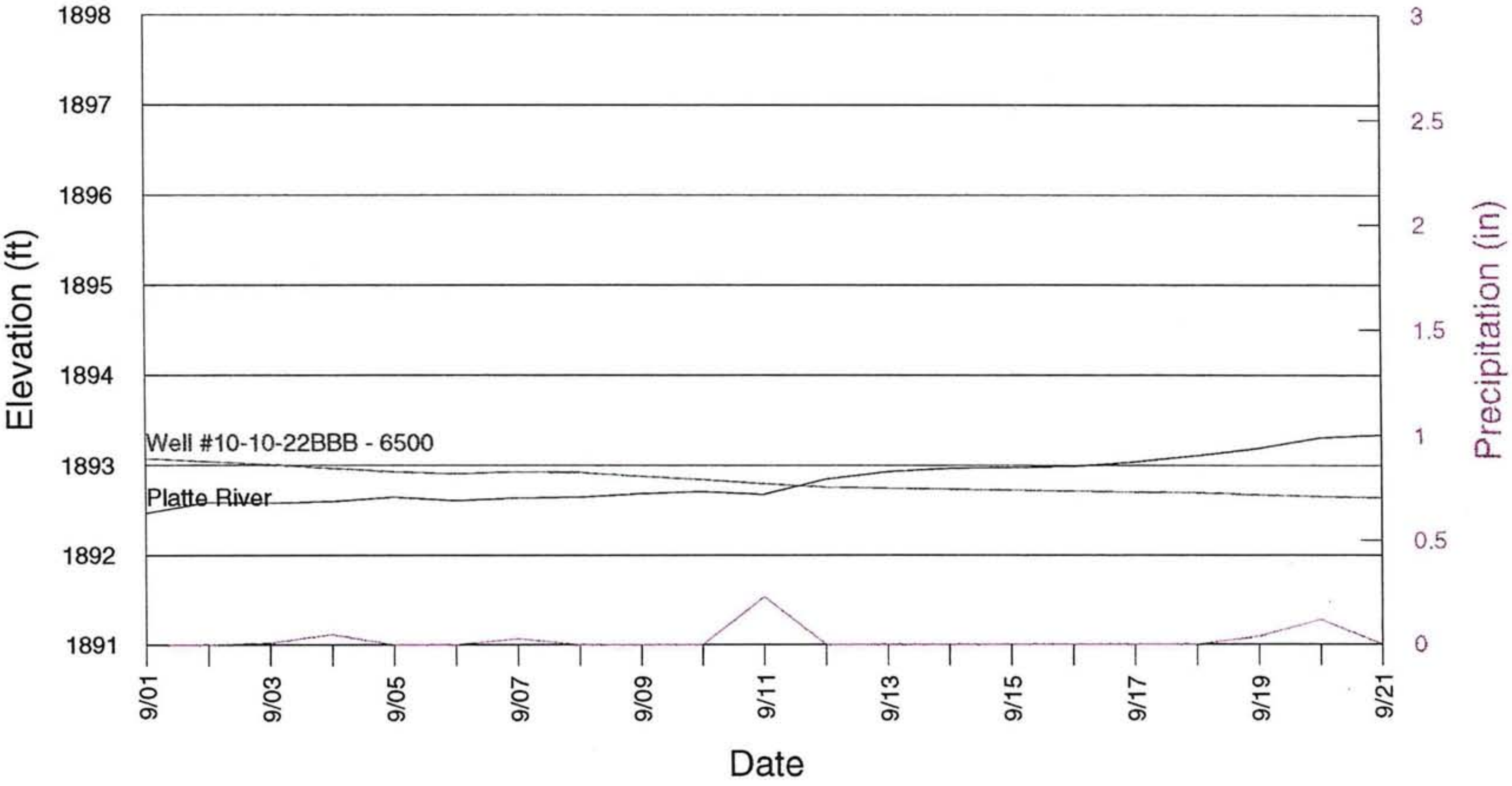
Alda Transect Wells (D)
Elevations for August 1999



Platte River = 1890.4 ft

Alda Transect Wells (D)

Elevations for September 1999



Platte River = 1890.4 ft

Well 8-14-3CBB

Minden downstream transect - 100 feet north of the river.

The correlation factor between the well (Mndn- D-1) and the river gage at Kearney for the period May 4 to September 21, 1999 is 0.974 (Appendix F, table 1)

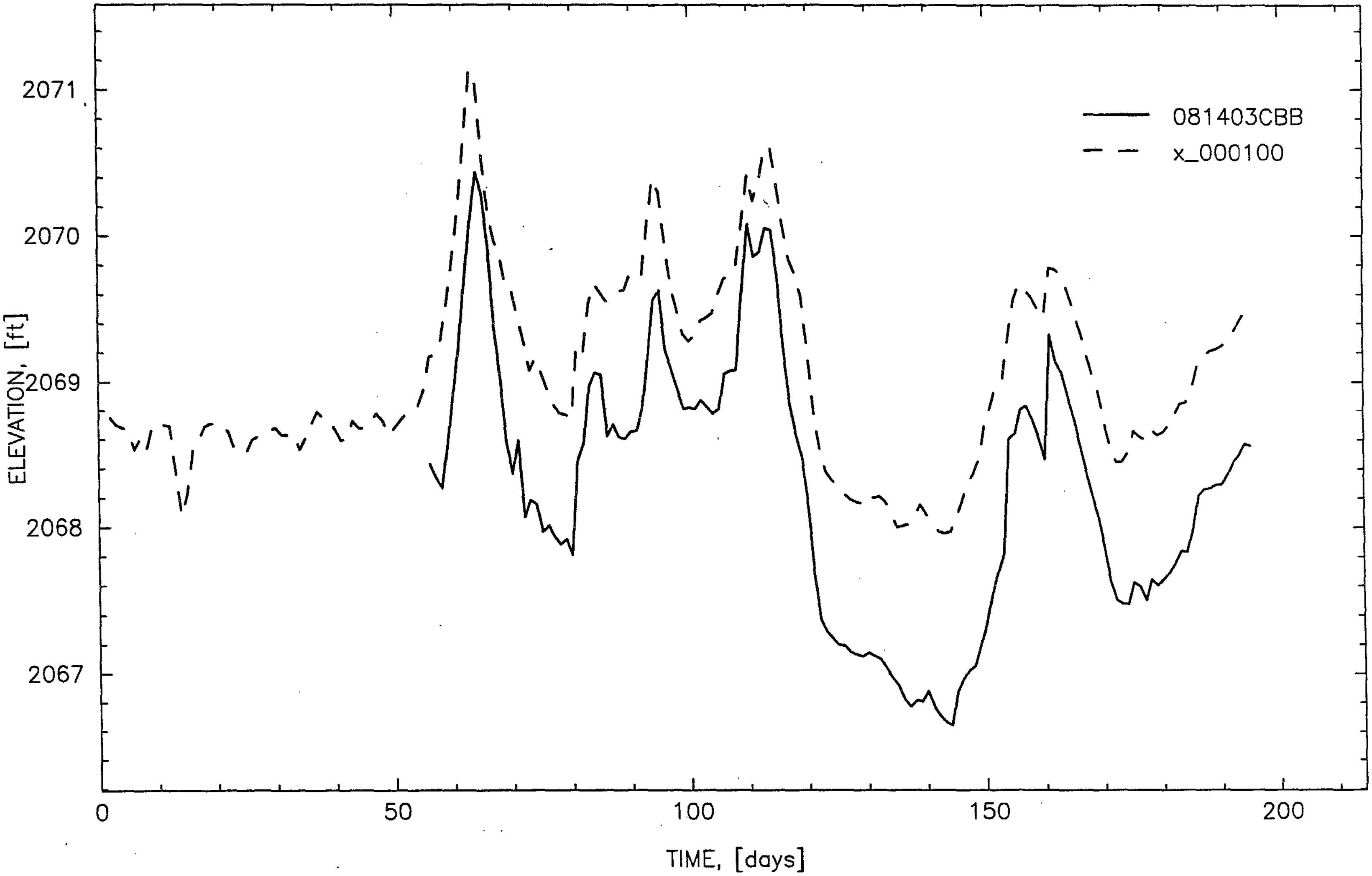
Bank Storage comparison using a transmissivity of 20,000 ft^2/day (the highest plausible aquifer values) shows that the change in water surface at the well would track the fluctuations that occurred in the river from March 17 to July 15 staying within about 0.1 feet at most times. Actually, the well did follow the river elevations except as noted below. The graph on the following page shows the actual well hydrograph as a solid line, and the bank storage simulation as a dashed line.

Indications that the water level in the well responds to river stage include:

1. The well hydrograph traces the river hydrograph except immediately after significant rainfalls.

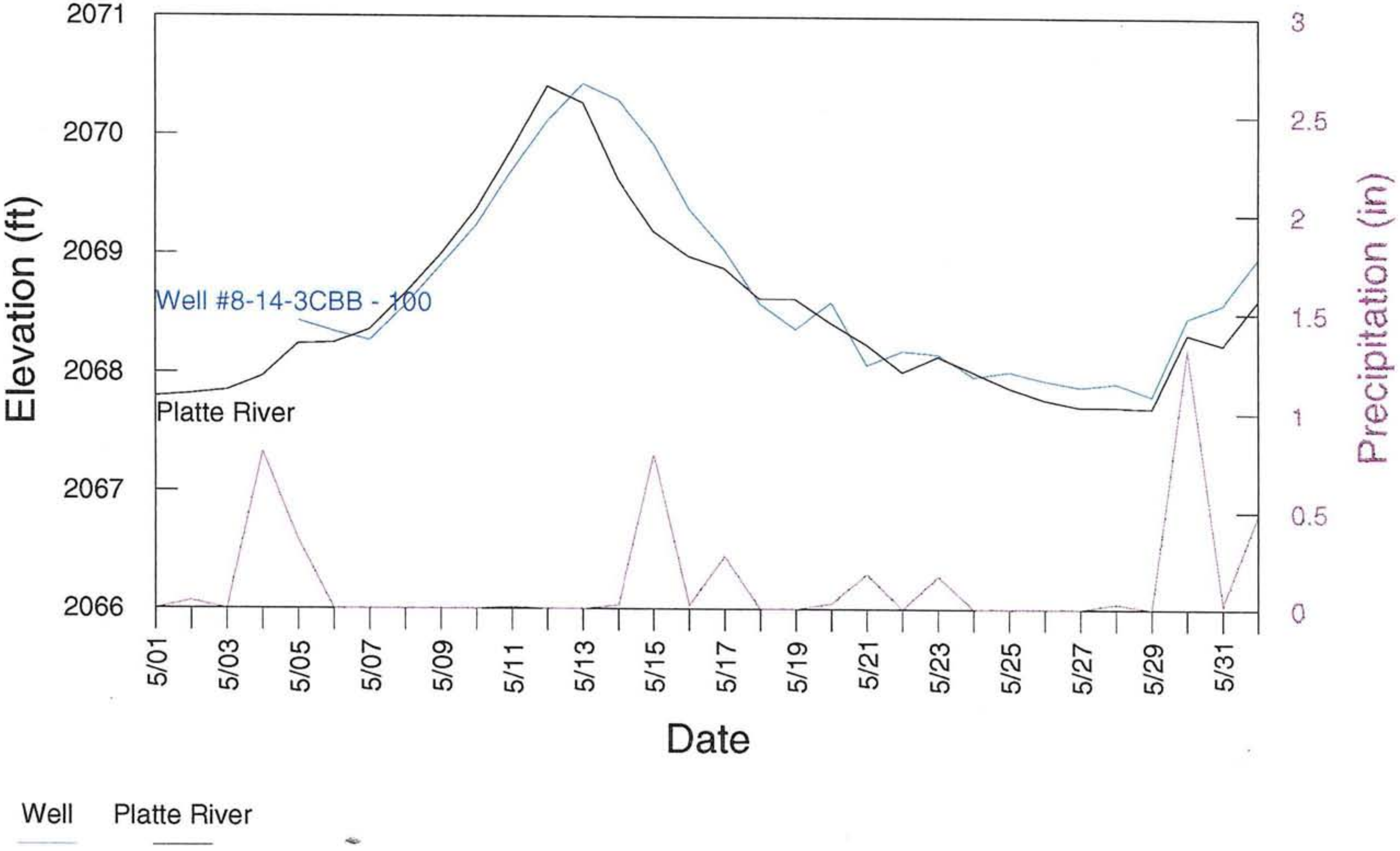
Indications that the well also responds to other factors such as precipitation include:

1. After each significant rainfall, the well rose above the river by as much as ½ foot and generally remained higher than the river during the decline in elevations following the rain.


081403CBB
x_000100
2071
2070
2069
2068
2067
ELEVATION, [ft]
0
50
100
150
200
TIME, [days]

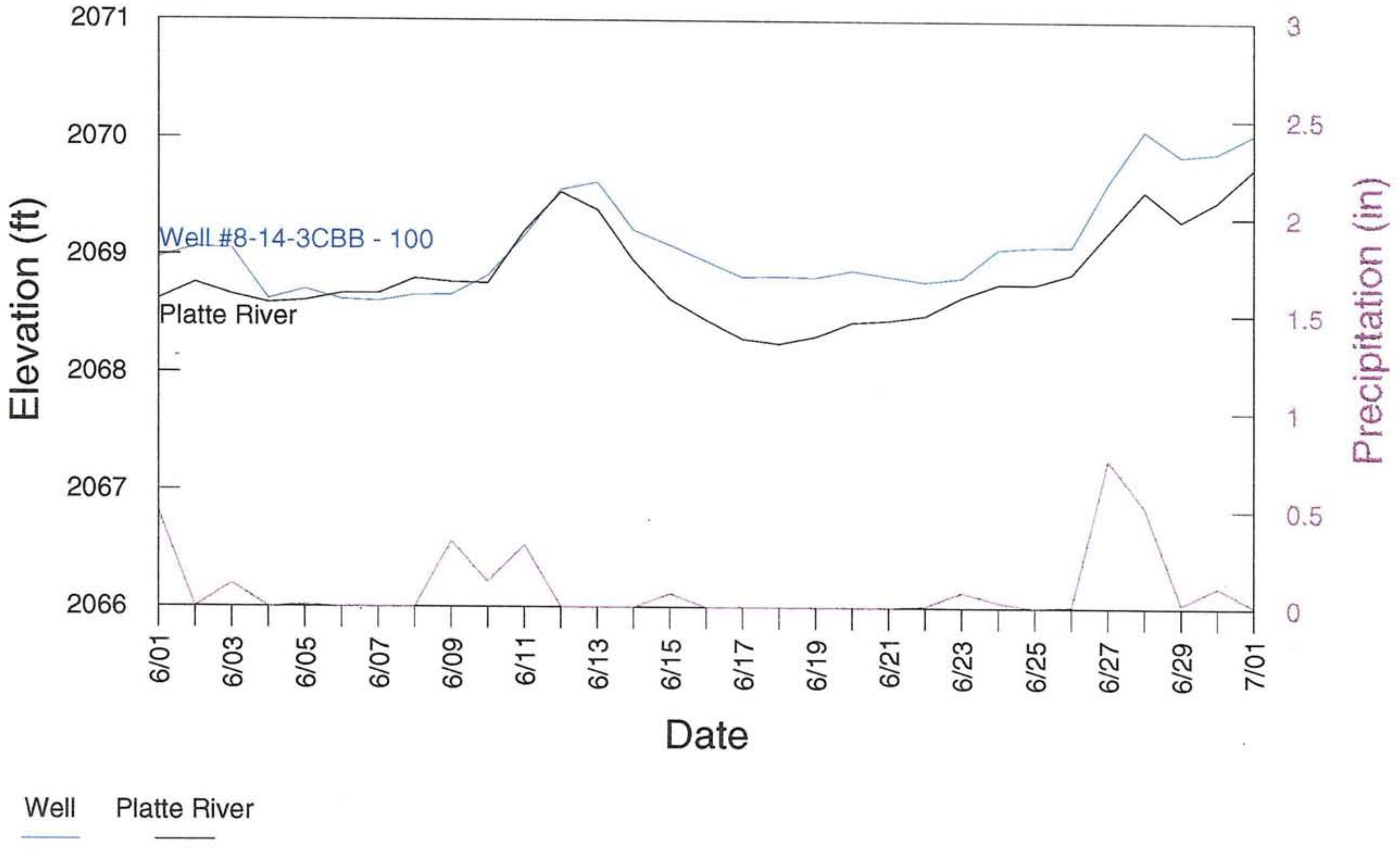
Minden Transect Wells (D)

Elevations for May 1999



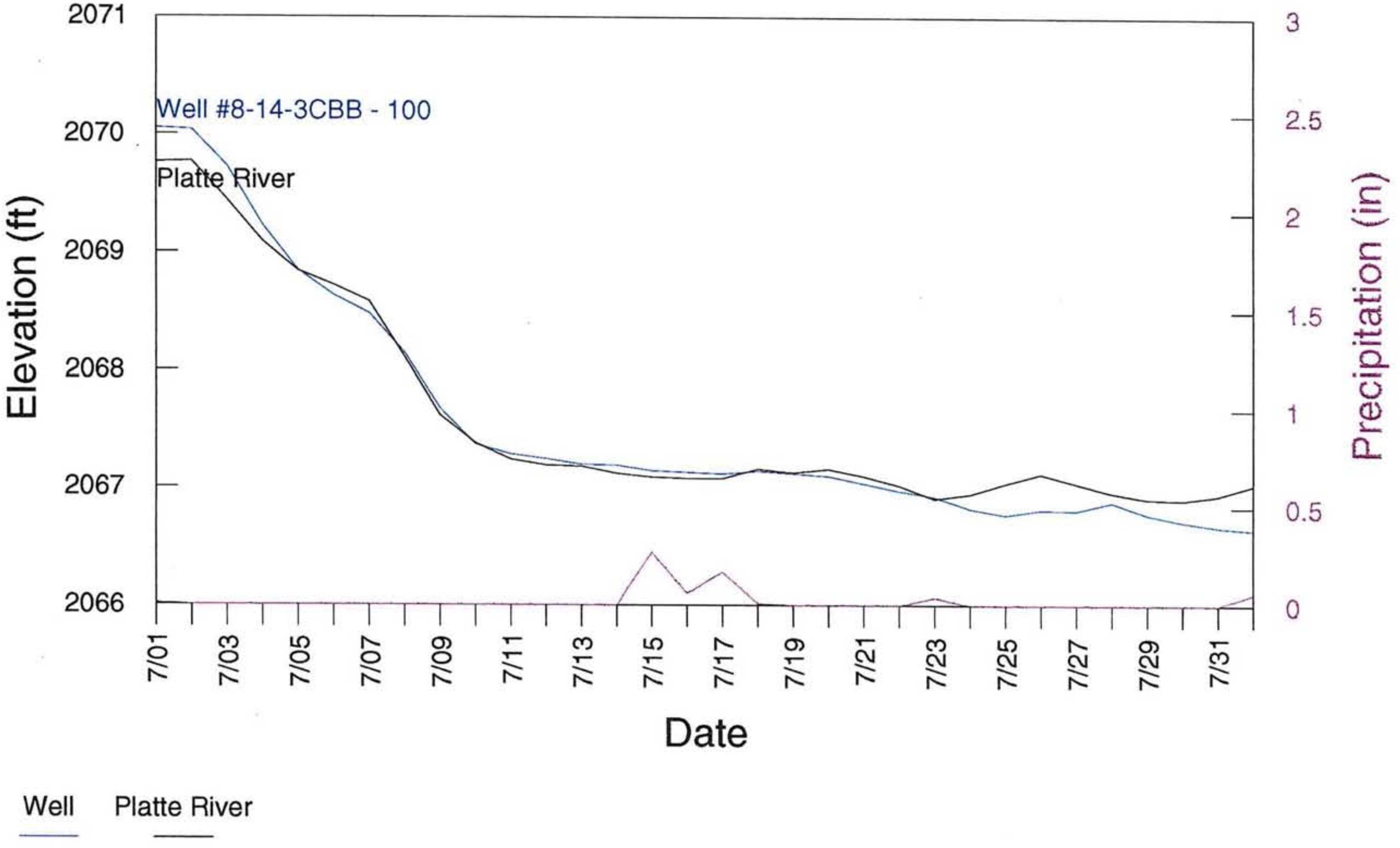
Minden Transect Wells (D)

Elevations for June 1999



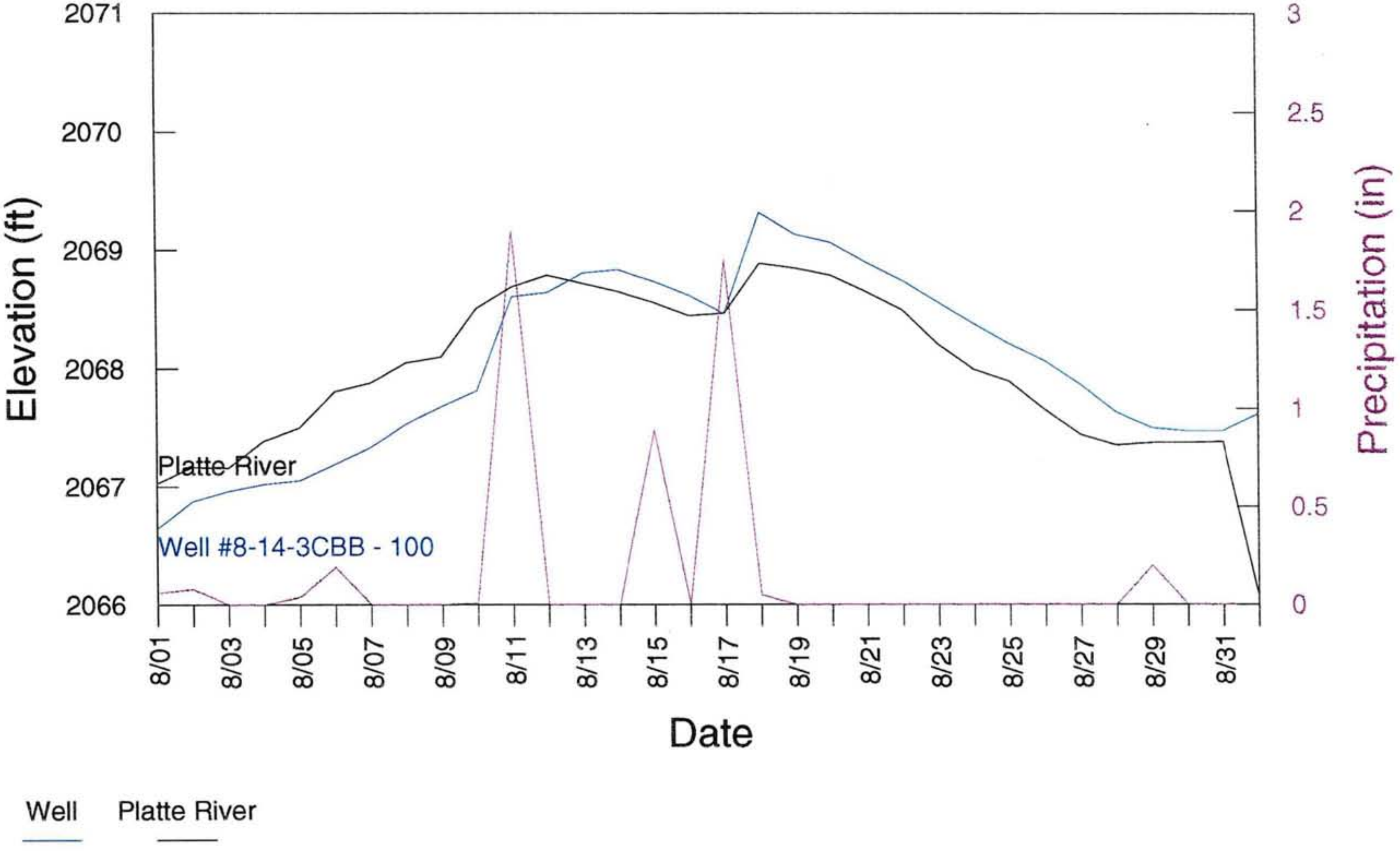
Minden Transect Wells (D)

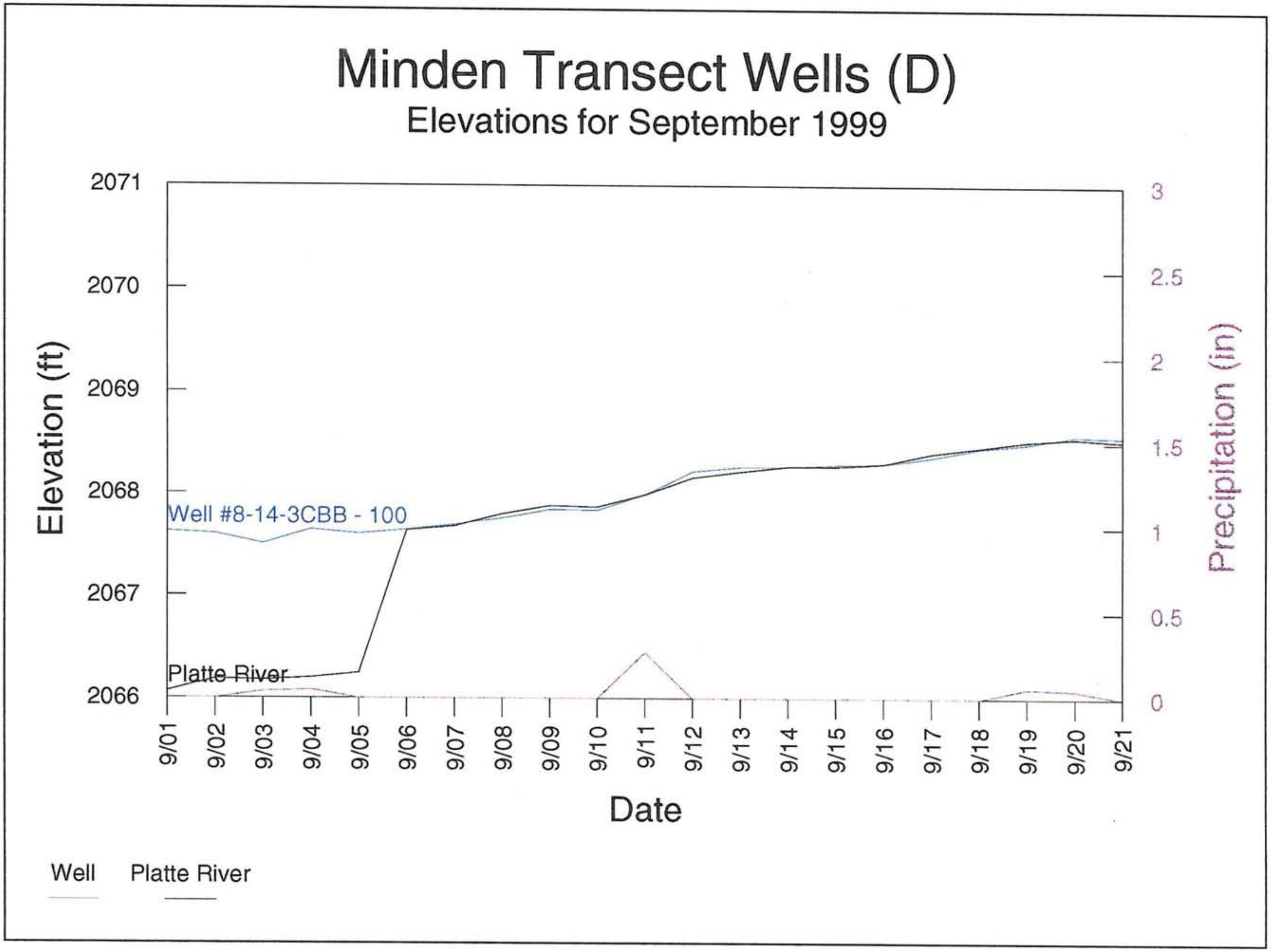
Elevations for July 1999



Minden Transect Wells (D)

Elevations for August 1999




Minden Transect Wells (D)
Elevations for September 1999
Elevation (ft)
2071
2070
2069
2068
2067
2066
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
Well #8-14-3CBB - 100
Platte River
9/01
9/02
9/03
9/04
9/05
9/06
9/07
9/08
9/09
9/10
9/11
9/12
9/13
9/14
9/15
9/16
9/17
9/18
9/19
9/20
9/21
Date
Well
Platte River

Well 8-14-4CBB

Minden upstream transect - 700 feet (1/8 miles) north of the river.

The correlation factor between the well (Mndn U-1) and the river gage at Kearney for the period March 11 to August 16, 1999 is 0.882 (Appendix F, table 1)

Bank Storage comparison using a transmissivity of 20,000 ft^2/day (the highest plausible aquifer values) shows that the change in water surface at the well would parallel the fluctuations that occurred in the river from March 17 to July 15 with the well lagging by 1 to 2 days and falling short of the peaks by as much as 1.4 feet. Actually, the well hydrograph has a general pattern similar to the river, but the well rises higher at the peaks than would be expected and recedes less than expected between peaks. The graph on the following page shows the actual well hydrograph as a solid line, and the bank storage simulation as a dashed line.

Indications that the water level in the well responds to river stage include:

1. The water level in the well rose from May 8 to 13 as the river was rising and in the absence of a rainfall. The well then reverses direction on May 14 just as the river elevation drops below the well.

2. The peak in the water surface in the well on May 14 lags the river stage peak by a day and is about 0.3 feet lower than the river stage peak. This is consistent with the Bank Storage prediction.

3. The well appears to track the river in a downward trend from May 13 to 29 with the exception that the well shows more influence from precipitation events than does the river.

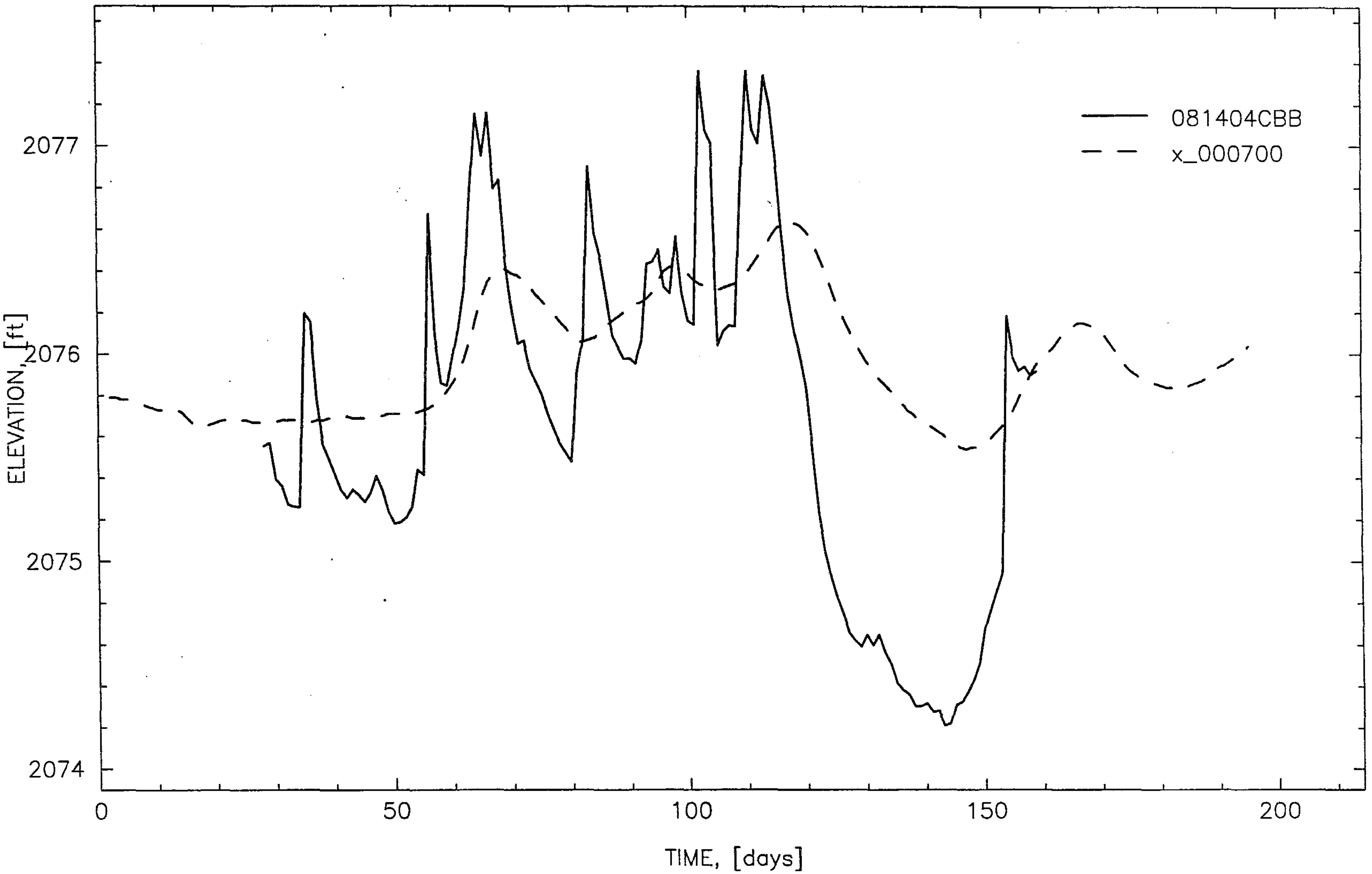
4. It appears that the well may be seeking the level of the river from June 1 -7 as it begins more than a foot higher than the river and drops fairly steeply.

5. Through the first 10 days of July, the well tracks the river in a decline with a lag time of 1 to 3 days. For the remainder of the month, both hydrographs are nearly level and very near the same elevation.

6. The first 10 days of August, the river rises by 1.5 feet with negligible rainfall, and the well again tracks the river upward with a lag time of about 2 days.

Indications that the well also responds to other factors such as precipitation include:

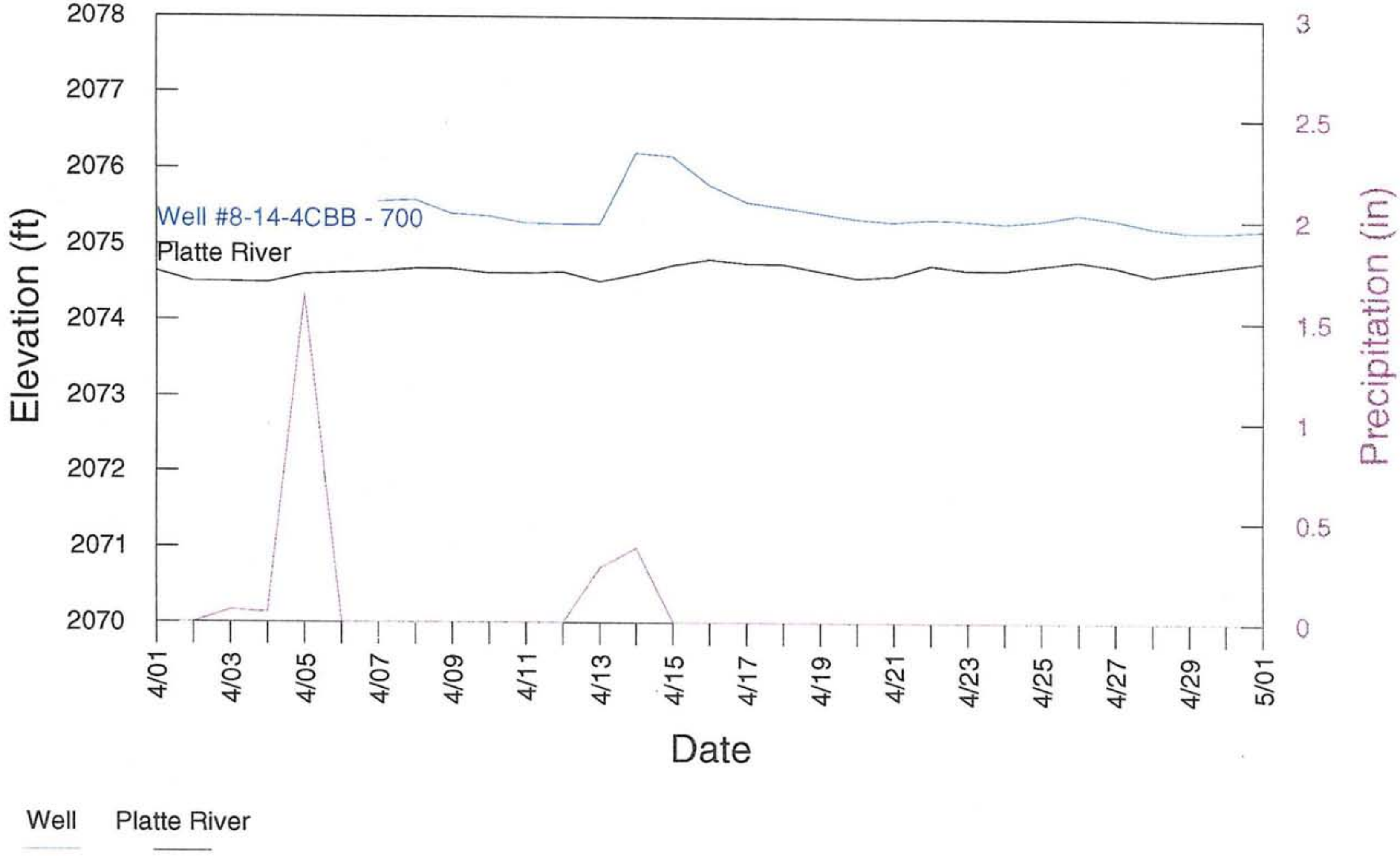
1. The well responds more quickly and more consistently to rainfall than does the river.

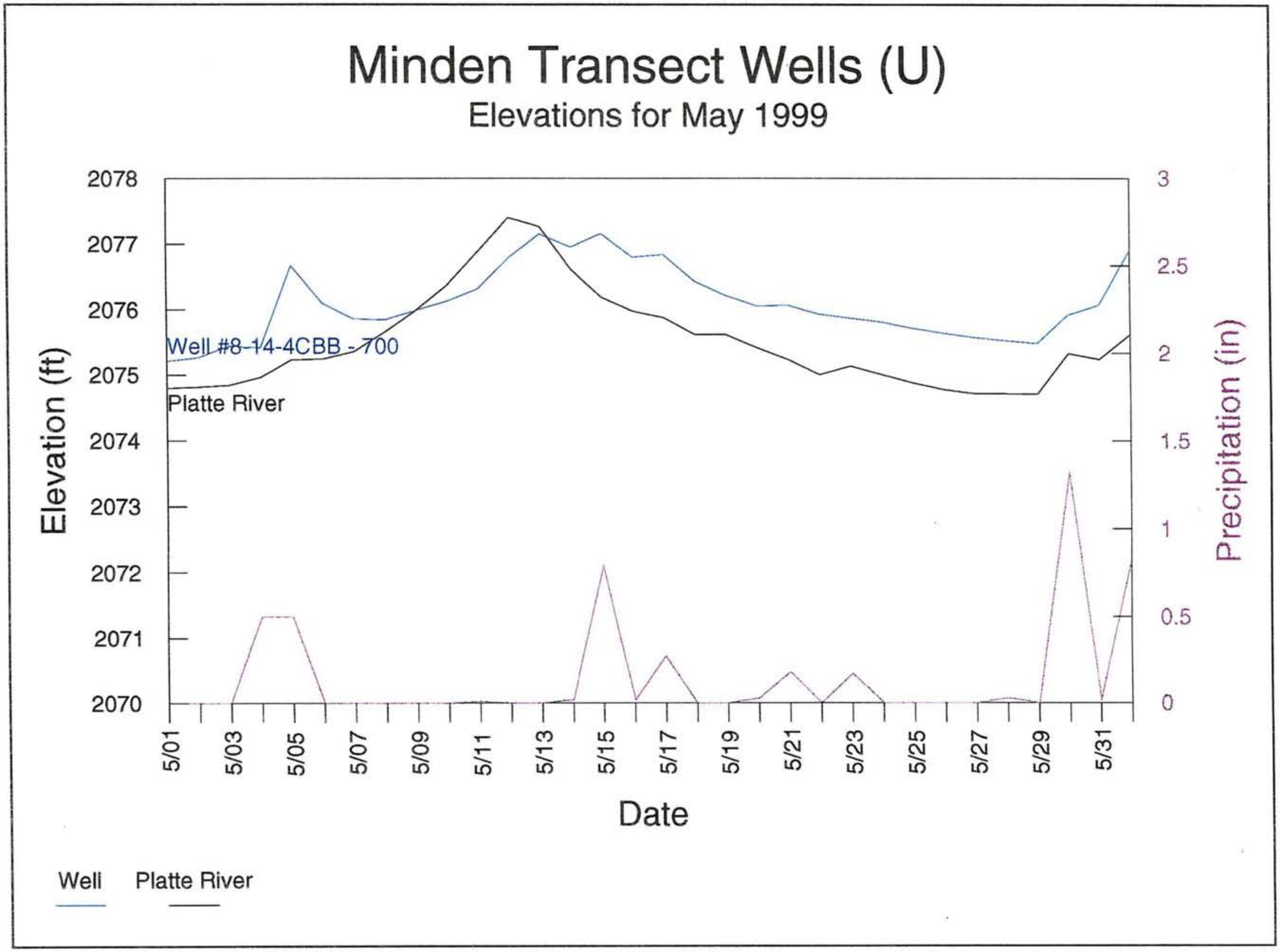


081404CBB
x_000700
ELEVATION, [ft]
2077
2076
2075
2074
0
50
100
150
200
TIME, [days]

Minden Transect Wells (U)

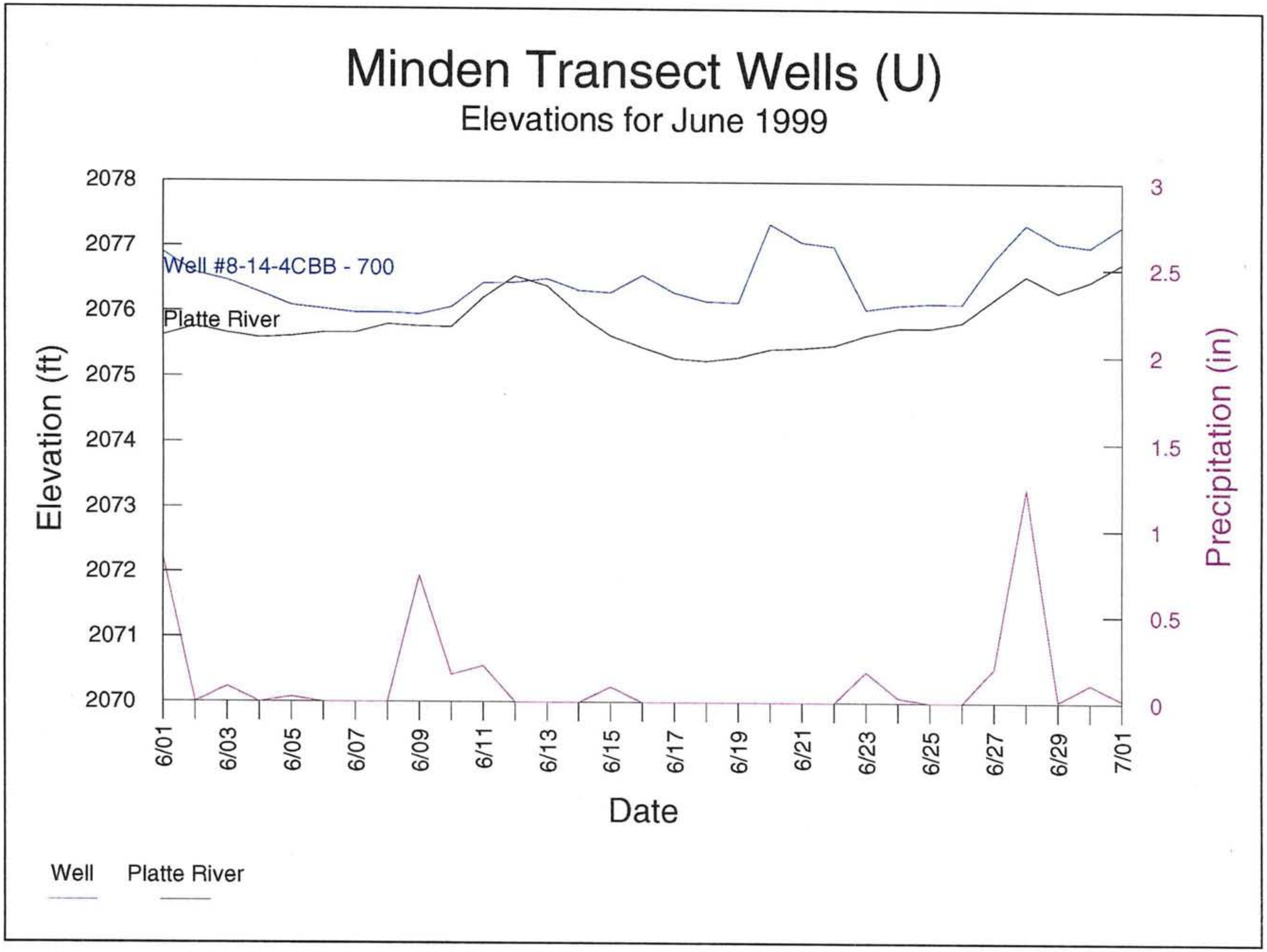
Elevations for April 1999





Minden Transect Wells (U)

Elevations for May 1999

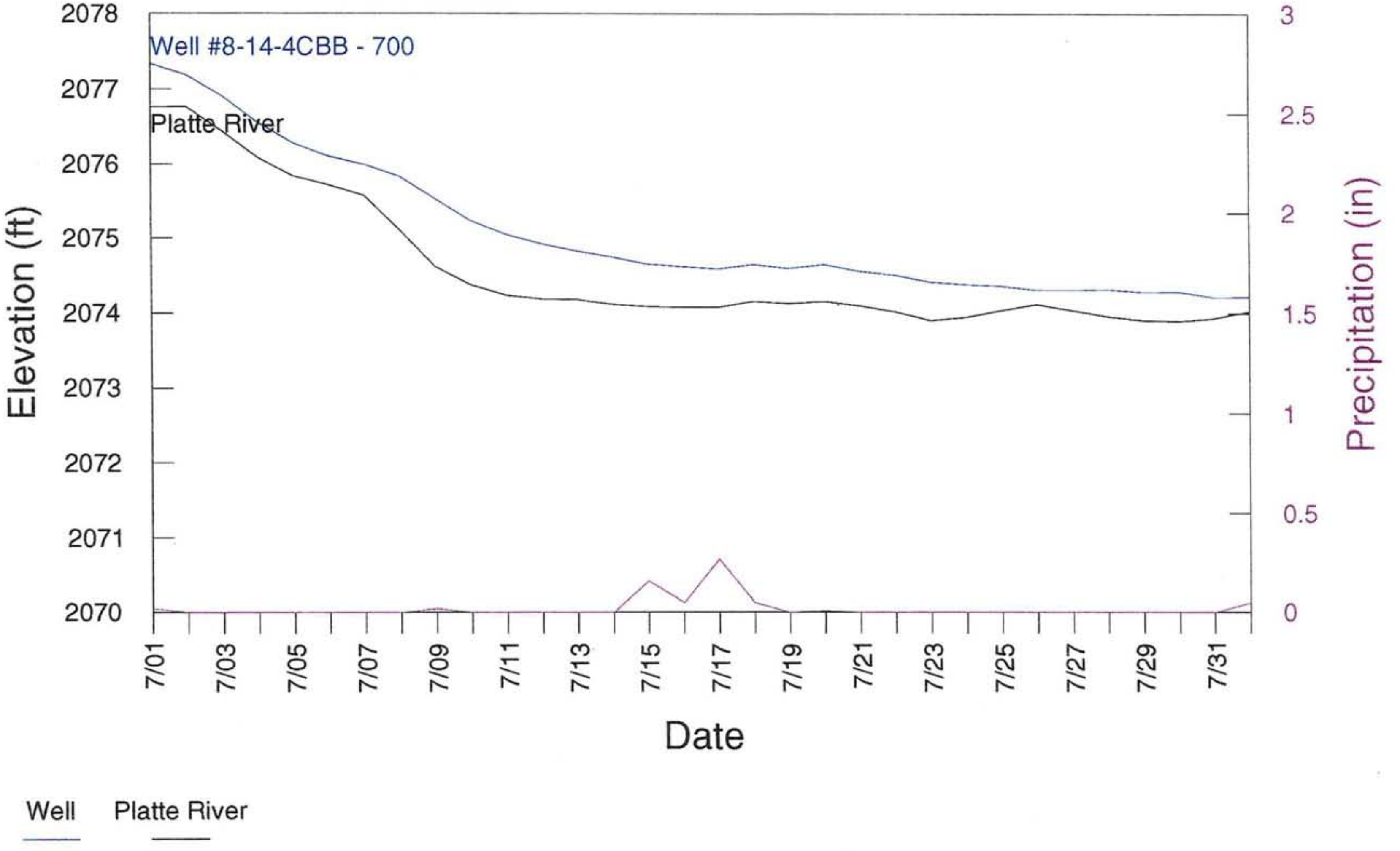


Minden Transect Wells (U)

Elevations for June 1999

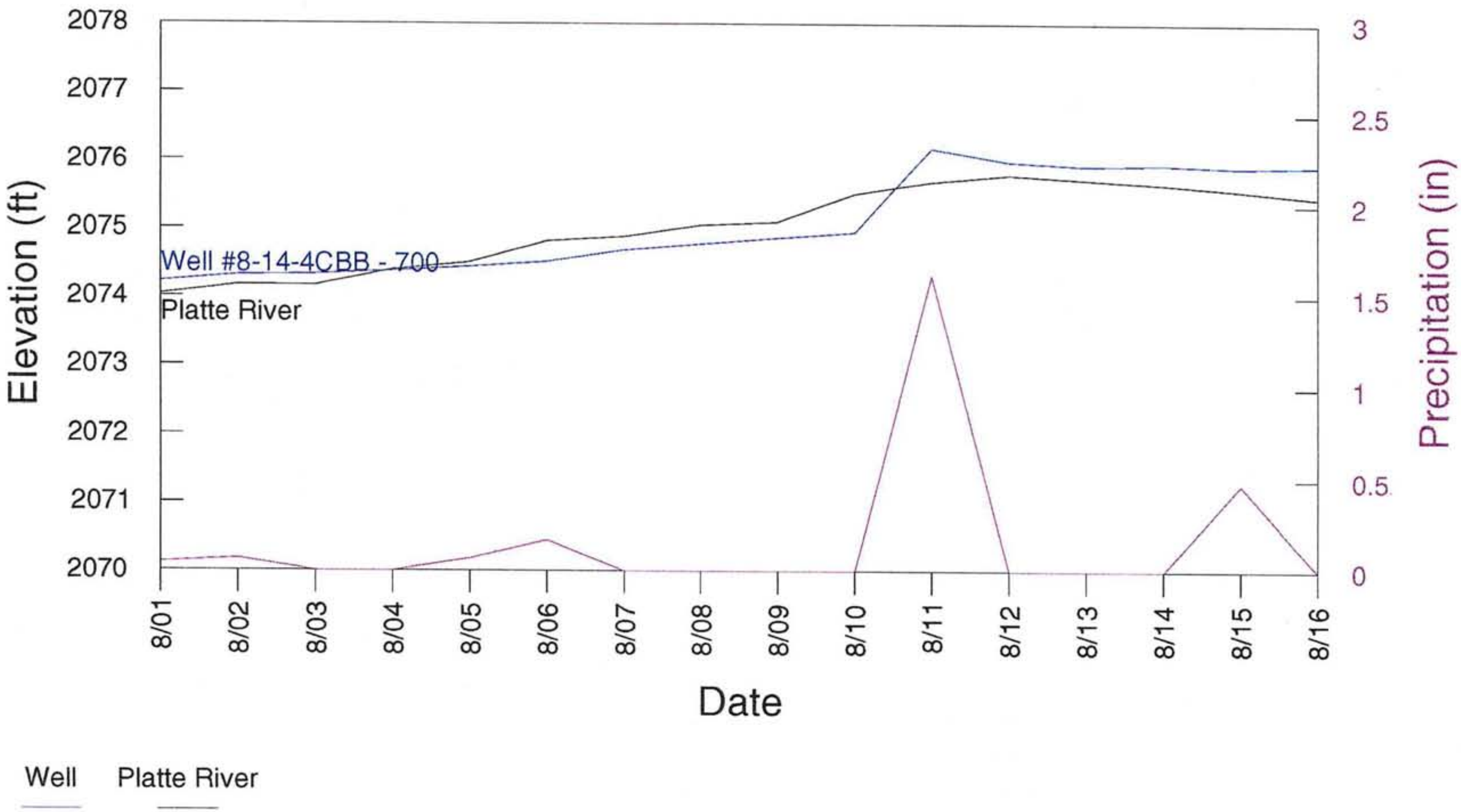
Minden Transect Wells (U)

Elevations for July 1999



Minden Transect Wells (U)

Elevations for August 1999



Dataloggers Removed in August 1999

Well 8-14-4BBB

Minden upstream transect - 3.800 feet (3/4 miles) north of the river.

The correlation factor between the well (Mndn U-2) and the river gage at Kearney for the period March 11 to August 16, 1999 is 0.648 (Appendix F, table 1)

Bank Storage comparison using a transmissivity of 20,000 ft^2/day (the highest plausible aquifer values) shows that the change in water surface at the well would rise 0.3 feet as a result of the high river elevations that occurred from May 1 to July 15. Actually the well rose 2.5 feet between May 1 and 7 and fluctuated through a range of 6.5 feet over the monitoring period. The graph on the following page shows the actual well hydrograph as a solid line, and the bank storage simulation as a dashed line.

Indications that the water level in the well responds to river stage include:

1. A slight rise in the well on May 14 could indicate that the bank storage from the river that began on May 3 is just reaching the well. However, the well reached even lower elevations by May 28 and was still lower than the river.

2. The well appears to track the river in a rising mode from August 1 - 10. In the absence of other indications, this is very likely caused by the water table recovering from irrigation pumping.

Indications that the well also responds to other factors such as precipitation include:

1. From March 13 - 29, the well is at a lower elevation than the river and is declining.

2. Through April, the well responds quickly and consistently to each rainfall and then rapidly declines between events whether it is higher or lower than the river.

3. The well rise on May 4 and 5 far exceeds the corresponding river rise, so the well must be responding to rainfall.

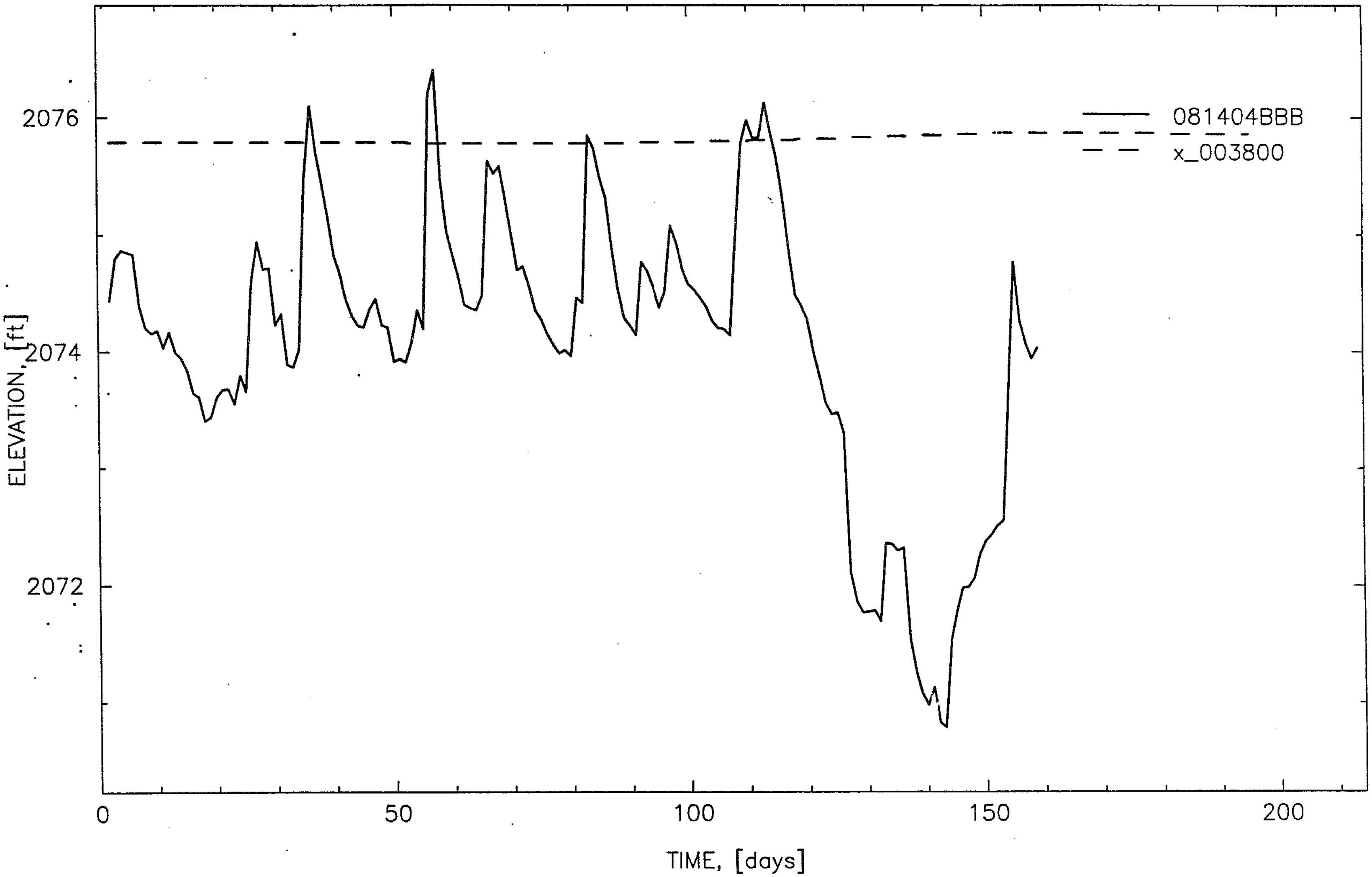
4. The well decline from May 6 to 13 is apparently returning to the ground water level that prevailed before the rainfall. It is not responding to the river even though the river is up to 3 feet higher in elevation.

5. The rain on May 15 caused a significant rise in the well but only slowed the rate of decline in the river. Again, the well is not responding to the river because if it were, it would be held at the higher level or rising until the river had declined to a lower elevation than the well.

6. From May 17 to 28, both the river and the well are in decline, but the well is at a lower elevation than the river and is declining at a slightly faster pace. Therefore, the well must be responding to some other influence such as a pumping well.

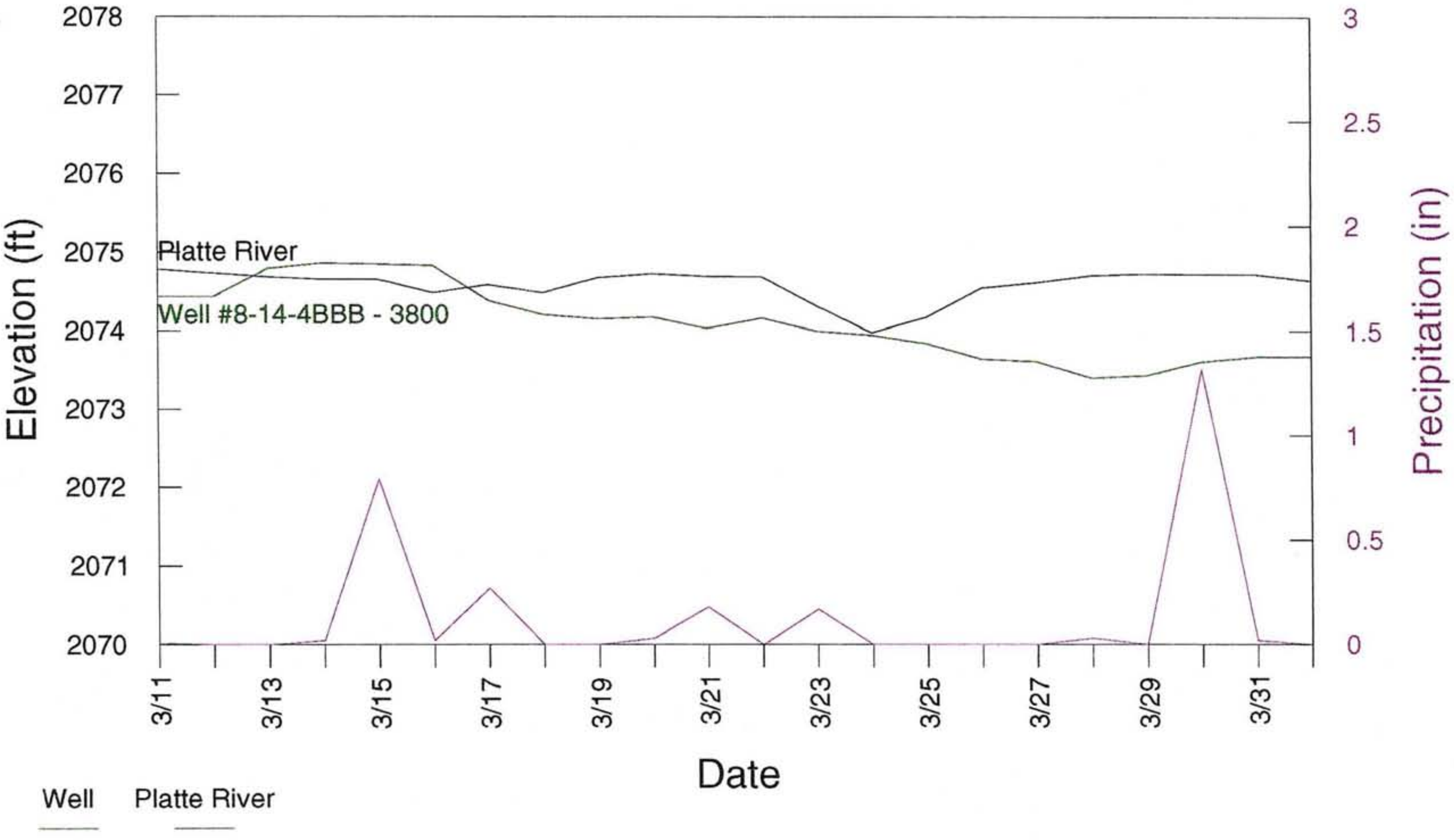
7. On June 1 -9, 10- 13, and 15 -25 and through nearly all of July, the well is at a lower elevation than the river and declining. This indicates a response to pumping of a nearby well.

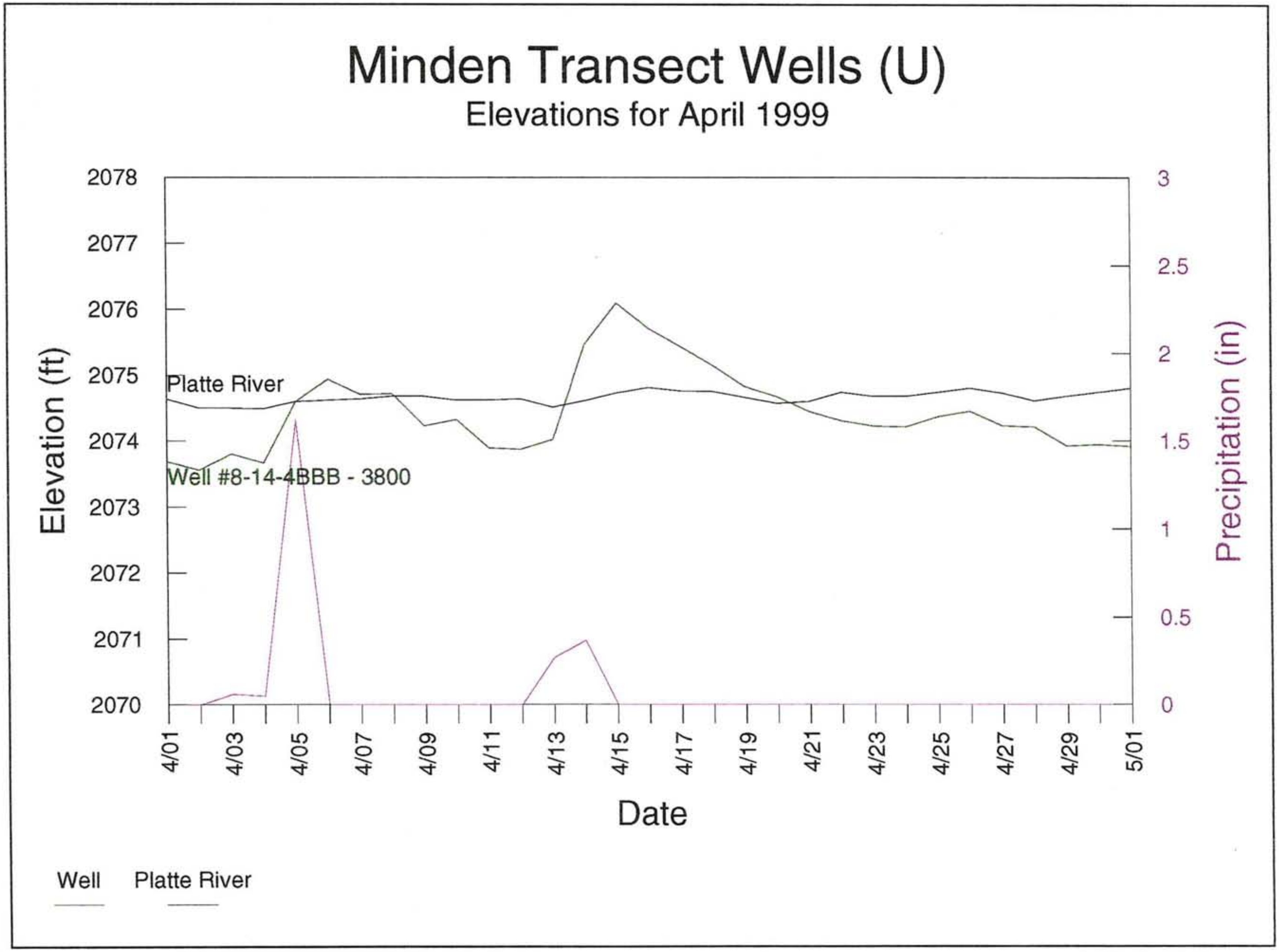
8. The well responds consistently to each rainfall of ½-inch or more.

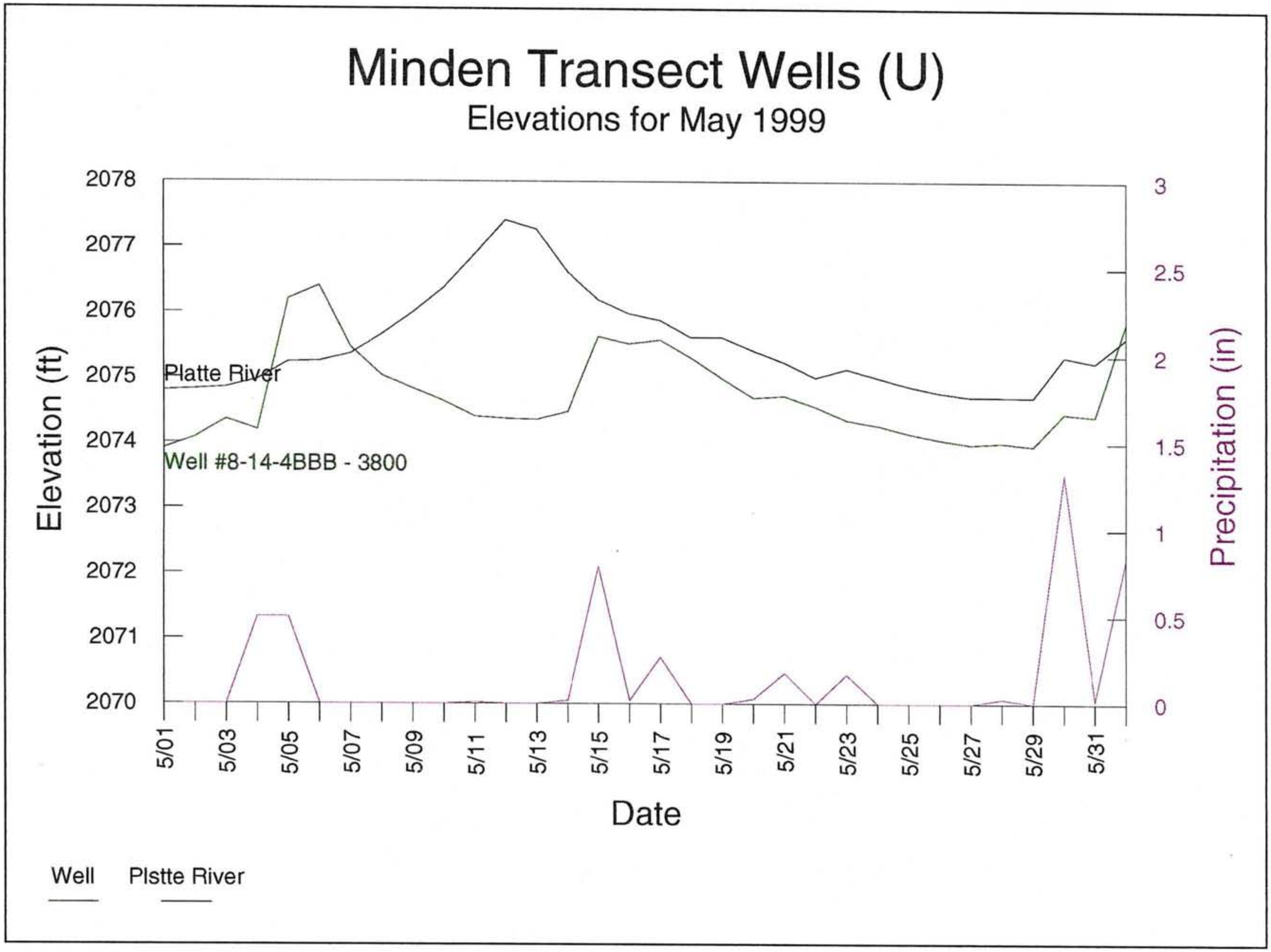

2076
2074
2072
ELEVATION, [ft]
0
50
100
150
200
TIME, [days]
081404BBB
x_003800

Minden Transect Wells (U)

Elevations for March 1999




Minden Transect Wells (U)
Elevations for April 1999
Elevation (ft)
2078
2077
2076
2075
2074
2073
2072
2071
2070
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
Platte River
Well #8-14-4BBB - 3800
4/01
4/03
4/05
4/07
4/09
4/11
4/13
4/15
4/17
4/19
4/21
4/23
4/25
4/27
4/29
5/01
Date
Well
Platte River

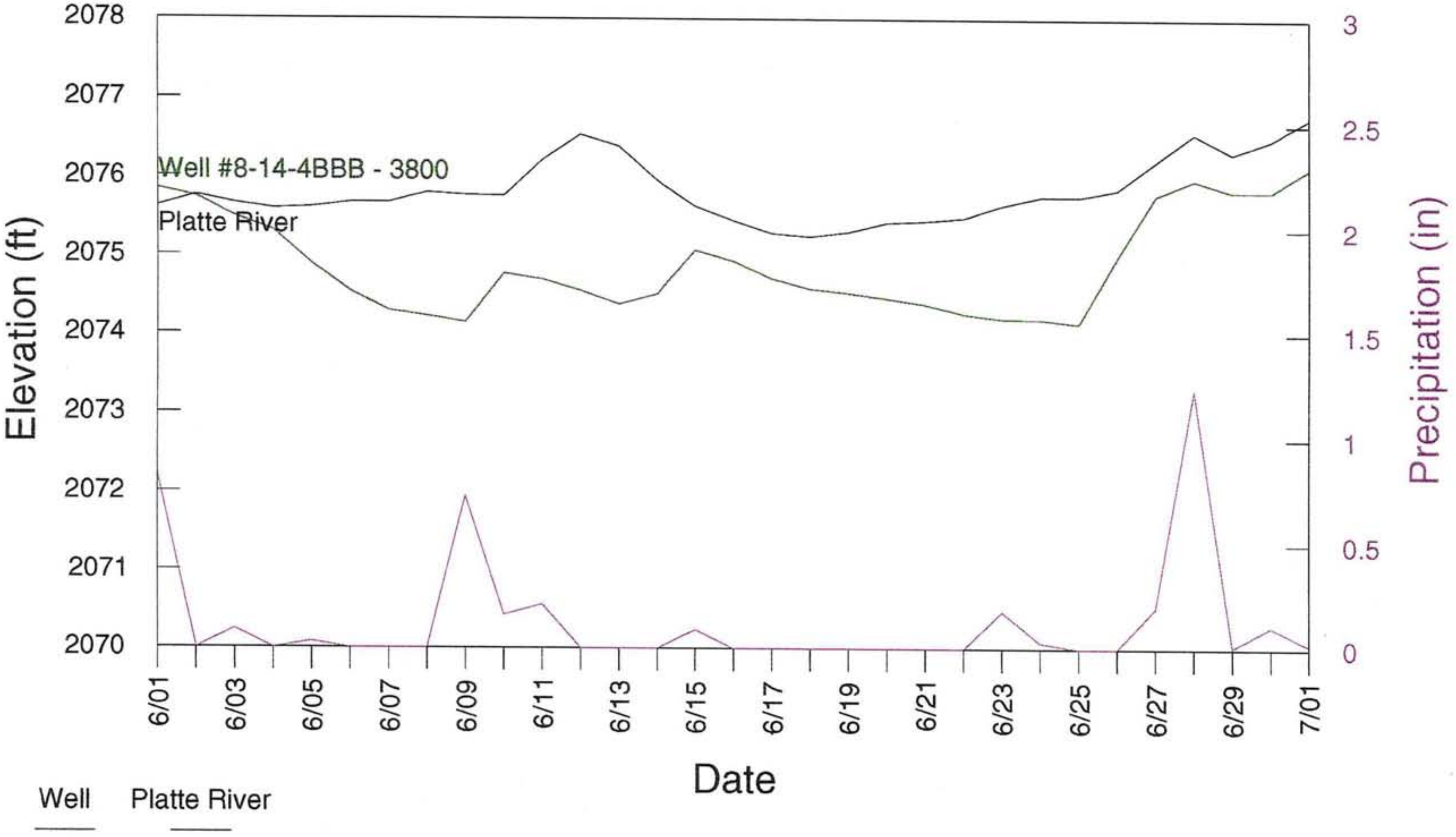


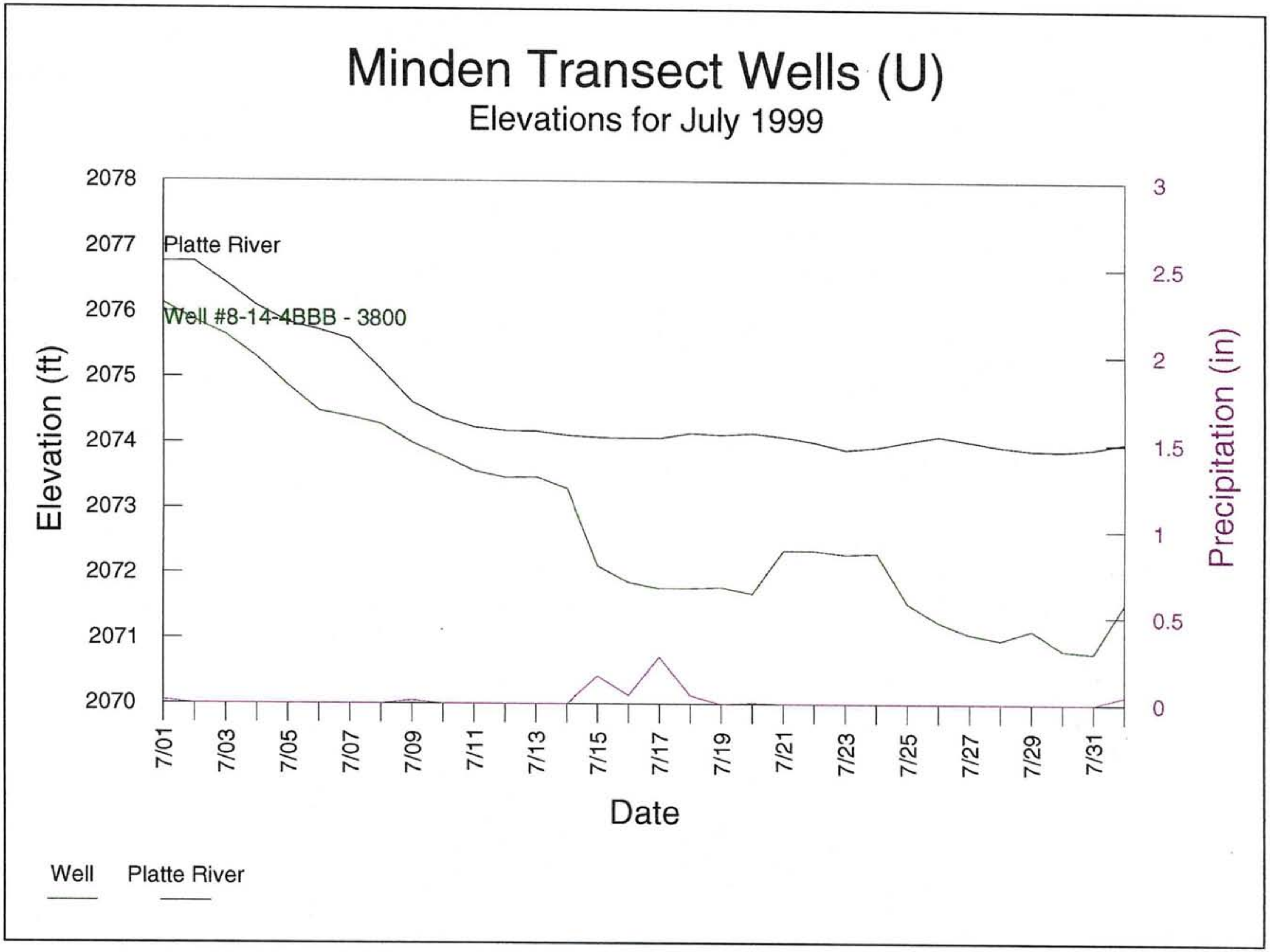
Minden Transect Wells (U)

Elevations for May 1999

Minden Transect Wells (U)

Elevations for June 1999



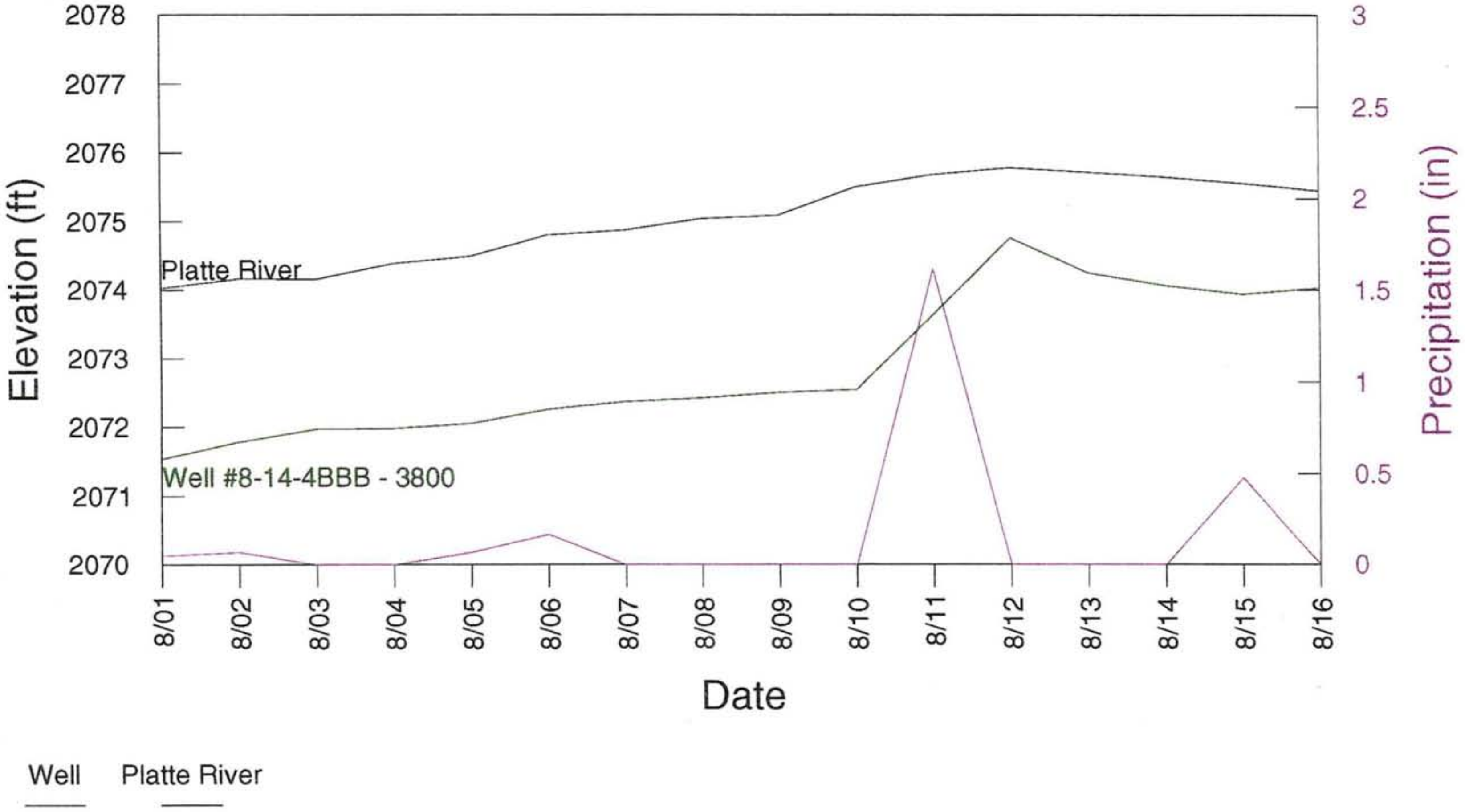


Minden Transect Wells (U)

Elevations for July 1999

Minden Transect Wells (U)

Elevations for August 1999



Dataloggers Removed in August 1999

Well 9-14-28AAA

Minden downstream transect - 13,000 feet (2.5 miles) north of the river.

The correlation factor between the well (Mdnd D-3) and the river gage at Kearney for the period March 11 to September 21, 1999 is 0.270 (Appendix F, table 1)

Bank Storage comparison using a transmissivity of 20,000 ft^2/day (the highest plausible aquifer values) shows that the water surface at the well would have no measurable response as a result of the high river elevations that occurred from May 1 to July 15. Actually, the well rose 2.7 feet between May 8 and July 8. The graph on the following page shows the actual well hydrograph as a solid line, and the bank storage simulation as a dashed line.

Indications that the water level in the well responds to river stage include:

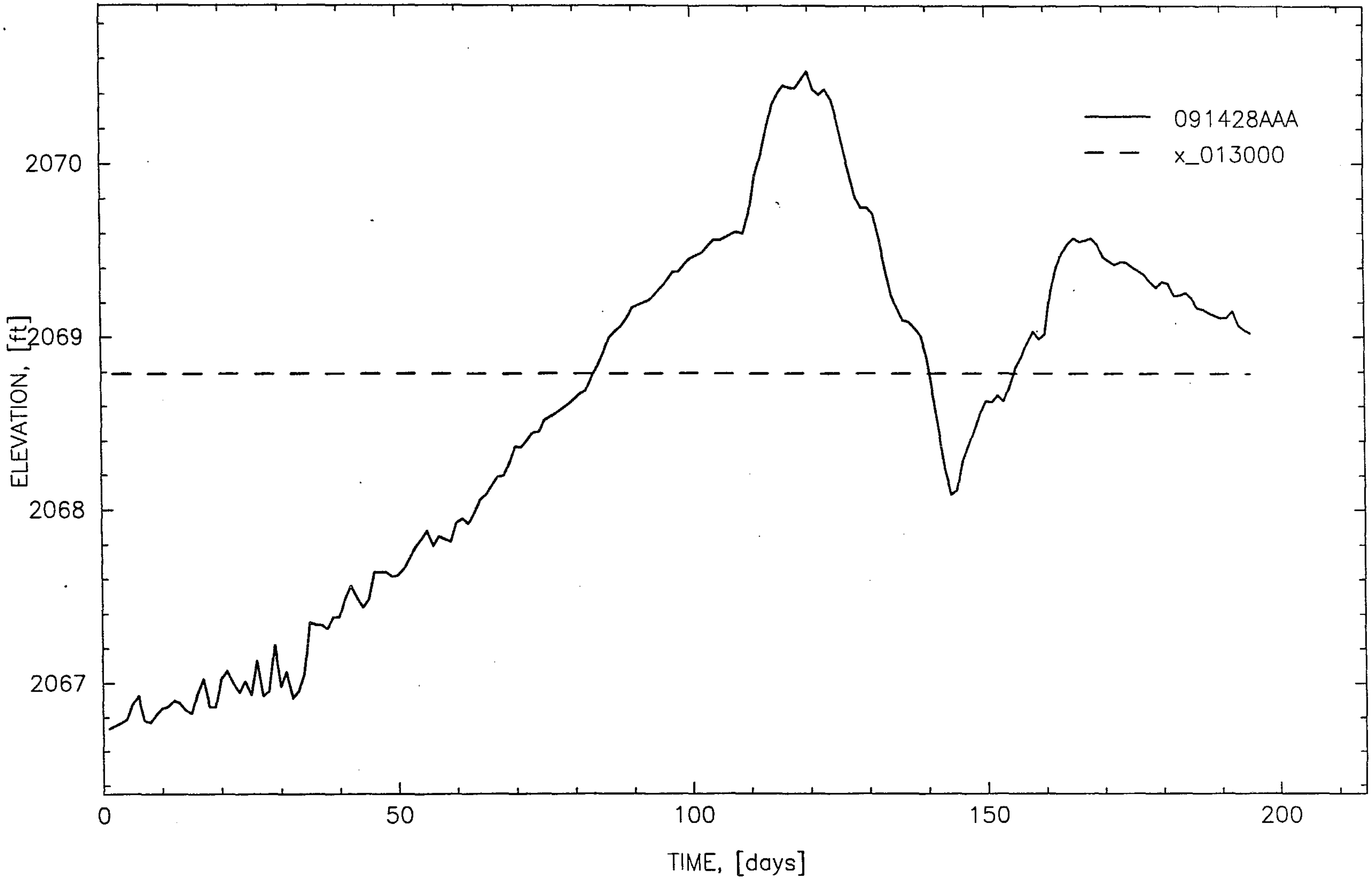
1. The long decline in the well from July 10 to August 1 could be interpreted as a correlation. However, in the absence of other indications, this is more likely a case of the water table being drawn down by irrigation pumps. This is also a period of little precipitation

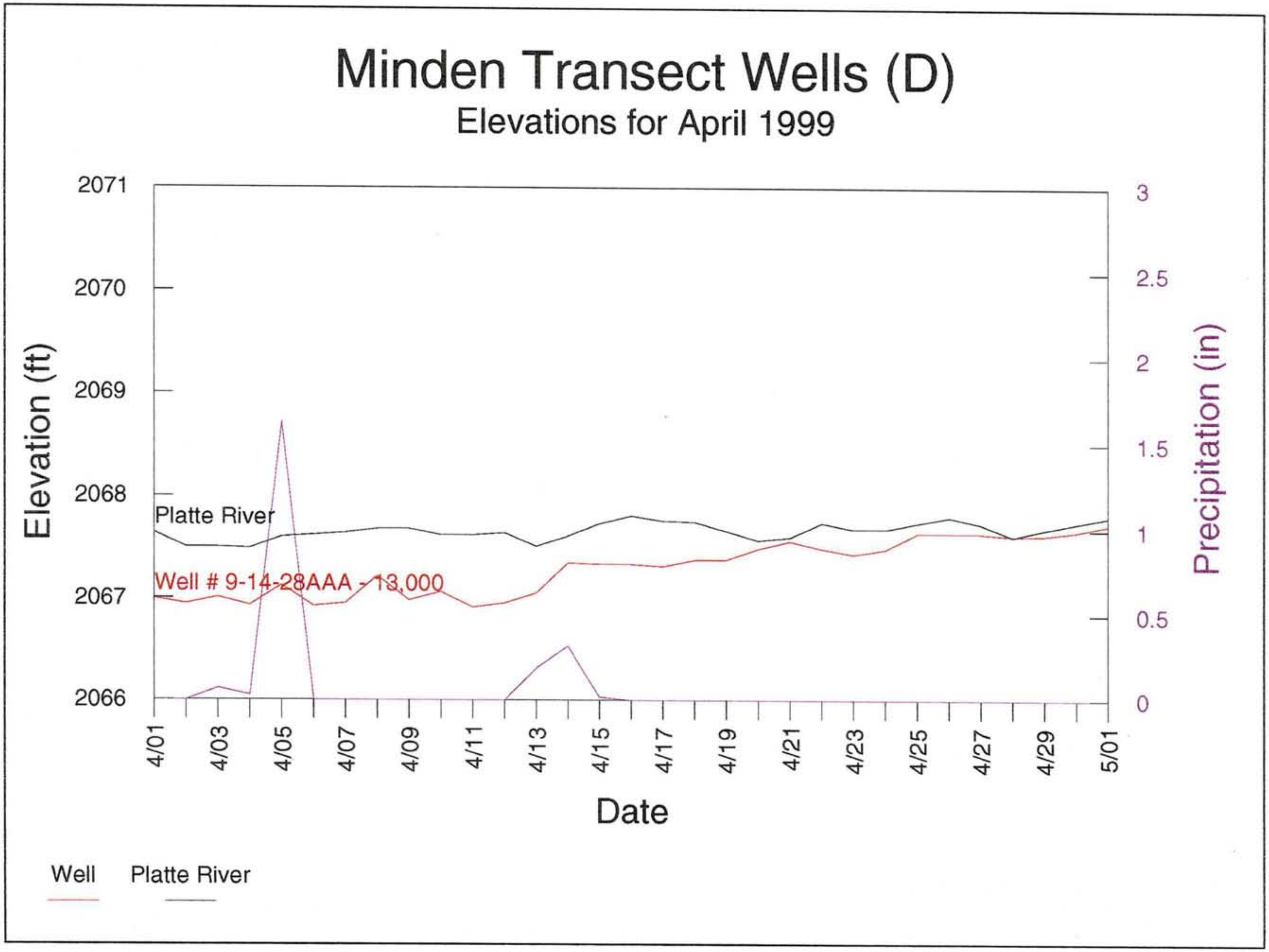
Indications that the well also responds to other factors such as precipitation include:

1. The river is about ½ foot higher than the well through March and early April, but the well does not react to the difference.

2. From May 11 to 28, the river is falling while the well is rising and the elevations cross on May 20. From May 20 to Sept 15, when monitoring was discontinued, the well was higher than the river all but 3 days.

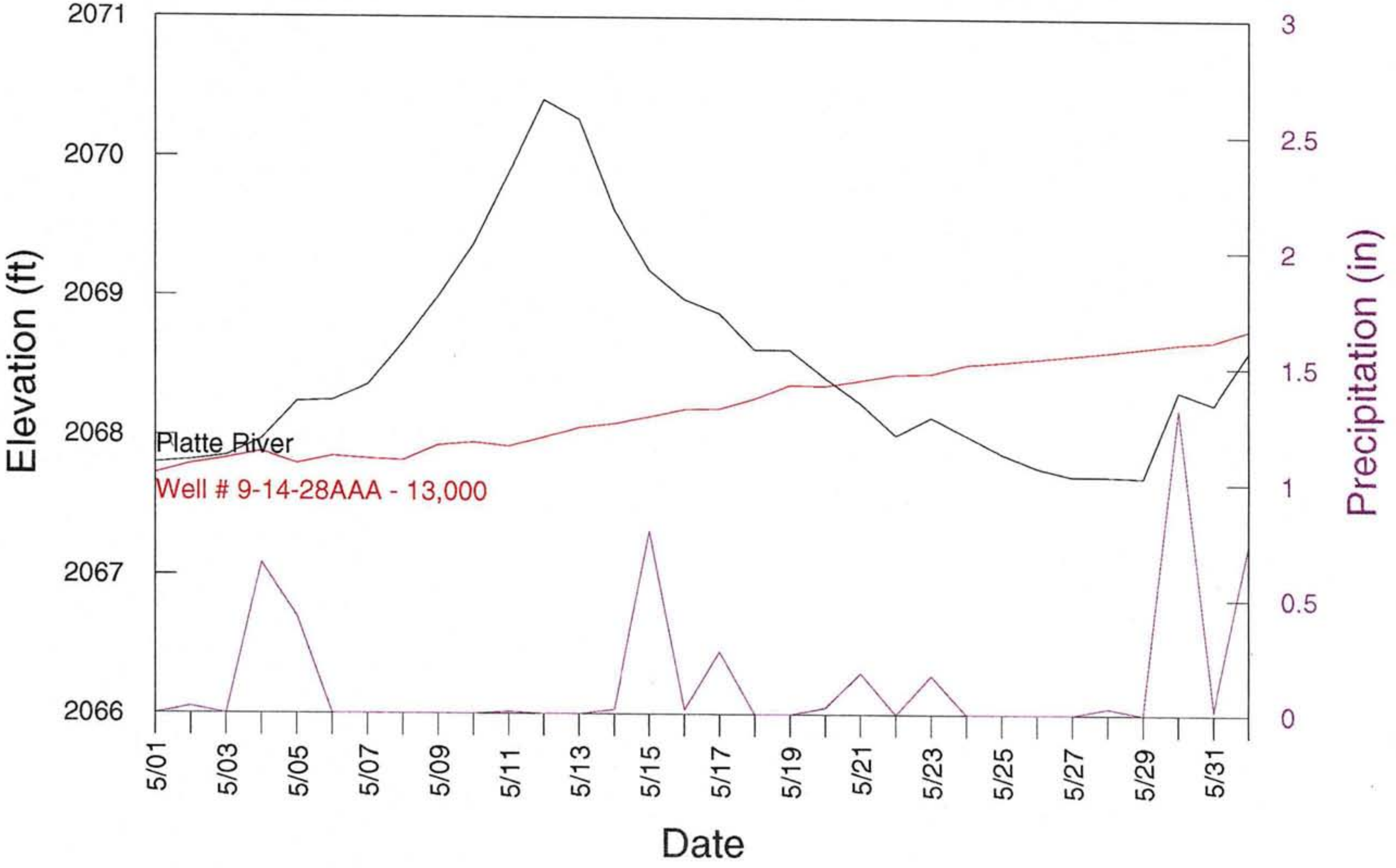
3. During the time the well is higher than the river, there are 4 periods of several days duration in which the well is rising while the river is falling. The periods are May 12 - 29, June 12 - 18, July 2 - 9, and August 19 - 25.


091428AAA
x_013000
2070
2069
2068
2067
ELEVATION, [ft]
0
50
100
150
200
TIME, [days]


Minden Transect Wells (D)
Elevations for April 1999
Elevation (ft)
2071
2070
2069
2068
2067
2066
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
Platte River
Well # 9-14-28AAA - 13,000
4/01
4/03
4/05
4/07
4/09
4/11
4/13
4/15
4/17
4/19
4/21
4/23
4/25
4/27
4/29
5/01
Date
Well
Platte River

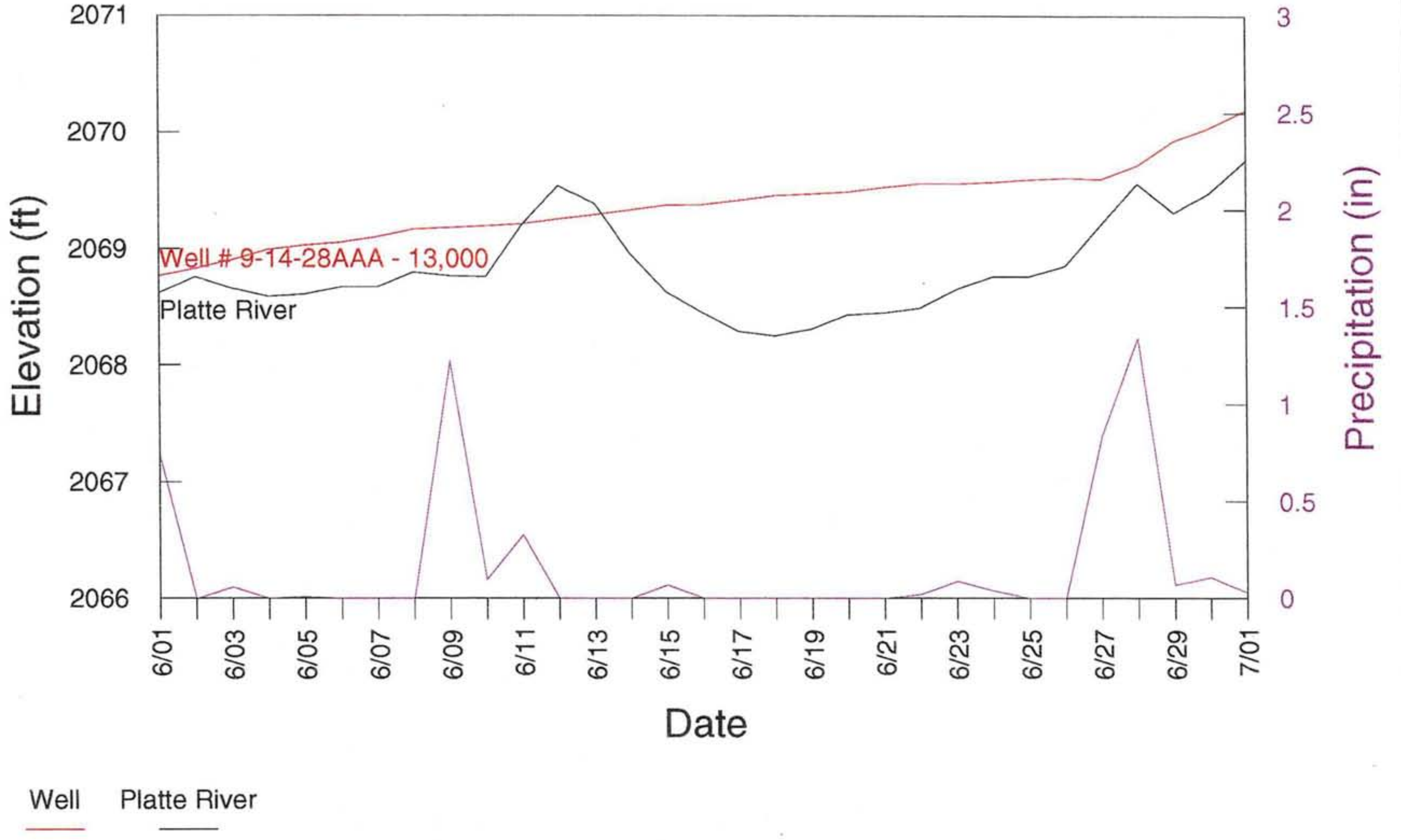
Minden Transect Wells (D)

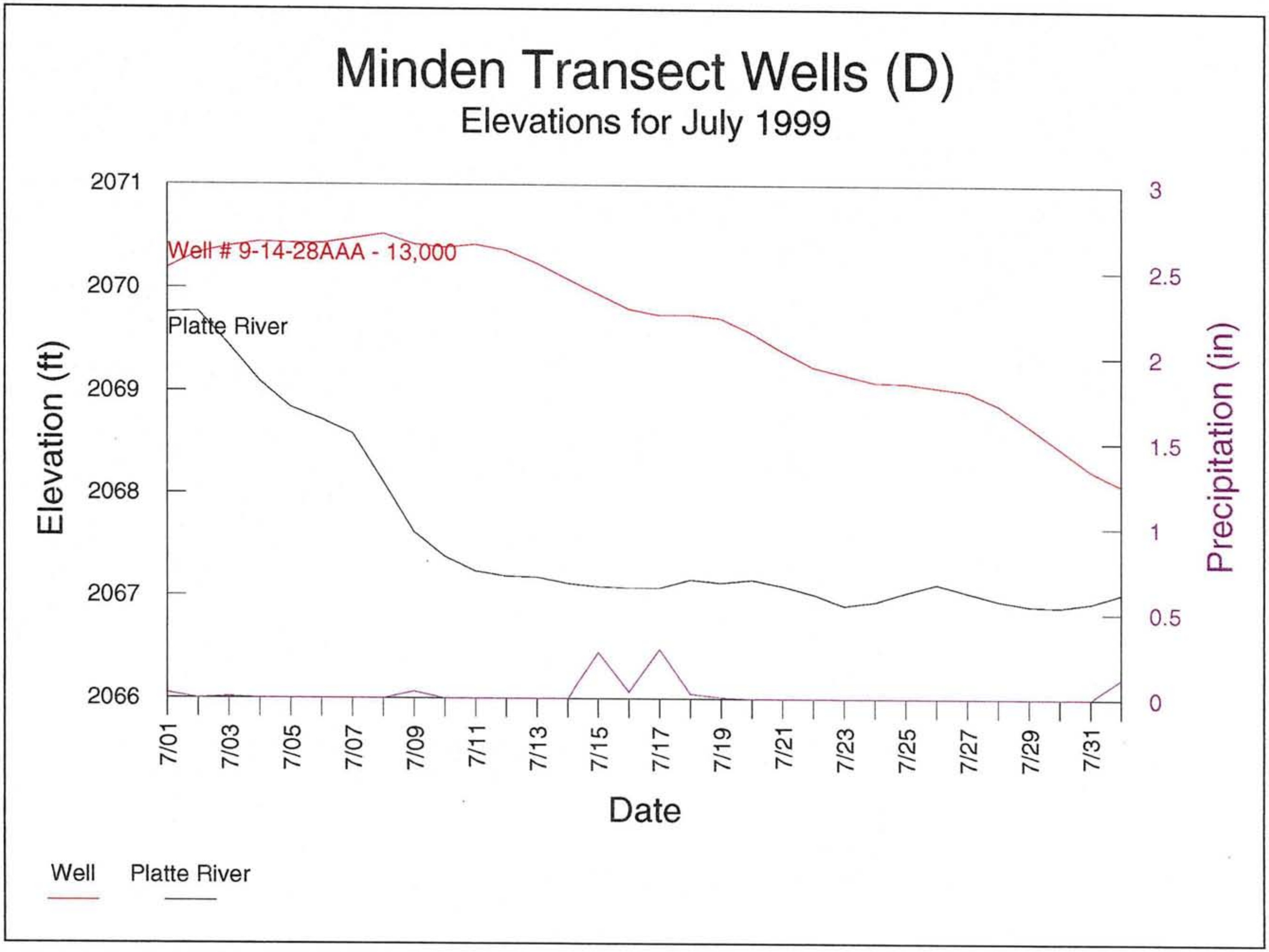
Elevations for May 1999



Minden Transect Wells (D)

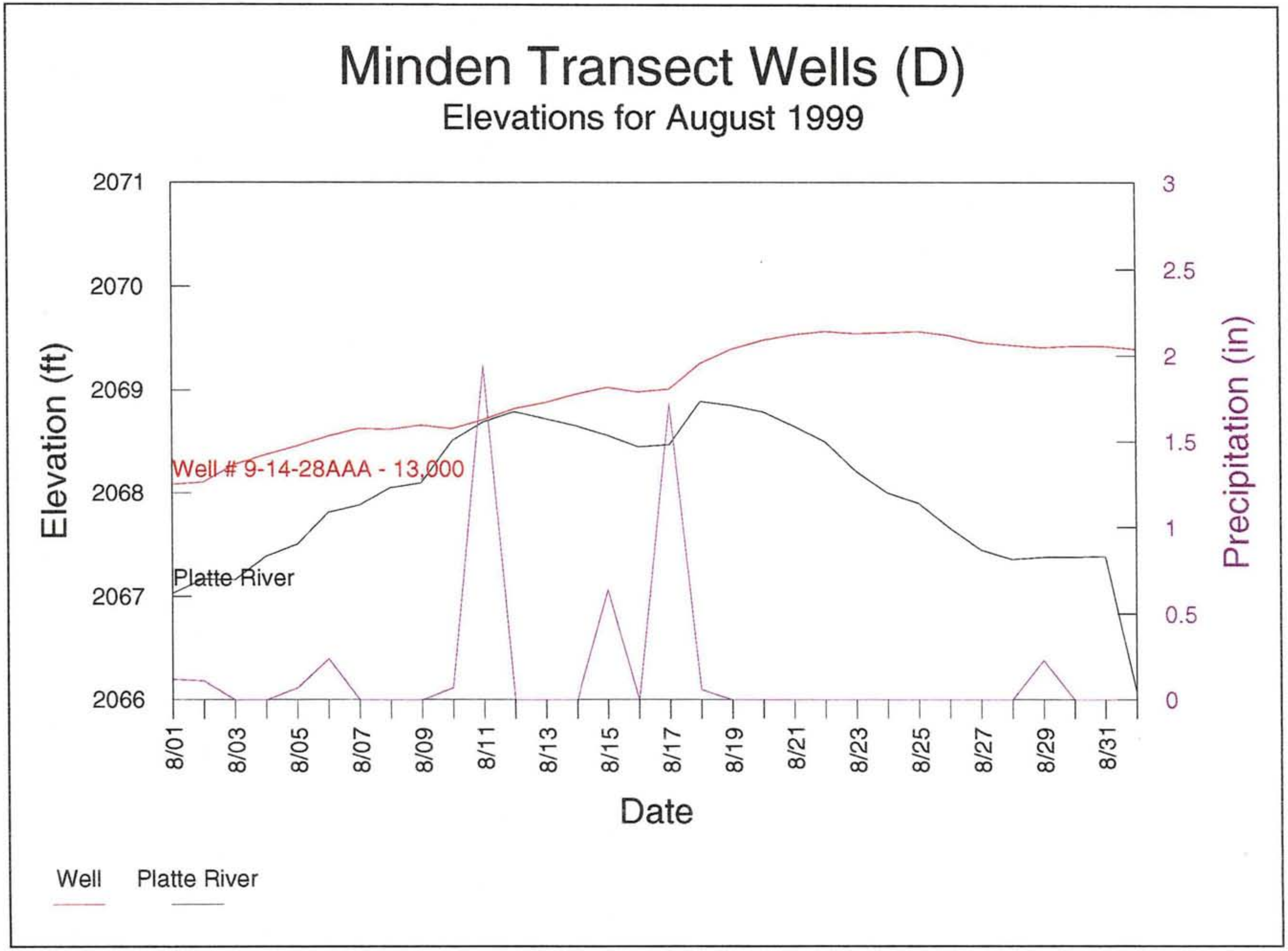
Elevations for June 1999





Minden Transect Wells (D)

Elevations for July 1999

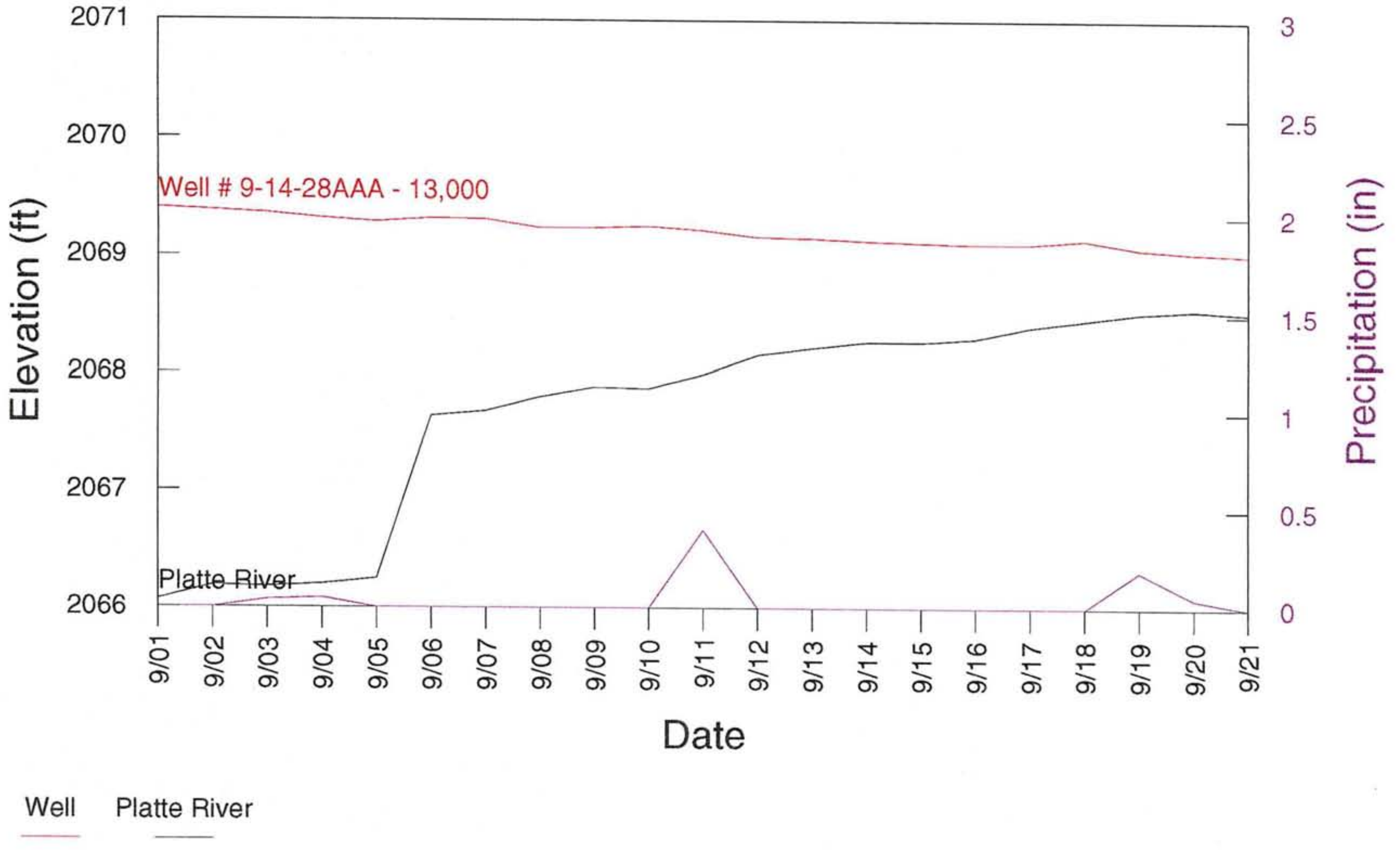


Minden Transect Wells (D)

Elevations for August 1999

Minden Transect Wells (D)

Elevations for September 1999



APPENDIX C

STATISTICAL ANALYSIS OF GROUND WATER DATA

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.

Statistical Analysis of Platte River Ground Water/Surface 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 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 paper. The results are presented in a series of tables and plots. The naming conventions in the tables and plots are as follows - Ovtn = Overton, ElmC = Elm Creek, Mndn = Minden, and Alda = Alda; U = upstream and D = downstream for the 2 subsets of wells located in each transect; well 1 is nearest the river, with each greater number farther from the river - 4 is always the farthest well from the river. Example: Ovtn-U-3 is the 3rd well from the river in the Overton upstream transect.

All 28 correlations (one for each well) of ground water surface elevation with river surface elevation (river stage) were statistically significant, but only 4 of those of stage with precipitation were statistically significant. In other words all of the wells show a significant correlation between WSE and gage height.

A review of the data for April, when 2 significant precipitation events (> 1" in a day), were recorded (Example - figure 1; a complete set of plots is included in Attachment A) was performed to evaluate the response to precipitation. It was noted that there is an increase in the WSE following precipitation. However, there is really no way to correlate WSE and precipitation, *i.e.*, precipitation ends, WSE remains up - there is now a higher WSE but no precipitation. Because of this, a ΔWSE term was used, *i.e.*, the daily change in WSE (the previous days WSE subtracted from each day's WSE). There were then 20 statistically significant correlations of ΔWSE with the daily change in surface elevation (river stage or gage height [GH]), but there were 22 significant correlations between ΔWSE and precipitation out of a total of 28 (*i.e.* 75 and 79 percent respectively). Individual correlations for both WSE and ΔWSE are shown in Table 1; significant correlations are highlighted and summarized in Table 2.

ANOVA and multiple regression was performed to look at effects and interactions; a number of the data sets were missing certain of the interaction categories - mostly falling gages at higher levels of precipitation, *i.e.* > 0.5" per day. These were run as covariates, and the total model F-values are shown in the summary tables 3-6 (see footnote); these include the majority of the wells in the Elm Creek and Minden transects (see tables 4 and 5) and the only ones that are statistically significant in those transects. The absence of falling gages when there was higher precipitation indicates a response of the gages to precipitation. Results of the ANOVA show significant interaction effects only at wells in the Alda transect (Table 7). In general the wells nearer the river show a significant relationship between the ΔWSE and a rising or falling gage; to a great extent this is also true of the relationship between the ΔWSE and precipitation (rain).

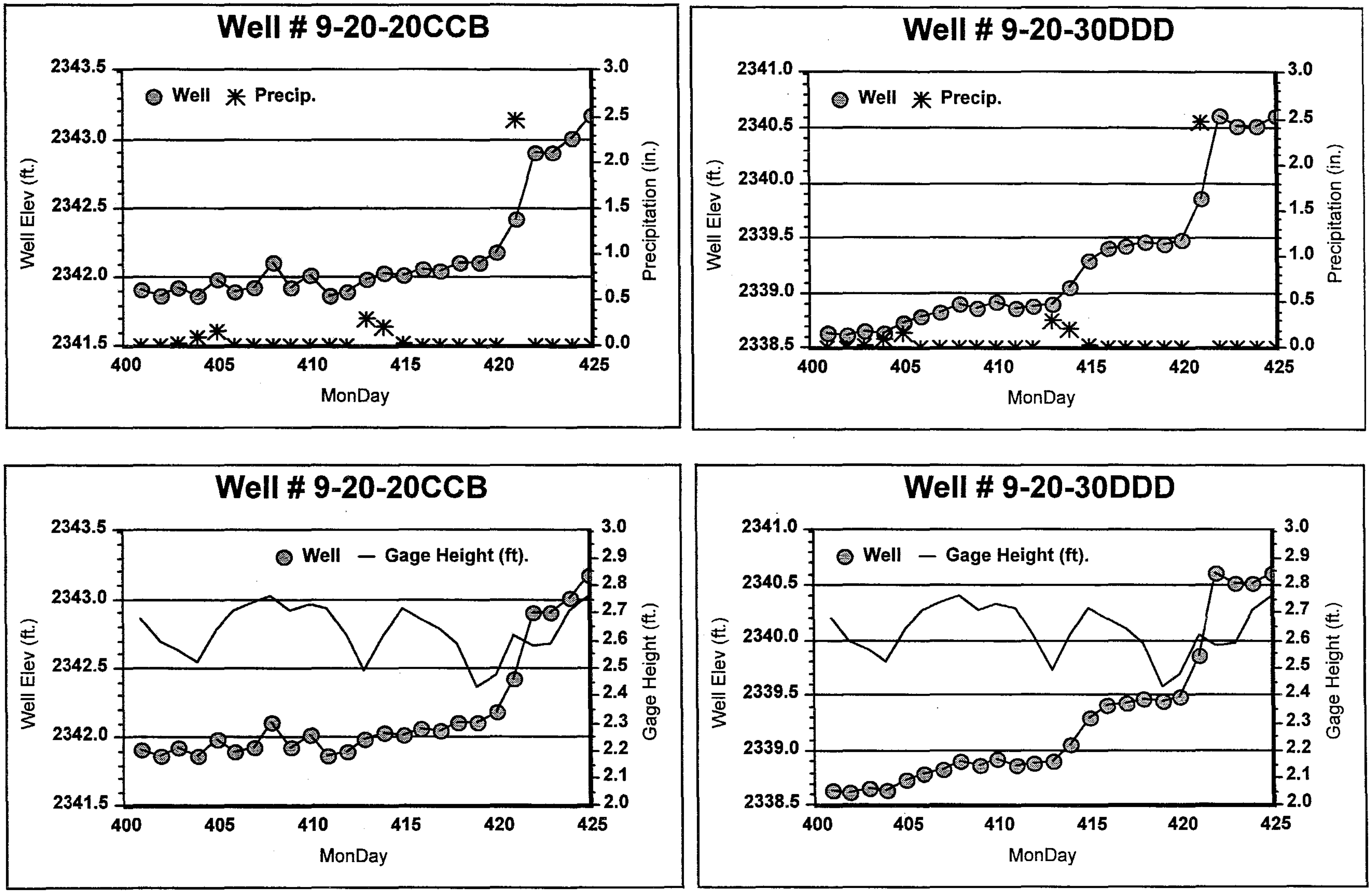


Figure 1: Overton Upstream Wells

Table 1. Correlations of well water surface elevation (WSE) and change in WSE with precipitation and gage readings

			Well WSE			Daily Change in Well WSE		
Transect	Well number	Statistic	Gage Height	Stage Change	Local Precipitation	Gage Height	Stage Change	Local Precipitation
Overton	Ovtn-U-3	Corr. Coeff.	0.459731	-0.130667	-0.010702	0.147863	0.125282	0.016110
		Prob. > r	< 0.000001	0.133839	0.916703	0.090652	0.152334	0.854532
		No. of Obs.	133	133	98	132	132	132
	Ovtn-U-2	Corr. Coeff.	0.199799	-0.026444	0.081297	0.073378	0.271959	0.240391
		Prob. > r	0.005339	0.715077	0.309891	0.311784	0.000136	0.000783
		No. of Obs.	193	193	158	192	192	192
	Ovtn-U-1	Corr. Coeff.	0.472594	0.147438	0.106238	-0.163167	0.035797	0.178430
		Prob. > r	0.000004	0.172951	0.327399	0.133334	0.743508	0.100238
		No. of Obs.	87	87	87	86	86	86
	Ovtn-D-3	Corr. Coeff.	0.413958	-0.193235	0.098609	0.119324	0.285073	0.186697
		Prob. > r	0.000011	0.048265	0.416705	0.227632	0.003355	0.057742
		No. of Obs.	105	105	70	104	104	104
	Ovtn-D-2	Corr. Coeff.	0.297693	-0.004304	0.121809	0.031344	0.208968	0.329766
		Prob. > r	0.000026	0.952626	0.127347	0.666038	0.003628	0.000003
		No. of Obs.	193	193	158	192	192	192
	Ovtn-D-1	Corr. Coeff.	0.397409	0.022037	0.114782	-0.009941	0.153901	0.350802
		Prob. > r	< 0.000001	0.760977	0.150980	0.891146	0.033064	0.000001
		No. of Obs.	193	193	158	192	192	192
Elm Creek	ElmC-U-4	Corr. Coeff.	0.444745	-0.150725	-0.119747	0.072712	-0.189332	-0.261308
		Prob. > r	< 0.000001	0.083319	0.240211	0.407357	0.029685	0.002475
		No. of Obs.	133	133	98	132	132	132
	ElmC-U-3	Corr. Coeff.	0.571207	-0.013434	0.115104	0.085799	0.355596	0.483477
		Prob. > r	< 0.000001	0.852513	0.148526	0.235463	< 0.000001	< 0.000001
		No. of Obs.	194	194	159	193	193	193
	ElmC-U-2	Corr. Coeff.	0.191161	-0.197195	0.030655	0.108101	0.030156	0.048810
		Prob. > r	0.018317	0.014889	0.742835	0.187922	0.714118	0.553084
		No. of Obs.	152	152	117	150	150	150

Table 1 (continued)

			Well WSE			Daily Change in Well WSE		
Transect	Well number	Statistic	Gage Height	Stage Change	Local Precipitation	Gage Height	Stage Change	Local Precipitation
Elm Creek	ElmC-U-1	Corr. Coeff.	0.756265	0.139577	0.165421	0.042321	0.520963	0.396906
		Prob. > r	< 0.000001	0.052873	0.037789	0.559996	< 0.000001	< 0.000001
		No. of Obs.	193	193	158	192	192	192
	ElmC-D-4	Corr. Coeff.	0.572072	-0.089035	0.039987	0.130341	0.152215	0.163098
		Prob. > r	< 0.000001	0.216996	0.616770	0.070807	0.034581	0.023433
		No. of Obs.	194	194	159	193	193	193
	ElmC-D-3	Corr. Coeff.	0.354633	-0.076251	0.063841	0.164621	0.277505	0.174556
		Prob. > r	< 0.000001	0.290633	0.424020	0.022151	0.000093	0.015185
		No. of Obs.	194	194	159	193	193	193
	ElmC-D-2	Corr. Coeff.	0.534295	0.114665	0.216667	0.001209	0.209672	0.266938
		Prob. > r	< 0.000001	0.17733	0.026416	0.988730	0.013239	0.001490
		No. of Obs.	140	140	105	139	139	139
	ElmC-D-1	Corr. Coeff.	0.446926	0.234263	0.510559	-0.040752	0.194106	0.725119
		Prob. > r	0.000036	0.037710	0.000002	0.724916	0.090733	< 0.000001
		No. of Obs.	79	79	79	77	77	77
Minden	Mndn-U-4	Corr. Coeff.	0.196171	-0.134082	0.042554	0.326329	0.087019	0.200989
		Prob. > r	0.005986	0.062335	0.554733	0.000003	0.227627	0.004953
		No. of Obs.	195	194	195	194	194	194
	Mndn-U-3	Corr. Coeff.	0.455610	-0.190724	-0.021443	0.441702	0.092115	0.141431
		Prob. > r	< 0.000001	0.007726	0.766048	< 0.000001	0.201447	0.049175
		No. of Obs.	195	194	195	194	194	194
	Mndn-U-2	Corr. Coeff.	0.64806	-0.014475	0.094001	0.059089	0.19527	0.427118
		Prob. > r	< 0.000001	0.85675	0.238569	0.460831	0.013943	< 0.000001
		No. of Obs.	159	158	159	158	158	158
	Mndn-U-1	Corr. Coeff.	0.881629	-0.010419	0.173995	0.117339	0.462558	0.518812
		Prob. > r	< 0.000001	0.905618	0.046012	0.181956	< 0.000001	< 0.000001
		No. of Obs.	132	132	132	131	131	131

Table 1 (continued)

			Well WSE			Daily Change in Well WSE		
Transect	Well number	Statistic	Gage Height	Stage Change	Local Precipitation	Gage Height	Stage Change	Local Precipitation
Minden	Mndn-D-3	Corr. Coeff.	0.270252	-0.130479	0.023251	0.416935	0.135026	0.155245
		Prob. > r	0.000133	0.069775	0.746964	< 0.000001	0.060498	0.030660
		No. of Obs.	195	194	195	194	194	194
	Mndn-D-2	Corr. Coeff.	0.569126	-0.170946	-0.002291	0.303769	0.187578	0.134322
		Prob. > r	< 0.000001	0.017164	0.974638	0.000017	0.008817	0.061865
		No. of Obs.	195	194	195	194	194	194
	Mndn-D-1	Corr. Coeff.	0.974060	0.04085	0.126473	0.163670	0.813890	0.283473
		Prob. > r	< 0.000001	0.631789	0.136483	0.054202	< 0.000001	0.000721
		No. of Obs.	140	140	140	139	139	139
Alda	Alda-U-4	Corr. Coeff.	0.533534	-0.189043	0.100683	0.260064	0.137109	0.115577
		Prob. > r	< 0.000001	0.029312	0.248866	0.002600	0.116952	0.186942
		No. of Obs.	133	133	133	132	132	132
	Alda-U-3	Corr. Coeff.	0.668632	-0.001338	0.104310	0.039762	0.257591	0.361836
		Prob. > r	< 0.000001	0.985187	0.146721	0.582003	0.000288	< 0.000001
		No. of Obs.	195	195	195	194	194	194
	Alda-U-2	Corr. Coeff.	0.741198	-0.049572	0.056308	0.118657	0.364484	0.331412
		Prob. > r	< 0.000001	0.491318	0.434291	0.099383	< 0.000001	0.000002
		No. of Obs.	195	195	195	194	194	194
	Alda-U-1	Corr. Coeff.	0.980883	0.102092	0.116298	0.092194	0.800044	0.366401
		Prob. > r	< 0.000001	0.155552	0.105431	0.201057	< 0.000001	< 0.000001
		No. of Obs.	195	195	195	194	194	194
	Alda-D-3	Corr. Coeff.	0.621010	-0.07465	0.051038	0.167963	0.301026	0.234424
		Prob. > r	< 0.000001	0.299655	0.478582	0.019233	0.000020	0.001002
		No. of Obs.	195	195	195	194	194	194
	Alda-D-2	Corr. Coeff.	0.621290	-0.061512	0.053052	0.128371	0.273483	0.309658
		Prob. > r	< 0.000001	0.392963	0.461377	0.074450	0.000114	0.000011
		No. of Obs.	195	195	195	194	194	194

Table 1 (continued)

			Well WSE			Daily Change in Well WSE		
Transect	Well number	Statistic	Gage Height	Stage Change	Local Precipitation	Gage Height	Stage Change	Local Precipitation
Alda	Alda-D-1	Corr. Coeff.	0.693872	-0.229727	0.078258	0.283003	0.265623	0.435777
		Prob. > r	< 0.000001	0.006325	0.358058	0.000736	0.001576	< 0.000001
		No. of Obs.	140	140	140	139	139	139

Table 2. Correlations between WSE & change in WSE and precipitation and gage readings

		Well WSE		Well change in WSE	
Transect	Well No.	Gage Height	Precipitation	Stage change	Precipitation
Overton	Ovtn-U-3	Significant			
	Ovtn-U-2	Significant		Significant	Significant
	Ovtn-U-1	Significant			
	Ovtn-D-3	Significant		Significant	
	Ovtn-D-2	Significant		Significant	Significant
	Ovtn-D-1	Significant		Significant	Significant
Elm Creek	ElmC-U-4	Significant		Significant	Significant
	ElmC-U-3	Significant		Significant	Significant
	ElmC-U-2	Significant			
	ElmC-U-1	Significant	Significant	Significant	Significant
	ElmC-D-4	Significant		Significant	Significant
	ElmC-D-3	Significant		Significant	Significant
	ElmC-D-2	Significant	Significant	Significant	Significant
	ElmC-D-1	Significant	Significant		Significant
Minden	Mndn-U-4	Significant			Significant
	Mndn-U-3	Significant			Significant
	Mndn-U-2	Significant		Significant	Significant
	Mndn-U-1	Significant	Significant	Significant	Significant
	Mndn-D-3	Significant			Significant
	Mndn-D-2	Significant		Significant	
	Mndn-D-1	Significant		Significant	Significant
Alda	Alda-U-4	Significant			
	Alda-U-3	Significant		Significant	Significant
	Alda-U-2	Significant		Significant	Significant
	Alda-U-1	Significant		Significant	Significant
	Alda-D-3	Significant		Significant	Significant
	Alda-D-2	Significant		Significant	Significant
	Alda-D-1	Significant		Significant	Significant
Total	28 wells	28	4	20	22

Table 3. Multivariate Analysis of the daily change in ground water surface elevation on stage change and precipitation at the Alda Transect

A. Two-way Analysis of Variance

	Distance	Stage change		Precipitation		Stage X Precipitation	
Well No.	to river (ft)	F	Prob. > F	F	Prob. > F	F	Prob. > F
Alda_U_1	50	34.8513	< 0.000001	1.9073	0.151395	3.4628	0.009360
Alda_U_2	3,000	1.8068	0.167070	17.1094	< 0.000001	4.7271	0.001180
Alda_U_3	8,000	12.2396	0.000010	2.8355	0.061244	5.1002	0.000639
Alda_U_4	23,300	0.0288	0.971633	1.0512	0.352636	1.0604	0.379141
Alda_D_1	1,200	8.4147	0.000366	1.6188	0.202099	2.2259	0.069684
Alda_D_2[1]	6,500	6.0060	0.002969	60.1503	< 0.000001	19.7415	< 0.000001
Alda_D_3	11,000	16.5033	< 0.000001	3.9036	0.021851	4.4597	0.001831

B. Multiple regression -

		Regression		Stage change		Precipitation	
Well No.	R^2	F	Prob. > F	t	Prob. > t	t	Prob. > t
Alda_U_1	0.678787	201.8105	< 0.000001	17.9943	< 0.00001	4.7981	< 0.00001
Alda_U_2	0.199506	23.8013	< 0.000001	4.6256	0.00001	3.9880	0.00009
Alda_U_3	0.164463	18.7977	< 0.000001	2.7689	0.00618	4.7358	< 0.00001
Alda_U_4	0.026877	1.7814	0.172516	1.3387	0.18303	1.0348	0.30270
Alda_D_1	0.228223	20.1084	< 0.000001	2.5987	0.01039	5.2710	< 0.00001
Alda_D_2	0.140896	15.6624	0.000001	3.1633	0.00182	3.8336	0.00017
Alda_D_3	0.121236	13.1754	0.000004	3.7956	0.00020	2.5798	0.01064

[1] Empty cell prevents partitioning sum of squares; F-value under stage X precipitation is for the combined model, not the interaction. Stage and precipitation are run as covariates.

Table 4. Multivariate Analysis of the daily change in ground water surface elevation on stage change and precipitation at the Minden Transect

A. Two-way Analysis of Variance

Dependent	Distance	Stage		Precipitation		Stage X Precipitation	
Variable	to River	F	Prob. > F	F	Prob. > F	F	Prob. > F
Mndn_U_1[1]	700	8.6601	0.000299	15.7524	1E-006	9.7393	< 0.000001
Mndn_U_2[1]	3,800	2.0984	0.126174	71.4494	< 0.000001	7.9395	< 0.000001
Mndn_U_3	9,000	2.5539	0.080519	1.3294	0.267147	1.1220	0.347540
Mndn_U_4	14,200	0.9126	0.403265	0.3279	0.720822	0.1440	0.965437
Mndn_D_1[1]	100	45.5275	< 0.000001	7.2448	0.001029	18.9997	< 0.000001
Mndn_D_2[1]	7,700	5.4036	0.005223	1.8601	0.158493	2.2247	0.034076
Mndn_D_3	13,000	1.7912	0.169635	0.7684	0.465238	0.1823	0.947379

B. Multiple regression -

		Regression		Stage		Precipitation	
Well No.	R^2	F	Prob. > F	t	Prob. > t	t	Prob. > t
Mndn_U_1	0.3826	39.6564	< 0.000001	4.8489	< 0.00001	5.9124	< 0.00001
Mndn_U_2	0.1916	18.3668	< 0.000001	1.3250	0.18711	5.4243	< 0.00001
Mndn_U_3	0.0244	2.3901	0.094356	0.9296	0.35377	1.7661	0.07898
Mndn_U_4	0.0427	4.2637	0.015432	0.6835	0.49509	2.6489	0.00875
Mndn_D_1	0.6845	147.5479	< 0.000001	16.1386	< 0.00001	3.0872	0.00245
Mndn_D_2	0.0458	4.5855	0.011347	2.3579	0.01939	1.4588	0.14628
Mndn_D_3	0.0353	3.4953	0.032293	1.4896	0.13798	1.8387	0.06751

[1] Empty cell prevents partitioning sum of squares; F-value under stage X precipitation is for the combined model, not the interaction. Stage and precipitation are run as covariates.

Table 5. Multivariate Analysis of the daily change in ground water surface elevation on stage change and precipitation at the Elm Creek Transect

Two-way Analysis of Variance

	Distance	Stage		Precipitation		Stage X Precipitation	
Well No.	to River	F	Prob. > F	F	Prob. > F	F	Prob. > F
ElmC_U_1[1]	100	14.579108	0.000001	12.726322	0.000007	11.038354	< 0.000001
ElmC_U_2[1]	1,500	2.415029	0.092952	0.058394	0.943301	1.568519	0.149440
ElmC_U_3[1]	6,300	9.253776	0.000147	18.456333	< 0.000001	14.56653	< 0.000001
ElmC_U_4	17,300	1.522338	0.222283	2.612478	0.077420	0.761611	0.552211
ElmC_D_1[1]	2,700	0.024161	0.976136	16.746450	< 0.000001	6.938921	0.000008
ElmC_D_2[1]	6,900	2.346608	0.099614	7.906073	0.000568	8.177956	< 0.000001
ElmC_D_3[1]	12,100	2.511763	0.083845	3.652362	0.027787	3.032194	0.004840
ElmC_D_4[1]	17,400	3.777741	0.024630	1.222484	0.296828	2.422443	0.021378

Multiple regression -

		Regression		Stage		Precipitation	
Well No.	R^2	F	Prob. > F	t	Prob. > t	t	Prob. > t
ElmC_U_1	0.359868	53.125697	< 0.000001	7.72911	< 0.00001	5.11071	< 0.00001
ElmC_U_2	0.002744	0.202216	0.817145	0.23078	0.81781	0.51998	0.60386
ElmC_U_3	0.302836	41.26643	< 0.000001	4.33917	0.00002	6.93336	< 0.00001
ElmC_U_4	0.084908	5.984710	0.003269	-1.53094	0.12823	-2.62986	0.00958
ElmC_D_1	0.474492	33.408036	< 0.000001	0.08058	0.93599	7.84256	< 0.00001
ElmC_D_2	0.094063	7.060373	0.001210	1.85035	0.06643	2.74246	0.00692
ElmC_D_3	0.092300	9.660138	0.000101	3.59754	0.00041	1.78904	0.07520
ElmC_D_4	0.041788	4.143023	0.017332	1.73535	0.08430	1.92142	0.05617

[1] Empty cell prevents partitioning sum of squares; F-value under stage X precipitation is for the combined model, not the interaction. Stage and precipitation are run as covariates.

Table 6. Multivariate Analysis of the daily change in ground water surface elevation on stage change and precipitation at the Overton Transect

A. Two-way Analysis of Variance

Dependent Variable	Distance to River	Stage		Precipitation		Stage X Precipitation	
		F	Prob. > F	F	Prob. > F	F	Prob. > F
Ovtn_U_1	5,000	0.763036	0.469741	1.338054	0.268386	0.587111	0.672930
Ovtn_U_2	11,200	3.869687	0.022593	4.982804	0.007814	0.503685	0.733066
Ovtn_U_3	15,500	0.729727	0.484115	0.138400	0.870886	0.095742	0.983649
Ovtn_D_1	6,000	4.233198	0.016301	5.808187	0.003729	2.209032	0.070758
Ovtn_D_2	11,000	4.368678	0.014016	5.799995	0.003612	1.623767	0.170087
Ovtn_D_3	17,500	2.428503	0.093625	1.515453	0.224972	1.146579	0.339503

B. Multiple regression -

Well No.	R^2	Regression F	Prob. > F	Stage t	Stage Prob. > t	Precipitation t	Precipitation Prob. > t
Ovtn_U_1	0.032042	1.373742	0.258853	0.13234	0.89503	1.62407	0.10815
Ovtn_U_2	0.115503	12.340343	0.000009	3.51177	0.00056	2.97935	0.00327
Ovtn_U_3	0.015822	1.036896	0.357489	1.42821	0.15565	-0.12849	0.89796
Ovtn_D_1	0.134113	14.636584	0.000001	1.55307	0.12208	4.90951	< 0.00001
Ovtn_D_2	0.135567	14.820206	0.000001	2.42163	0.01640	4.48251	0.00001
Ovtn_D_3	0.103157	5.80864	0.004094	2.77343	0.00661	1.57012	0.11952

Table 7. ANOVA and multiple regressions between change in WSE and precipitation and gage readings

		ANOVA			Multiple Regression	
Transect	Well No.	Stage change	Precipitation	Interaction	Stage change	Precipitation
Overton	Ovtn-U-1					
	Ovtn-U-2	Significant	Significant		Significant	Significant
	Ovtn-U-3					
	Ovtn-D-1	Significant	Significant			Significant
	Ovtn-D-2	Significant	Significant		Significant	Significant
	Ovtn-D-3				Significant	
Elm Creek	ElmC-U-1	Significant	Significant		Significant	Significant
	ElmC-U-2					
	ElmC-U-3	Significant	Significant		Significant	Significant
	ElmC-U-4					Significant
	ElmC-D-1		Significant			Significant
	ElmC-D-2		Significant			Significant
	ElmC-D-3		Significant		Significant	
	ElmC-D-4	Significant				
Minden	Mndn-U-1	Significant	Significant		Significant	Significant
	Mndn-U-2		Significant			Significant
	Mndn-U-3					
	Mndn-U-4					Significant
	Mndn-D-1	Significant	Significant		Significant	Significant
	Mndn-D-2	Significant			Significant	
	Mndn-D-3					
Alda	Alda-U-1	Significant		Significant	Significant	Significant
	Alda-U-2		Significant	Significant	Significant	Significant
	Alda-U-3	Significant		Significant	Significant	Significant
	Alda-U-4					
	Alda-D-1	Significant			Significant	Significant
	Alda-D-2	Significant	Significant		Significant	Significant
	Alda-D-3	Significant	Significant	Significant	Significant	Significant
Total	28 wells	14	14	4	15	18

NOTE - 12 of the interactions cannot be evaluated because of empty cells

The multiple regressions show results similar to those of the ANOVA, although there are a few additions to the list of significant wells. With one exception, all of the wells that show a significant relationship between the ΔWSE and precipitation in the ANOVA's show a significant relationship in the multiple regressions. The ANOVA's showed 14 wells with significant relationships between ΔWSE and rising and falling gages and likewise 14 between WSE and precipitation. The multiple regressions showed 15 wells with significant relationships between change in WSE and rising and falling gages and 18 between WSE and precipitation (Table 7).

Recall from Table 2 that the correlations between WSE and gage height and precipitation and the equivalent correlations between the daily changes in WSE, gage height, and precipitation varied somewhat among the transects. To explore this further, a set of physical measurements for the wells and gages were developed and evaluated against the magnitude of the various correlation coefficients. The physical data for the wells are summarized in Table 8; the gage data are summarized in Table 9. To complete the picture, total precipitation at each well is plotted on Figure 2.

The physical data for the wells consist of the distance of the well to the Platte River, the ground surface elevation of the well, the minimum, median, and maximum WSE in the well, the range in WSE in the well (maximum less the minimum WSE), the difference between the interpolated gage elevation and the minimum, median, and maximum WSE, and the number of WSE observations in the well. This latter measurement is included because some of the wells do not have observations in the earlier part of the study period, some do not have observations in the later months of the study period, and some are missing both the early and later months; this has the potential to affect the correlations. The gage information consists of a measure of the distance downstream and an estimate of the elevation of the river at the transect location.

Correlations of the correlation coefficients (r) for WSE with GH and precipitation with the physical data are shown in Table 10. Significant correlations are highlighted and the associated probabilities are shown in the table.

The gage variables (elevation and distance downstream) both correlate similarly with the r's for WSE and ΔWSE with GH. Those are the only r-values that correlate significantly with the gage variables.

The variable "transect number" is not shown in either Table 8 or Table 9. The transect number is simply a way of transforming the transect names by assigning the number 1 through 4 from upstream to downstream (Overton to Alda). This correlates with the r's for each of the WSE and ΔWSE correlations with GH only (Table 10). This would indicate that the r-values for WSE and ΔWSE with GH increase as transect number increases, while the other correlations with transect show no downstream trend. These results are consistent with the previous correlations for the gage variables.

Table 8. Summary of physical data on wells

Transect	Well	Well ID	Distance from River	Ground Surf. Elev.	Ground Water Surface Elevations		
					Minimum	Median	Maximum
Overton	U 1	092030DDD	5,000	2346.7	2338.56	2340.58	2343.13
	U 2	092020CCB	11,200	2353.3	2341.75	2344.97	2348.34
	U 3	092017CCC	15,500	2354.1	2344.77	2346.02	2354.10
	D 1	092033BBB	6,000	2341.0	2331.98	2333.83	2336.43
	D 2	092028BBB	11,000	2344.8	2334.47	2337.43	2340.77
	D 3	092016CBC	17,500	2347.3	2338.91	2340.14	2343.16
Elm Creek	U 1	081908DDA	100	2290.8	2285.75	2286.20	2286.92
	U 2	081917AAA	1,500	2294.6	2284.53	2292.79	2294.60
	U 3	081916CCC	6,300	2301.0	2289.82	2291.25	2292.27
	U 4	081933BBB	17,300	2358.8	2319.07	2324.58	2329.97
	D 1	081915BBB	2,700	2283.3	2277.21	2280.04	2283.30
	D 2	081915CCC	6,900	2289.0	2283.23	2284.32	2286.10
	D 3	081927BBB	12,100	2311.4	2328.06	2329.04	2332.75
	D 4	081927CCC	17,400	2326.2	2343.28	2345.69	2348.83
Minden	U 1	081404CBB	700	2081.4	2074.21	2075.84	2077.36
	U 2	081404BBB	3,800	2079.6	2070.79	2074.26	2076.41
	U 3	091432AAB	9,000	2087.3	2075.47	2076.64	2078.44
	U 4	091420DDD	14,200	2088.9	2073.43	2075.09	2076.57
	D 1	081403CBB	100	2071.7	2066.64	2068.37	2070.43
	D 2	091434BBB	7,700	2080.8	2066.71	2068.08	2069.56
	D 3	091428AAA	13,000	2081.9	2066.73	2068.82	2070.53
Alda	U 1	101029DAA	50	1912.7	1903.44	1904.34	1906.10
	U 2	101028BBC	3,000	1911.1	1901.93	1903.36	1906.09
	U 3	101020AAA	8,000	1905.3	1897.23	1898.74	1901.76
	U 4	101005AAB	23,300	1910.1	1890.09	1892.57	1894.73
	D 1	101022CCB	1,200	1898.7	1894.96	1896.56	1897.72
	D 2	101022BBB	6,500	1901.2	1891.28	1893.24	1896.37
	D 3	101009DDD	11,000	1896.6	1886.76	1887.87	1890.29

Table 8 (continued)

Transect	Well	Distance from River	WSE Range	Elevation difference from gage Minimum	Median	Maximum	Number of Obs.
Overton	U 1	5,000	4.57	5.56	7.58	10.13	87
	U 2	11,200	6.59	8.74	11.97	15.34	193
	U 3	15,500	9.33	11.77	13.02	21.10	133
	D 1	6,000	4.45	4.98	6.83	9.43	193
	D 2	11,000	6.30	7.47	10.43	13.77	193
	D 3	17,500	4.25	11.91	13.14	16.16	105
Elm Creek	U 1	100	1.17	-1.25	-0.80	-0.08	193
	U 2	1,500	10.07	-2.47	5.79	7.60	152
	U 3	6,300	2.44	2.82	4.25	5.27	194
	U 4	17,300	10.90	32.07	37.58	42.97	133
	D 1	2,700	6.09	-2.79	0.04	3.30	157
	D 2	6,900	2.86	3.23	4.32	6.10	140
	D 3	12,100	4.69	48.06	49.04	52.75	194
	D 4	17,400	5.56	63.28	65.69	68.83	194
Minden	U 1	700	3.15	2.21	3.84	5.36	132
	U 2	3,800	5.62	-1.22	2.26	4.41	159
	U 3	9,000	2.96	3.47	4.64	6.43	195
	U 4	14,200	3.13	1.43	3.09	4.57	195
	D 1	100	3.79	1.64	3.37	5.43	140
	D 2	7,700	2.85	1.71	3.08	4.56	195
	D 3	13,000	3.80	1.73	3.82	5.53	195
Alda	U 1	50	2.66	1.44	2.34	4.10	195
	U 2	3,000	4.15	-0.07	1.36	4.09	195
	U 3	8,000	4.52	-4.77	-3.26	-0.24	195
	U 4	23,300	4.63	-11.91	-9.43	-7.27	133
	D 1	1,200	2.76	0.96	2.56	3.72	140
	D 2	6,500	5.08	-2.72	-0.76	2.37	195
	D 3	11,000	3.53	-7.24	-6.13	-3.71	195

Table 9. Gage information summary

Transect	Location	Downstream	Gage-Elev
Overton	upstream	0	2333
	downstream	1	2327
Elm Creek	upstream	24	2287
	downstream	25	2280
Minden	upstream	54	2072
	downstream	55	2065
Alda	upstream	60	1902
	downstream	61	1894

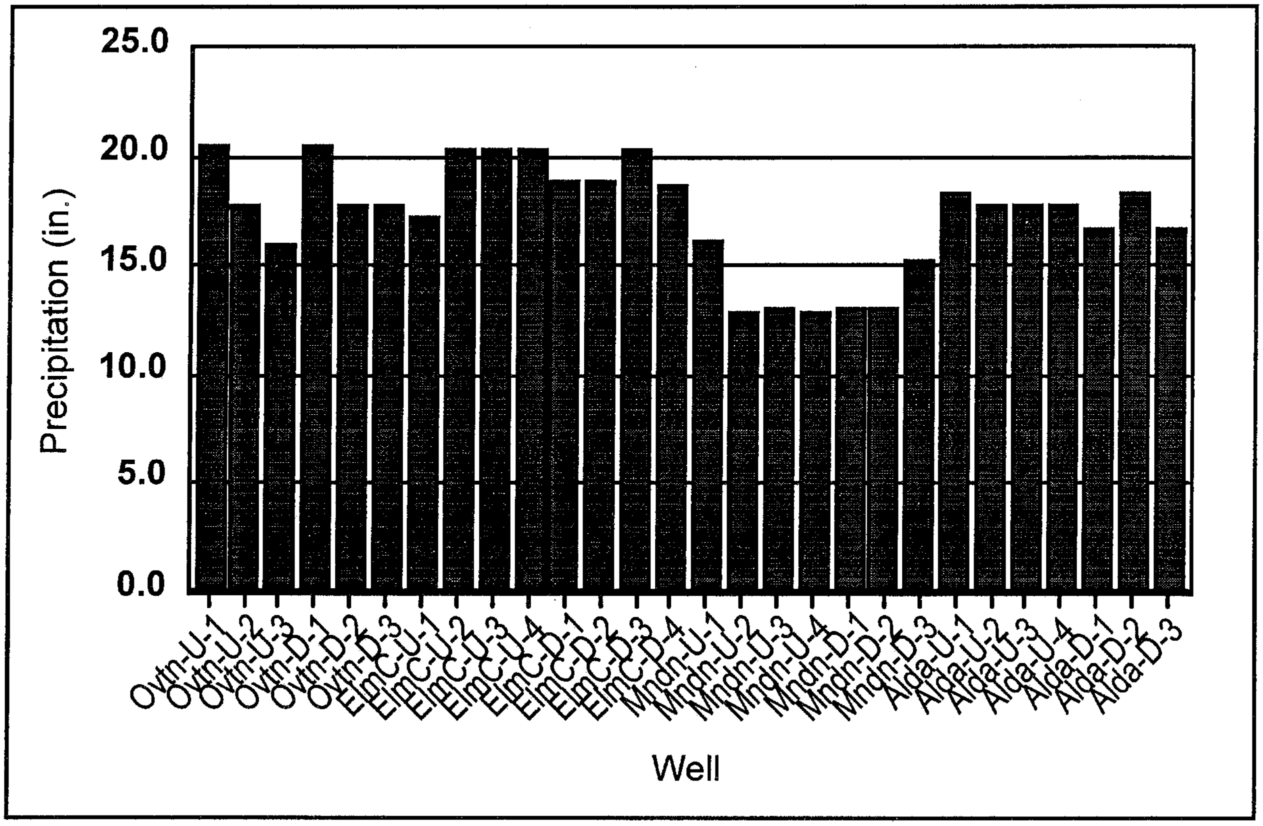


Figure 2: Total precipitation between March 11 and September 21, 1999, at each of the Platte River observation wells

Table 10. Correlations between well water correlations with gage data and precipitation as related to physical characteristics of the transects

	Dependent Variable:	Ground water surface elevation			Change in water surface elevation		
Independent	Statistic	r with GH	r with ΔGH	r with rain	r with ΔGH	r with GH	r with rain
Gage elevation	Corr. Coef. (r)	-0.521561	0.228202	0.133420	-0.322450	-0.457192	-0.168663
	Prob. > r	0.004422	0.242819	0.498507	0.094230	0.014445	0.390914
Distance down-stream	Corr. Coef.	0.536231	-0.209334	-0.104801	0.314603	0.479256	0.173201
	Prob. > r	0.003267	0.285029	0.595603	0.102990	0.009868	0.378103
Transect number	Corr. Coef.	0.538952	-0.199776	-0.098509	0.310628	0.459468	0.172073
	Prob. > r	0.003084	0.308088	0.617981	0.107653	0.013904	0.381263
Minimum elevation difference	Corr. Coef.	-0.180444	-0.137067	-0.279762	-0.212449	-0.048607	-0.371460
	Prob. > r	0.358167	0.486731	0.149347	0.277758	0.805974	0.051625
Median elevation difference	Corr. Coef.	-0.220391	-0.158400	-0.293300	-0.257097	-0.062778	-0.402210
	Prob. > r	0.259762	0.420784	0.129828	0.186590	0.750972	0.033854
Maximum elevation difference	Corr. Coef.	-0.233528	-0.161951	-0.302136	-0.277534	-0.077920	-0.425473
	Prob. > r	0.231698	0.410310	0.118137	0.152750	0.693496	0.023993
Ground surface elevation	Corr. Coef.	-0.526447	0.196536	0.088192	-0.347799	-0.439142	-0.215371
	Prob. > r	0.004004	0.316161	0.655406	0.069744	0.019389	0.271046
Distance from river	Corr. Coef.	-0.514527	-0.514359	-0.405328	-0.543138	0.293677	-0.616484
	Prob. > r	0.005089	0.005106	0.032370	0.002820	0.129313	0.000477
Minimum WSE	Corr. Coef.	-0.515077	0.206393	0.103137	-0.327302	-0.441886	-0.194065
	Prob. > r	0.005034	0.292004	0.601487	0.089103	0.018559	0.322405
Median WSE	Corr. Coef.	-0.517646	0.203924	0.101454	-0.330730	-0.442213	-0.196702
	Prob. > r	0.004784	0.297943	0.607464	0.085609	0.018462	0.315745
Maximum WSE	Corr. Coef.	-0.518155	0.202471	0.099337	-0.332565	-0.442571	-0.199679
	Prob. > r	0.004735	0.301472	0.615019	0.083783	0.018356	0.308328
Number of observations	Corr. Coef.	-0.062010	0.000416	-0.116923	0.172921	0.305527	0.181447
	Prob. > r	0.753924	0.998325	0.553498	0.378886	0.113864	0.355458
Range in elevation	Corr. Coef.	-0.452613	-0.230585	-0.262259	-0.551864	-0.232025	-0.526463
	Prob. > r	0.015588	0.237801	0.177590	0.002331	0.234801	0.004003

Number of observations: 28

The minimum WSE difference from the gage elevation for each well does not correlate with any of the r-values. The median and maximum WSE difference show significant inverse correlations only with the r-values for the correlations between ΔWSE and precipitation. In other words as the difference between the WSE and the gage elevation increases, the smaller the r-values for the correlations between ΔWSE and precipitation become.

The number of observations does not correlate with any of the r-values. This would seem to indicate that the variation in the number of WSE readings from the various wells and the timing of the measurement does not affect the resulting correlations between WSE or ΔWSE and GH (or ΔGH) or precipitation.

The range in WSE in the wells correlates with 4 of the 6 sets of r-values for the relationship between WSE and GH or precipitation. These significant correlations include the r-values for the relationships between WSE with GH, WSE with precipitation, ΔWSE with ΔGH, and ΔWSE with precipitation. All of the correlations are inverse indicating the greatest r-values are associated with wells that have a narrow range in WSE during the monitoring period.

There are other ways of trying to evaluate factors that may affect the r-values for the correlations. Table 11 shows the results of an attempt to isolate factors based on cluster analysis. The results show that the best variable with which to create the clusters is the distance from the river. Cluster 1 includes all wells that are <9000' from the river, while cluster 2 includes all wells that are >11,000' from the river. Figure 3 shows a comparison of the distributions of the r-values in each of the clusters. As an example, for the r-values for the relationship between WSE and GH, the mean r-value for cluster 1 is 0.62, while cluster 2 shows a mean r-value of 0.4; the range of r-values in cluster 1 Is from -0.02 to 0.98 and completely overlaps the range of cluster 2 (Table 11). This result indicates that, in general, the wells less than 1½ miles from the river show a much better correlation between WSE and GH than those farther from the river, an entirely expected result.

The other factors being evaluated are also summarized by cluster group in table 11. The variables that differ the most on the average in the two cluster groups are the difference between the median WSE and the gage elevation (median difference in Table 11), well number, and the elevation range.

Discriminant analysis on 4 of the correlations was used to evaluate how well the cluster analysis actually performed. The results are summarized in Table 12. Table 12A shows the mean r-values for the cluster groups along with the F-values and their associated statistical probabilities. Only 2 of the 4 discriminant analyses are statistically significant, including the one for the r's for WSE and GH and for ΔWSE with precipitation. The application of the significant discriminant functions allows for a 71

Table 11. Summary of Cluster Analysis Results

	Cluster 1: Summary Statistics				Cluster 2 : Summary Statistics			
Variable	Minimum	Mean	Maximum	St. Dev.	Minimum	Mean	Maximum	St. Dev.
Distance to the river (ft.)	50	4,032	9,000	3,096	11,000	14,864	23,300	3,817
r: WSE & GH	0.19	0.62	0.98	0.21	0.20	0.40	0.62	0.15
r: WSE & ΔGH	-0.23	-0.01	0.23	0.13	-0.19	-0.11	0	0.06
r: WSE & RAIN	-0.02	0.12	0.51	0.12	-0.12	0.04	0.12	0.07
r: ΔWSE & ΔGH	0.03	0.31	0.81	0.23	-0.19	0.16	0.30	0.14
r: ΔWSE & GH	-0.16	0.10	0.44	0.14	0.03	0.17	0.42	0.12
r: ΔWSE & RAIN	0.05	0.34	0.73	0.16	-0.26	0.14	0.33	0.15
Gage elevation (ft.)	1894	2113	2333	173.19	1894	2190.91	2333	174.4
Distance downstream (mi)	0	41	61	21.57	0	27.82	61	25.65
Transect number	1	2.76	4	1.03	1	2.18	4	1.17
Median difference (ft.)	-3.26	2.79	7.58	2.85	-9.43	17.48	65.69	23.49
Ground surface elev. (ft.)	1898.7	2122.13	2346.7	174.18	1896.6	2215.76	2358.8	185.23
Well number	1	1.71	3	0.77	2	3.18	4	0.75
Maximum WSE (ft.)	1896.37	2117.82	2343.13	174.61	1890.29	2211.82	2354.1	190.34
Elevation range (ft.)	1.17	4.07	10.07	2	3.13	5.7	10.9	2.46

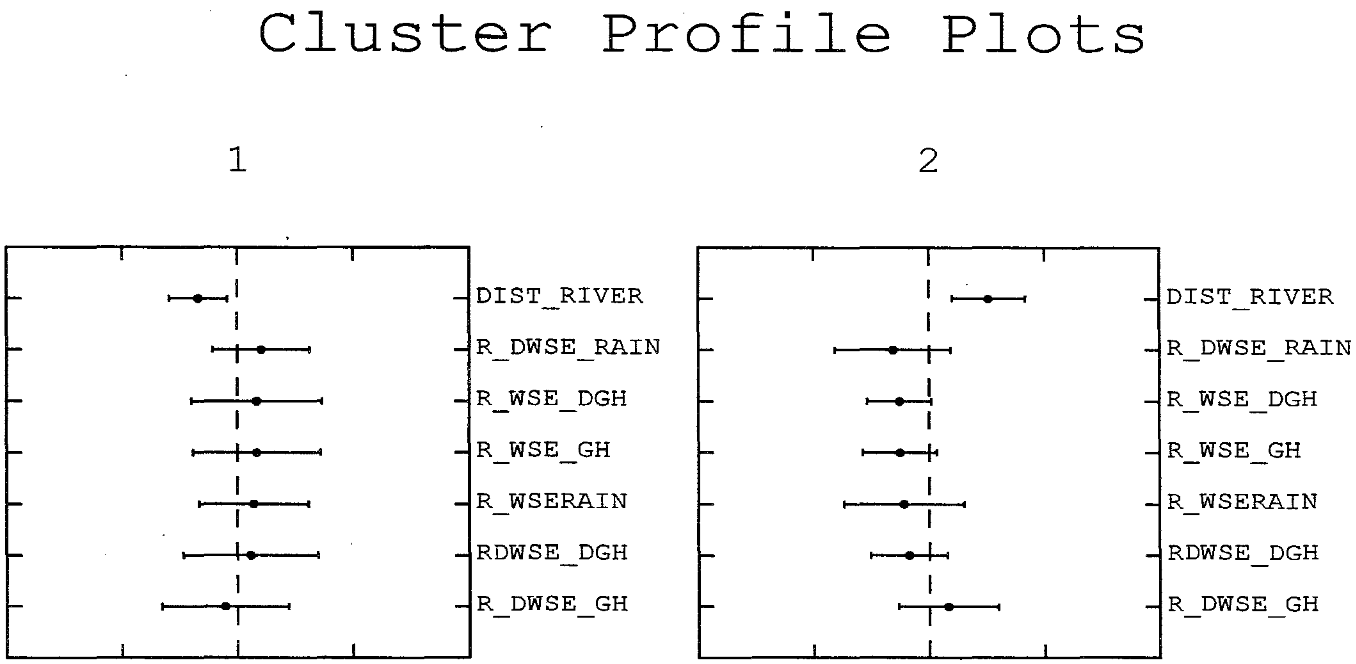


Figure 3: Distribution of r-values for 6 sets of correlations as related to distance of wells from the river

Table 12. Discriminant analysis of cluster groups based on r-values

A. Summary statistics

Correlation		Correlation		Discriminant analysis	
Variable 1	Variable 2	r_1	r_2	F	Prob. > F
WSE	GH	0.623777	0.396691	9.9157	0.0041
WSE	Rain	0.119905	0.044784	3.6889	0.0658
ΔWSE	ΔGH	0.306637	0.162895	3.4376	0.0751
ΔWSE	Rain	0.338866	0.141413	10.1935	0.0037

B. Classification

Correlation		Classification functions[1]				
Variable 1	Variable 2	a-group 1	b-group 1	a-group 2	b-group 2	% classified
WSE	GH	17.959227	-6.294428	8.119046	-2.303522	71
WSE	Rain	11.736227	-1.396764	4.383390	-0.791299	68
ΔWSE	ΔGH	7.638947	-1.864339	4.058056	-1.023667	57
ΔWSE	Rain	13.266050	-2.940854	5.536095	-1.084586	79

[1] Equation: $y = ax + b$, where x = r-value and y = discriminant function

and 79 percent correct level of classification. The classification is performed by applying the equations, which are of the form of 2 linear regressions. The result with the higher value of the discriminant function is the one used to classify the input variable into a category.

One further statistical technique, principal components analysis (PCA), was used to evaluate interrelationships among the physical variables and the r-values from the various correlations. PCA does not provide any means of prediction, but it does show which of the input variables show the greatest degree of association. PCA is performed by creating a correlation matrix of the input variables; a vector analysis is performed on the correlation matrix. The variance is then partitioned among the vectors (components). The components that explain the majority of the variance are then evaluated to see which variables contribute significantly. PCA results for the unmodified WSE correlations are shown in Table 13, and those for the ΔWSE correlations are shown in Table 14.

Component 1 (Table 13) explains about 45 percent of the total variance (S^2). Seven of the 11 variables load significantly (value > 0.5) on component 1, including the r for the WSE-GH correlation. The r for the WSE-GH correlation and the transect number both load inversely (negative value) on the component relative to the other 5 variables. This would mean that the r for the WSE-GH correlation generally increases as the transect number increases, as was earlier shown in Table 10. The correlations were previously shown in Table 1; they are graphically presented on Figure 4 which includes a trend line to illustrate the relationship between the r-value and transect number. Alternatively the r for the WSE-GH correlation would generally decrease as the other variables

Table 13. Principal components for WSE correlations and independent variables shown in Table 8

	Components		
Variables	1	2	3
Ground Surface Elev.	0.970542	0.193307	0.057632
Median WSE	0.968271	0.203452	0.074556
Gage Elev.	0.959216	0.240850	0.054117
Transect No.	-0.944253	-0.213464	-0.005265
r: WSE & GH	-0.645733	0.369578	-0.164158
Gage/WSE Diff.	0.588887	-0.300147	0.258265
Elev. - range	0.557922	-0.357350	-0.358030
r: WSE & ΔGH	0.040681	0.901461	0.122488
r: WSE & rain	-0.027496	0.835694	-0.033434
Distance to river	0.364245	-0.689705	-0.009012
No. of Obs.	-0.269455	-0.130272	0.912820
S^2 Explained (%)	45.2	23.1	9.8

Table 14. Principal components for change in WSE correlations and independent variables shown in Table 8

	Components		
Variables	1	2	3
Ground Surface Elev.	0.952738	-0.231848	0.142391
Median WSE	0.948427	-0.245865	0.162779
Gage Elev.	0.936988	-0.280756	0.131406
Transect No.	-0.920101	0.275474	-0.079541
Elev. - range	0.609730	0.350460	-0.374494
Gage/WSE Diff.	0.604535	0.251585	0.420952
r: ΔWSE & ΔGH	-0.525893	-0.563249	0.204799
r: ΔWSE & rain	-0.415366	-0.764630	0.095931
Distance to river	0.375742	0.742443	0.105101
r: ΔWSE & GH	-0.413160	0.644901	0.337979
No. of Obs.	-0.337838	0.063650	0.783804
S^2 Explained (%)	46.8	21.2	10.7

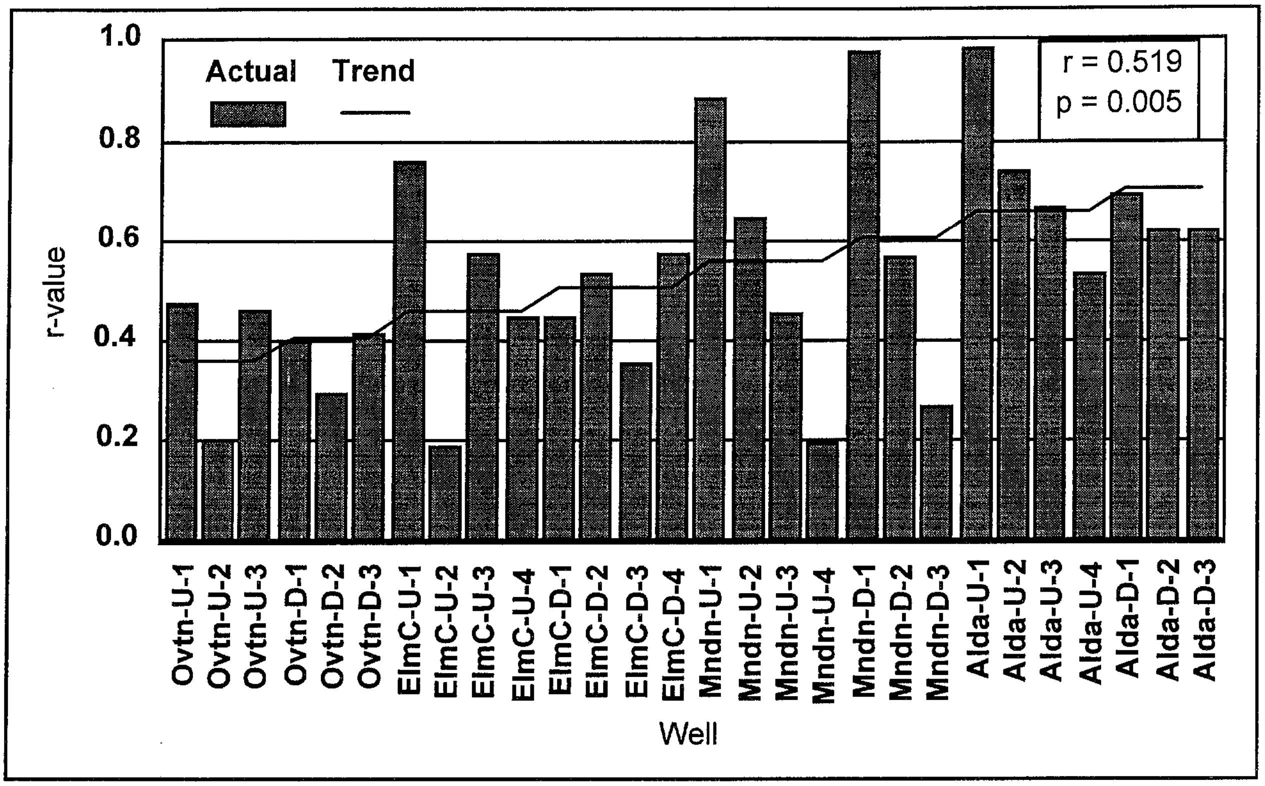


Figure 4: Trend in r-values for the correlation between WSE and GH by transect

(ground surface elevation, median WSE, gage elevation, and WSE range) increase, all of which were also shown to be significant in Table 10.

The other 2 WSE r-values load significantly on component 2 (Table 13) with distance to the river. Only the number of observation loads significantly on component 3, which seems to indicate that the differences in the number of observations in the WSE data set has no effect on the results of this analysis.

Table 14 shows the similar results for the PCA for the ΔWSE correlations. Component 1 once again explains about 47 percent of the total variance in the correlation matrix. All but 3 of the variables load significantly on component 1 (Table 14). Transect number once again loads inversely along with 2 sets of the r-values (ΔWSE & ΔGH and ΔWSE & rain). Both of these sets of r-values also load significantly on component 2, along the with the 3rd of the r-values and distance to the river. As in Table 14, the number of observations loads significantly on component 3 by itself.

Table 15 summarizes the PCA for all of the r-values for both WSE and ΔWSE. The results are similar to those in tables 13 and 14. Most variables load on component 1, which explains about 40 percent of the variance. Several of the r-values load significantly on component 2, along with distance to the river. The number of observations loads on component 3 by itself. What is remarkable about the PCA in

Table 15. Principal components for WSE & change in WSE correlations and independent variables

Variables	Components			
	1	2	3	4
Ground Surface Elev.	-0.914504	0.343241	0.130059	0.067445
Median WSE	-0.908083	0.355730	0.147876	0.081717
Gage Elev.	-0.895092	0.386307	0.131267	0.033646
Transect No.	0.883770	-0.365166	-0.091092	0.003760
r: WSE & GH	0.704086	0.284035	-0.235403	0.552583
Elev. - range	-0.641101	-0.223623	-0.408442	-0.010238
r: WSE & ΔGH	0.622783	0.442052	0.150118	0.447105
Gage/WSE Diff.	-0.600809	-0.149322	0.254157	0.559937
r: ΔWSE & rain	0.502581	0.710042	0.203226	-0.254566
r: WSE & ΔGH	0.091142	0.897156	0.015798	0.015415
r: WSE & rain	0.168522	0.815276	0.000325	-0.363449
r: ΔWSE & GH	0.296026	-0.750662	0.326189	-0.083147
Distance to river	-0.470090	-0.605194	0.047500	-0.098031
No. of Obs.	0.285949	-0.144190	0.826927	-0.030324
S^2 Explained (%)	39.8	27.1	8.6	7.5

Table 15 is component 4. The only variables that load significantly on component 4 are the r for the correlation for WSE with GH and Gage/WSE Diff, both of which showed a relationship to many of the physical variables on component 1. This result would indicate that in addition to all of the relationships to the physical variables, there is a significant relationship independent of the others.

So what does this all mean, if anything? To answer this, a review of Table 8, which summarizes physical data, may provide some insight.

The final results of the PCA and discriminant analysis indicate that the distance from the river provides a significant influence on the relationships among the WSE, GH, and precipitation. There are no wells in the Overton transect immediately adjacent to the river. The nearest well to the river in that transect is nearly a mile away (Table 8). In the other transects there is only one of the number 1 wells that is more than ¼ mile from the river (Elm Creek D 1).

The range is WSE and the minimum, median, and maximum differences between the WSE in the wells and the gage elevation all show a general decrease in the downstream direction (Table 8). Several of these maximum differences in the Alda transect are negative, *i.e.* the WSE is always below the gage elevation. Because water generally flows from a higher elevation to a lower one, it would be expected that the water would flow from the river to the ground water under these circumstances. However, the odd thing about the negative differences is that the wells that exhibit them are the farthest ones from the river. All of the transects run north to south. With the exception of the Alda transect, which runs at an oblique angle to the river, the transects lie generally perpendicular to the river. The farthest wells in the Alda transect (3rd wells in the upstream and downstream transects) are actually located very near and probably within the influence of a north channel of the Platte River. Any hydraulic connection to the river by the number 3 wells and the river is probably through this north channel, rather than the channel on which the gage is located. According to the topographic map of the area, the north channel contains numerous abandoned oxbows; it is also shown as being intermittent. Under these circumstances the channel probably only carries water during higher flow events; nevertheless it would be expected to have shallow ground water in its alluvial aquifer that could influence the nearby wells.

The 4th well in the upstream segment of the Alda transect is located to the north of the Wood River. Nevertheless its WSE is still correlated with the GH in the Platte River at the Grand Island gage (Table 1). This would seem to indicate that the Platte River and its interconnected ground water system extend well away from the mainstem of the river.

There is also a variation in precipitation within the study area. Figure 2 showed the total precipitation at each of the wells during the study period. The Minden wells show a much lower precipitation than the other wells (Table 16C). This was evaluated using Fisher's least significant difference test (LSD). The LSD is a *post-hoc* test for a Oneway ANOVA. The LSD results are also shown in Table 16 and show that the precipitation in the Minden transect was significantly lower than that in any of the other 3 transects. The LSD also shows that the precipitation in the Elm Creek transect was significantly greater than that in the Overton transect. Precipitation in the Alda transect did not differ significantly from that in either the Overton or Elm Creek transects. This variation in precipitation did not affect any of the relationships between WSE, GH, and precipitation discussed above, at least not in a way that would show in the number of observations.

The above indicates that there are interrelationships among the physical variables. These can be evaluated by the correlation matrix in Table 17. Once again significant correlations are highlighted. The table also includes the correlations for the r-values that were discussed earlier (Table 10). These will not be revisited here.

The first 3 columns in Table 17 includes variables that are various measures of a downstream progression. As the river flows downstream, the gage elevations decrease, the distance from the fixed upstream point increases, as does the transect number. The first set of significant correlations is with the range in WSE in the wells. This was noted above, as was the difference between the well minimum and maximum WSE. The 3 measures of well WSE also correlate significantly with the 3 variables that reflect the downstream progression. Because of this interrelationship, any of the 3

Table 16. Post Hoc test of precipitation - using least squares means

A. Matrix of pairwise mean differences, using model mean square error of 1.646 with 24 df.:

	Overton	Elm Creek	Minden
Elm Creek	1.659821		
Minden	-3.951429	-5.611250	
Alda	0.741905	-0.917917	4.693333

B. Fisher's Least-Significant-Difference Test - Matrix of pairwise comparison probabilities:

	Overton	Elm Creek	Minden
Elm Creek	0.019672		
Minden	0.000006	< 0.000001	
Alda	0.309001	0.197744	0.000001

For ANOVA: F = 26.549726; *d.f.* = 3, 24; probability > F < 0.000001

C. Average of the total precipitation at each well in the transect (inches)

	Overton	Elm Creek	Minden	Alda
Mean precipitation by transect	18.43	19.35	13.74	17.69

Table 17. Complete correlation matrix among r-values and among physical variables - Statistically significant correlations are highlighted

		r ΔWSE Rain	r ΔWSE ΔGH	r WSE GH	r WSE Rain	r Month	r Month & Day
Elev. range	r	-0.526463	-0.551864	-0.452613	-0.262259	-0.108769	-0.105539
	Prob. > r	0.004003	0.002331	0.015588	0.177590	0.581667	0.593000
No of obs.	r	0.181447	0.172921	-0.062010	-0.116923	0.416626	0.414460
	Prob. > r	0.355458	0.378886	0.753924	0.553498	0.027423	0.028320
Max WSE	r	-0.199679	-0.332565	-0.518155	0.099337	0.042338	0.042404
	Prob. > r	0.308328	0.083783	0.004735	0.615019	0.830616	0.830355
Med WSE	r	-0.196702	-0.330730	-0.517646	0.101454	0.043288	0.043358
	Prob. > r	0.315745	0.085609	0.004784	0.607464	0.826868	0.826596
Min WSE	r	-0.194065	-0.327302	-0.515077	0.103137	0.043919	0.043945
	Prob. > r	0.322405	0.089103	0.005034	0.601487	0.824383	0.824281
Well number	r	-0.602060	-0.513873	-0.422463	-0.521026	-0.154619	-0.153854
	Prob. > r	0.000700	0.005156	0.025119	0.004470	0.432097	0.434408
Distance to river	r	-0.616484	-0.543138	-0.514527	-0.405328	-0.116524	-0.117348
	Prob. > r	0.000477	0.002820	0.005089	0.032370	0.554860	0.552046
Ground surface	r	-0.215371	-0.347799	-0.526447	0.088192	0.034220	0.034319
	Prob. > r	0.271046	0.069744	0.004004	0.655406	0.862754	0.862361
Maximum difference	r	-0.425473	-0.277534	-0.233528	-0.302136	-0.087637	-0.087308
	Prob. > r	0.023993	0.152750	0.231698	0.118137	0.657444	0.658654
Median difference	r	-0.402210	-0.257097	-0.220391	-0.293300	-0.081707	-0.081332
	Prob. > r	0.033854	0.186590	0.259762	0.129828	0.679364	0.680756
Minimum difference	r	-0.371460	-0.212449	-0.180444	-0.279762	-0.076464	-0.076581
	Prob. > r	0.051625	0.277758	0.358167	0.149347	0.698955	0.698516
Transect number	r	0.172073	0.310628	0.538952	-0.098509	-0.096027	-0.095636
	Prob. > r	0.381263	0.107653	0.003084	0.617981	0.626907	0.628316
Distance downstream	r	0.173201	0.314603	0.536231	-0.104801	-0.082305	-0.082141
	Prob. > r	0.378103	0.102990	0.003267	0.595603	0.677139	0.677751
Gage Elev.	r	-0.168663	-0.322450	-0.521561	0.133420	0.052900	0.052938
	Prob. > r	0.390914	0.094230	0.004422	0.498507	0.789203	0.789056
r ΔWSE GH	r	-0.284626	-0.058623	-0.105957	-0.467441	0.054539	0.053958
	Prob. > r	0.142106	0.766990	0.591528	0.012138	0.782825	0.785085
r WSE ΔGH	r	0.589096	0.401810	0.316877	0.729646	0.228898	0.225875
	Prob. > r	0.000973	0.034049	0.100391	0.000011	0.241347	0.247789
r Month & Day	r	0.173695	-0.110130	-0.435477	0.156532	0.999944	
	Prob. > r	0.376722	0.576921	0.020546	0.426352	< 0.000001	
r Month	r	0.178370	-0.106434	-0.433664	0.160773		
	Prob. > r	0.363813	0.589851	0.021138	0.413769		
r WSE Rain	r	0.800456	0.322002	0.168181			
	Prob. > r	< 0.000001	0.094714	0.392289			
r WSE GH	r	0.387852	0.740929				
	Prob. > r	0.041413	0.000007				
r ΔWSE ΔGH	r	0.520475					
	Prob. > r	0.004520					

Table 17 (continued)

		r WSE ΔGH	r ΔWSE GH	Gage Elev.	Distance downstream	Transect number	Minimum difference
Elev. range	r	-0.230585	-0.232025	0.387232	-0.393671	-0.382235	0.288127
	Prob. > r	0.237801	0.234801	0.041768	0.038203	0.044713	0.137054
No of obs.	r	0.000416	0.305527	-0.244975	0.277387	0.278806	0.052413
	Prob. > r	0.998325	0.113864	0.208958	0.152977	0.150801	0.791100
Max WSE	r	0.202471	-0.442571	0.996769	-0.971499	-0.964810	0.521981
	Prob. > r	0.301472	0.018356	< 0.000001	< 0.000001	< 0.000001	0.004385
Med WSE	r	0.203924	-0.442213	0.996951	-0.971139	-0.964467	0.520346
	Prob. > r	0.297943	0.018462	< 0.000001	< 0.000001	< 0.000001	0.004532
Min WSE	r	0.206393	-0.441886	0.996928	-0.971450	-0.964872	0.520991
	Prob. > r	0.292004	0.018559	< 0.000001	< 0.000001	< 0.000001	0.004473
Well number	r	-0.587785	0.428278	-0.013506	0.047609	0.054775	0.381577
	Prob. > r	0.001005	0.022982	0.945616	0.809885	0.781908	0.045113
Distance to river	r	-0.514359	0.293677	0.157031	-0.188721	-0.190104	0.392094
	Prob. > r	0.005106	0.129313	0.424860	0.336165	0.332570	0.039052
Ground surface	r	0.196536	-0.439142	0.997366	-0.973254	-0.966769	0.499847
	Prob. > r	0.316161	0.019389	< 0.000001	< 0.000001	< 0.000001	0.006760
Maximum difference	r	-0.161951	-0.077920	0.483689	-0.429729	-0.419351	0.991438
	Prob. > r	0.410310	0.693496	0.009114	0.022473	0.026327	< 0.000001
Median difference	r	-0.158400	-0.062778	0.472895	-0.411493	-0.401107	0.995299
	Prob. > r	0.420784	0.750972	0.011042	0.029588	0.034393	< 0.000001
Minimum difference	r	-0.137067	-0.048607	0.452541	-0.394947	-0.385685	
	Prob. > r	0.486731	0.805974	0.015606	0.037526	0.042663	
Transect number	r	-0.199776	0.459468	-0.972644	0.998729		
	Prob. > r	0.308088	0.013904	< 0.000001	< 0.000001		
Distance downstream	r	-0.209334	0.479256	-0.978667			
	Prob. > r	0.285029	0.009868	< 0.000001			
Gage Elev.	r	0.228202	-0.457192				
	Prob. > r	0.242819	0.014445				
r ΔWSE GH	r	-0.723828					
	Prob. > r	0.000013					

Table 17 (continued)

		Median difference	Maximum difference	Ground surface	Distance to river	Well number	Min WSE
Elev. range	r	0.360582	0.410698	0.414748	0.319860	0.271468	0.395957
	Prob. > r	0.059429	0.029936	0.028200	0.097057	0.162297	0.036997
No of obs.	r	0.032317	0.012314	-0.241671	-0.062376	0.139567	-0.229882
	Prob. > r	0.870319	0.950413	0.215359	0.752516	0.478741	0.239273
Max WSE	r	0.541862	0.552431	0.998739	0.187820	0.023879	0.999934
	Prob. > r	0.002898	0.002302	< 0.000001	0.338522	0.904000	< 0.000001
Med WSE	r	0.540202	0.550231	0.998705	0.184653	0.021475	0.999965
	Prob. > r	0.003003	0.002416	< 0.000001	0.346875	0.913627	< 0.000001
Min WSE	r	0.540061	0.550054	0.998562	0.184744	0.020585	
	Prob. > r	0.003012	0.002426	< 0.000001	0.346633	0.917194	
Well number	r	0.388185	0.400335	0.030246	0.862255		
	Prob. > r	0.041224	0.034773	0.878569	< 0.000001		
Distance to river	r	0.391592	0.416948	0.195999			
	Prob. > r	0.039326	0.027292	0.317512			
Ground surface	r	0.521098	0.532483				
	Prob. > r	0.004464	0.003534				
Maximum difference	r	0.996842					
	Prob. > r	< 0.000001					

Table 17 (continued)

		Med WSE	Max WSE	No of obs.
Elev. range	r	0.401766	0.406483	-0.275684
	Prob. > r	0.034070	0.031833	0.155618
No of obs.	r	-0.231108	-0.232178	
	Prob. > r	0.236708	0.234483	
Max WSE	r	0.999972		
	Prob. > r	< 0.000001		

Note - For all correlations in the table, the number of observations: 28

variables could be used in correlation analysis in lieu of the others (see the correlations among the 3 variables at the bottom of the table).

The last 3 columns of the first page of Table 17 include the 3 measures of the difference between the WSE in the wells and the nearest gage. These do show one difference among the different measures, *i.e.* only the maximum difference correlates with the range in WSE in the wells. All 3 measures correlate with the 3 measures of WSE and with well number and distance to the river. The latter 2 measurements are interrelated measures of distance from the river, the 1st is relative while the 2nd is absolute.

The first column of the second page of Table 17 shows the remaining ground surface elevation correlations. The additional significant ground surface correlations include the range in WSE in the wells and each of the WSE measures. The ground surface elevation increases laterally and decreases downstream. The predominant factor seems to be the downstream part of the variation; neither well number nor distance from the river correlates significantly, while all of the measures of downstream progression do.

The next 2 columns of Table 17 include the related distance to the river and well number. There are no additional significant correlations with any of the physical measures.

Table 17 includes 2 sets of r-values from correlations that have not been previously mentioned, those with month and a combination of month and day. These were developed to look at trends over time. The only thing that correlates with these r-values is the number of observations. The results indicate that the more complete WSE records yield better correlations with time than those with fewer data points. This is probably a reflection of the presence or absence of spring data more than anything else.

The only remaining relationships among physical variables that appear on the 3rd page of Table 17 that have not been mentioned before concerns those among the measures of WSE. As can be seen, they are very highly correlated and apparently interchangeable. For this reason only the median was reported in the earlier correlations and PCA results.

The behavior of the WSE data can be generalized from the correlations between the measures of WSE and both those with gage elevation, distance downstream, and transect number and those with distance from the river and well number. The WSE range increases in a downstream direction, although none of the r-values for the correlations are particularly high. The range does not significantly change with distance from the river.

The median difference between the WSE and the gage height (a measure of the normal WSE in the wells relative to the elevation in the river) decreases with distance downstream (Table 8). The data are plotted and the trend is shown on Figure 5. The large spikes on Figure 5 are the 3 and 4 wells on the Elm Creek transect. These represent the WSE in the "ground water mound" to the south of the Platte River. The wells in the Elm Creek transect that are located nearer the river show approximately the same WSE as the wells in the Minden transect. Based on this, the ground water mound has only a localized effect on WSE within the Elm Creek transect. The data for all of the other wells, which are located to the north of the river, show a much more definitive decreasing trend of decreasing WSE in the downstream direction (Figure 6).

The wells in the Alda transect show median WSE's near or below the river elevation. It should be noted that the difference between the WSE in the wells and the river are based on the elevation of "gages" that are located at the end of the transects. The "gages" are monumented, but their elevations were not surveyed in the field because the river remained too high during the monitoring period to permit access. The elevations for these gages were estimated from topographic maps. The elevations for the "gages" may be off by as much as several feet. Therefore, the differences shown may be much greater or much less than those shown on figures 5 and 6. This could be checked once the elevations have been more accurately determined. This information is needed to evaluate whether the downstream reach(es) represent a gaining or losing section of the river. Based on the data currently available, 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 (Table 8).

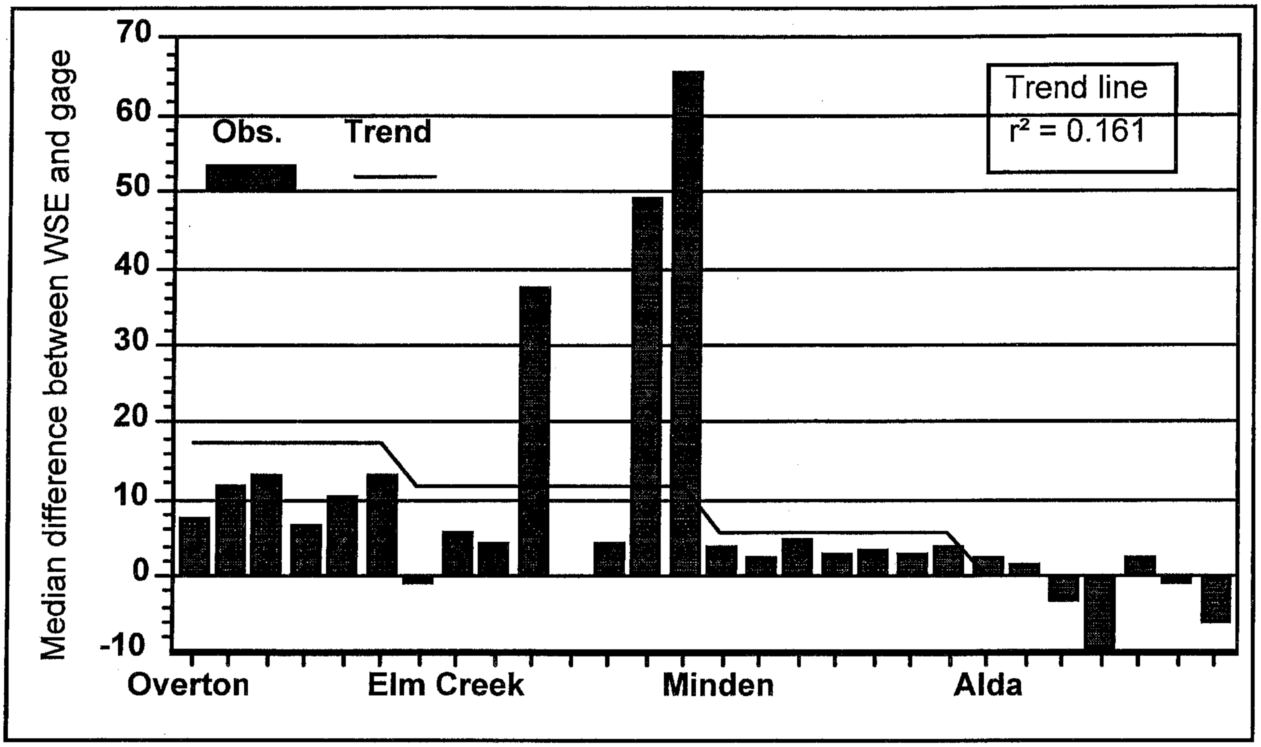


Figure 5: Median difference between WSE and the gage elevation by transect

Correlations with Lagged Data

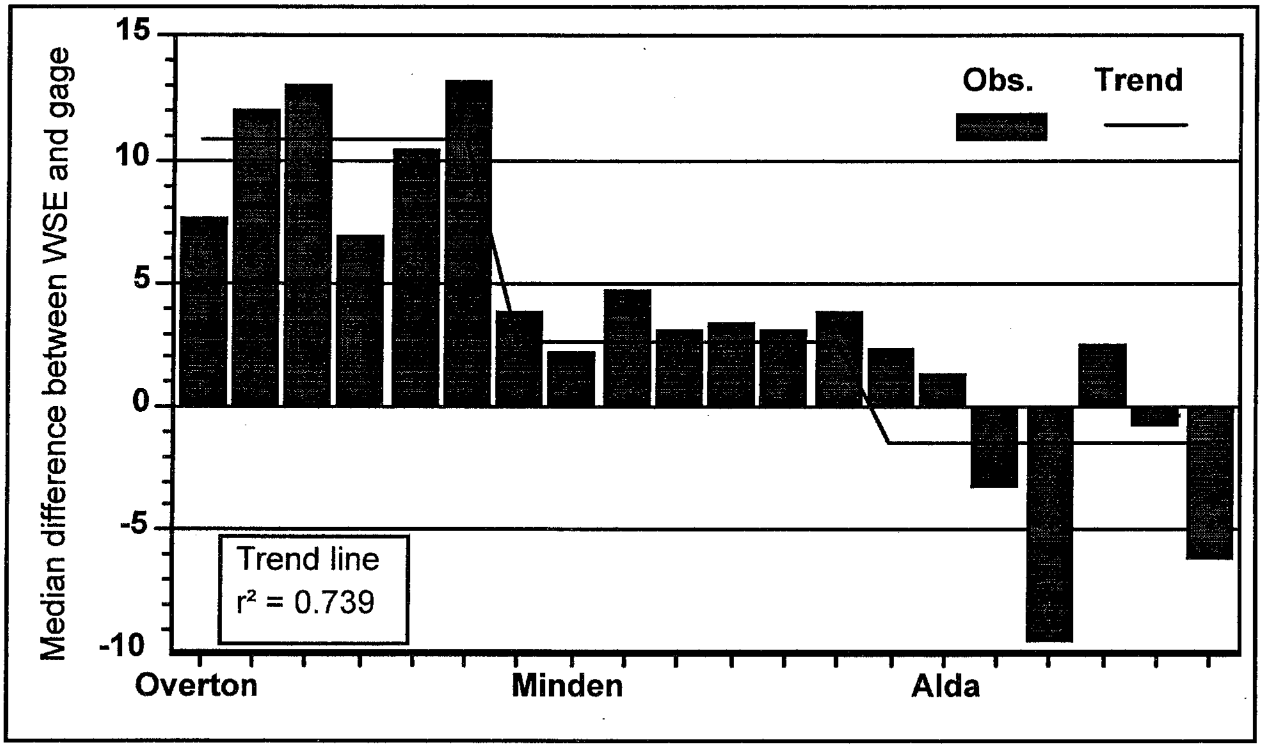


Figure 6: Median difference between WSE and the gage elevation - less Elm Creek transect

Correlations with Lagged Data

The data for the wells, river stages (gage data), and precipitation have been analyzed on a daily basis. Lagged data are developed by looking at the value for one day as it relates to data for the previous day (or days - lagged). Each lag represents a day. Lags of up to 4 days are included in the following analysis.

The river gage data provide the opportunity to present an example of how the lagged data can be used. For example, there is an estimated one-day travel time between each of the gages. Because of the travel time, the data for a downstream gage should correlate better with the previous days flow at the next upstream gage than they would data for any other time-step.

Correlations among the stages (gage heights) at the 3 gaging stations are shown on Table 18. All of the correlations are statistically significant. The Kearney gage is approximately 1-day's river travel downstream from Overton. The best correlation between the two gages should be with a 1-day lag. This is the case as shown in Table 18A. The data are graphically presented on Figure 7. The greater the spread of the data, the lower the r-value. If the data form a perfectly straight line, the r for the correlation would be 1.

Table 18. Pearson correlations among gage heights and lagged gage heights between upstream gages and downstream gages

A. Kearney and Grand Island stage with Overton stage

Gage	Statistic	Measured	1-day lag	2-day lag	3-day lag	4-day lag
Kearney	r	0.946428	0.963685	0.931149	0.872647	0.804037
	Prob > r	< 0.000001	< 0.000001	< 0.000001	< 0.000001	< 0.000001
	n	195	194	193	192	191
Grand Island	r	0.881261	0.930452	0.947903	0.925372	0.876721
	Prob > r	< 0.000001	< 0.000001	< 0.000001	< 0.000001	< 0.000001
	n	195	194	193	192	191

B. Grand Island stage with Kearney stage

Gage	Statistic	Measured	1-day lag	2-day lag	3-day lag	4-day lag
Grand Island	r	0.960575	0.979885	0.952407	0.895307	0.823758
	Prob > r	< 0.000001	< 0.000001	< 0.000001	< 0.000001	< 0.000001
	n	195	194	193	192	191

The Grand Island gage is a 1-day travel time from the Kearney gage, and thus a 2-day travel time from the Overton gage. The best correlation between the Overton and Grand Island gages should be based on a 2-day lag. As shown in Table 18A, the greatest r for the Overton-Grand Island correlations is based on the 2-day lag. The

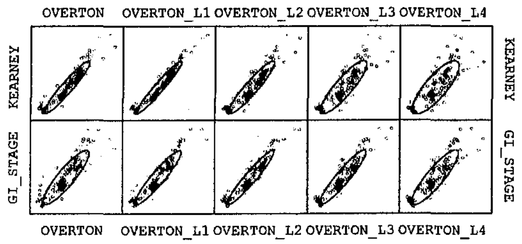


Figure 7: Scattergrams of flows at Kearney and Grand Island as related to lagged flows at Overton

best correlation between the Kearney and Grand Island gage heights is based on a 1-day lag.

Table 19 shows the correlations between the daily changes in stage at the 3 Platte River gages. With the exception of 2 of the correlations for the 4-day lag, all of the correlations are statistically significant. Although the r-values for this set of correlations are much lower than the previous ones shown in Table 18, the results as related to travel time and lagged stages provide the same results. The best correlation between the Overton and Kearney stages is based on a 1-day lag, the best correlation between the Overton and Grand Island stages is based on the 2-day lag, and the best correlation between the Kearney and Grand Island gages is based on the 1-day lag (Table 19).

Table 19. Pearson correlations among gage changes

A. Change in stage at Grand Island and Kearney with change at Overton

Gage	Statistic	Measured	1-day lag	2-day lag	3-day lag	4-day lag
Kearney	r	0.703749	0.814189	0.421458	0.161002	0.094409
	Prob > r	< 0.000001	< 0.000001	< 0.000001	0.026080	0.195098
	n	194	193	192	191	190
Grand Island	r	0.332662	0.548818	0.695278	0.451680	0.225456
	Prob > r	0.000002	< 0.000001	< 0.000001	< 0.000001	0.001763
	n	194	193	192	191	190

B. Change at Grand Island with change at Kearney

Gage	Statistic	Measured	1-day lag	2-day lag	3-day lag	4-day lag
Grand Island	r	0.628688	0.834583	0.527264	0.255812	0.098308
	Prob > r	< 0.000001	< 0.000001	< 0.000001	0.000355	0.177204
	n	194	193	192	191	190

The question as to why the second set of correlations has so much lower r-values may arise. It should be noted that the data consist of both positive values, *i.e.* increasing stages, and negative values, *i.e.* decreasing stages. Correlations are greatly affected by the peaks. Peaks have both a magnitude and a duration. At the farther upstream gages, peaks tend to have a larger magnitude and a shorter duration. As the water moves downstream, the peaks tend to decrease in magnitude and increase in duration, a phenomenon known as wave attenuation. This phenomenon has a potentially large effect on the magnitude of the r-value in the correlations. Once a peak stage begins to attenuate, the stages will be decreasing, *i.e.*, they will be negative. Both sets of data are plotted on Figure 8. The differences are difficult to discern at the scale of the figure. In the gage correlations shown in Table 18, the attenuation will be marked by a smaller large stage, rather than negative values. These types of increases and decreases tend to match up better in the least squares calculation than positive and negative values and result in the better correlations in Table 18.

Correlations among the WSE's for all of the wells were run. This results in 464 correlations, although there were 465 pairs of WSE data. There was no overlapping record for the Overton upstream well 1 and downstream well 3; so no correlation cold be calculated for that data pair. The results for the remaining 464 correlations are summarized in Table 20, and the complete set of correlations is shown in Attachment B.

Table 20. Summary data for correlations among wells

Category	Count	Percent
Total	464	-----
Significant	435	93.5%
Positive (significant)	430	92.5%
Negative correlations	17	3.7%
Negative Significant	5	1.1%

It should be noted that correlations do not necessarily imply cause and effect. A statistically significant correlation simply means that the distributions for the 2 input variables show some commonality. There may be a cause and effect relationship, but there may also be a common response to some outside driving force. In the case of the WSE's for the observation wells, significant correlations would be a reflection of the common response of different areas of the same aquifer. Consequently a large number of significant correlations should be expected, and that is the result that was obtained (93% - Table 20). The more interesting aspect of the correlation analysis concerns the nonsignificant correlations and even more so, the negative correlations.

Attachment B is arranged beginning with the most significant positive correlation first and running down the list to the most significant negative correlation. The nonsignificant correlations are in between the significant positive and significant negative correlations. The list generally follows the numerical correlation coefficients

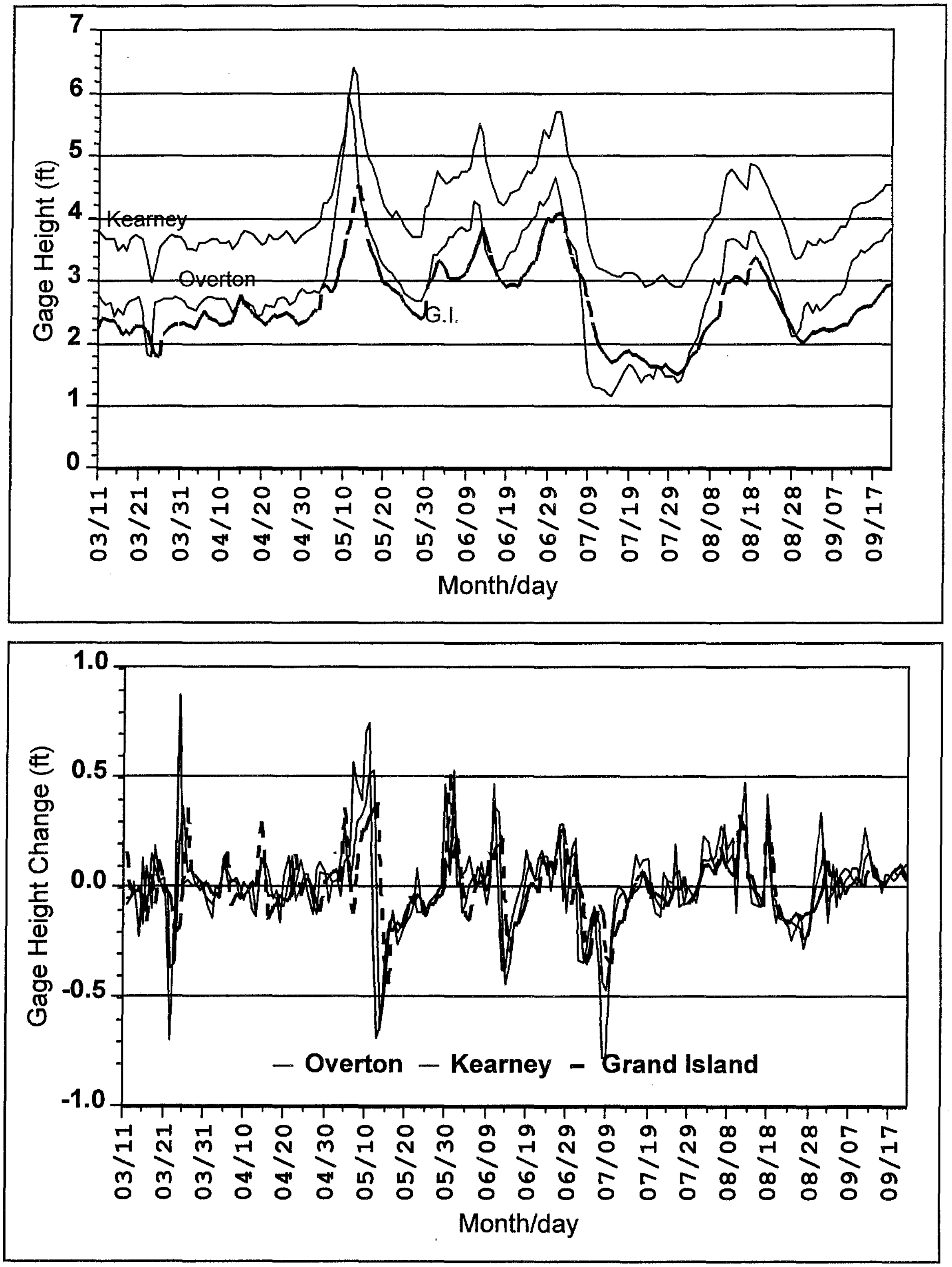


Figure 8: Daily gage height (GH) and change in gage height (ΔGH) at the Platte River gages at Overton, Kearney, and Grand Island

(r-values), but not completely so. There are cases where a lower r-value is more statistically significant than a larger one. This results from the difference in the number of data points that are entered into the correlation. As was noted previously, the number of observations did not affect any trends significantly; however, that does not mean that it does not affect individual correlations among the wells.

Over 90 percent of the correlations are positive and significant (Table 20). Less than 4 percent of the correlations are negative and only a little over 1 percent are negative and significant. Of the 17 negative correlations, 11 (65%) involve wells from the Elm Creek transect. The Elm Creek transect is the only one on the south side of the Platte River. It also intercepts the "ground water mound" at its southernmost extent in both the upstream and downstream sets of wells. The influence of the "ground water mound" would not be a factor in any of the other transects. Most of the other negative correlations include the wells from the Overton and Minden transects that have the fewest observations. These could be random effects related to the periods of record for the WSE data. This is supported by the fact that 4 of the 5 significant negative correlations include wells from the Elm Creek transect, 2 of which are also in the Overton transect. The remaining 12 negative correlations are nonsignificant and thus show no relationship.

In most cases the WSE of the wells is above that of the river. Consequently, the ground water should be flowing into the river at some point. This is particularly true of the wells in the Overton and Elm Creek transects. Lagged data for the WSE of the wells were correlated with the stage from each of the gages. This created another rather large set of correlations, which are also shown in Attachment B. A summary of the results showing the best number of lags for each well with each of the gages is shown in Table 21. In the vast majority of cases, the best correlation was between the unlagged WSE and the GH. This would indicate that there was no travel time between the wells and the gages, if a cause and effect relationship is assumed. Alternatively if a common response is assumed, no travel time is necessary.

The common response is further supported by the fact that the most significant relationship is usually between the WSE in the wells and the stage at the Grand Island gage (Table 22). None of the "best correlations" for the wells in the Overton transect includes the Overton gage. The only "best correlations" with the Overton gage are for the ΔWSE in the farthest well from the river in the upstream segment of the Elm Creek transect (see Table 22 - ElmC_U_4) and the nearest well in its downstream segment (ElmC_D_1). It should be noted that the correlation for well ElmC_U_4 is not statistically significant (r = 0.0905, probability of a greater r = 0.308). The vast majority of the WSE data (22 of 28 wells or 79%) correlate best with the GH at the Grand Island gage; The remainder correlate best with the Kearney GH. The majority of the ΔWSE also correlate best with the ΔGH at the Grand Island gage, but there is a somewhat

Table 21. Summary of lagged well WSE and GH correlations (see Attachment B for complete set of correlations)

	Water Surface Elevations (WSE)			Changes in WSE (ΔWSE)		
	Overton gage	Kearney gage	G.I. gage	Overton gage	Kearney gage	G.I. gage
Ovtn U 3	1 lag	1 lag	1 lag	No lags	1 lag	1 lag
Ovtn U 2	No lags	No lags	No lags	No lags	No lags	1 lag
Ovtn U 1	5 lags	5 lags	5 lags	5 lags	No lags	1 lag
Ovtn D 3	No lags	No lags	No lags	No lags	1 lag	2 lags
Ovtn D 2	No lags	No lags	No lags	No lags	1 lag	No lags
Ovtn D 1	1 lag	1 lag	1 lag	No lags	1 lag	No lags
ElmC U 4	No lags	No lags	No lags	4 lags	4 lags	3 lags
ElmC U 3	No lags	No lags	No lags	No lags	No lags	No lags
ElmC U 2	No lags	No lags	No lags	No lags	1 lag	No lags
ElmC U 1	No lags	No lags	1 lag	No lags	No lags	1 lag
ElmC D 4	No lags	No lags	No lags	No lags	1 lag	No lags
ElmC D 3	No lags	No lags	No lags	No lags	No lags	No lags
ElmC D 2	1 lag	1 lag	1 lag	1 lag	1 lag	No lags
ElmC D 1	4 lags	3 lags	3 lags	No lags	1 lags	2 lags
Mndn U 4	No lags	No lags	No lags	No lags	No lags	No lags
Mndn U 3	No lags	No lags	No lags	No lags	No lags	No lags
Mndn U 2	No lags	No lags	No lags	No lags	No lags	No lags
Mndn U 1	No lags	No lags	No lags	No lags	No lags	No lags
Mndn D 3	No lags	No lags	1 lag	No lags	No lags	1 lag
Mndn D 2	No lags	No lags	No lags	No lags	No lags	No lags
Mndn D 1	No lags	No lags	No lags	No lags	No lags	No lags
Alda U 4	No lags	No lags	No lags	No lags	1 lag	No lags
Alda U 3	No lags	No lags	No lags	No lags	No lags	No lags
Alda U 2	No lags	No lags	No lags	No lags	No lags	No lags
Alda U 1	No lags	No lags	No lags	No lags	No lags	No lags
Alda D 3	No lags	No lags	No lags	No lags	No lags	No lags
Alda D 2	No lags	No lags	No lags	No lags	No lags	No lags
Alda D 1	No lags	No lags	No lags	No lags	No lags	No lags

NOTE - The analysis included 5 lags for the Overton transect, 4 lags for the Elm Creek transect, and 2 lags each for the Minden and Alda transects

Table 22. Best correlation between the 3 gages and each well WSE

Well	WSE		Changes in WSE	
	r	Gage	r	Gage
Ovtn-U-3	0.6509	at Grand Island	0.2893	at Grand Island
Ovtn-U-2	0.3963	at Kearney	0.3598	at Kearney
Ovtn-U-1	0.6909	at Kearney	0.2592	at Kearney
Ovtn-D-3	0.6639	at Grand Island	0.4342	at Grand Island
Ovtn-D-2	0.4732	at Kearney	0.2998	at Grand Island
Ovtn-D-1	0.5634	at Grand Island	0.2692	at Kearney
ElmC_U_4	0.5424	at Grand Island	0.0905	at Overton
ElmC_U_3	0.6570	at Grand Island	0.3556	at Kearney
ElmC_U_2	0.2253	at Grand Island	0.1022	at Grand Island
ElmC_U_1	0.8119	at Grand Island	0.5210	at Kearney
ElmC_D_4	0.6578	at Grand Island	0.1916	at Grand Island
ElmC_D_3	0.3546	at Kearney	0.2775	at Kearney
ElmC_D_2	0.6078	at Grand Island	0.2976	at Grand Island
ElmC_D_1	0.6228	at Grand Island	0.3346	at Overton
Mndn_U_4	0.1962	at Kearney	0.1543	at Grand Island
Mndn_U_3	0.5040	at Grand Island	0.1427	at Grand Island
Mndn_U_2	0.7370	at Grand Island	0.3416	at Grand Island
Mndn_U_1	0.9318	at Grand Island	0.5070	at Grand Island
Mndn_D_3	0.2703	at Kearney	0.2022	at Grand Island
Mndn_D_2	0.6057	at Grand Island	0.2015	at Grand Island
Mndn_D_1	0.9790	at Grand Island	0.8139	at Kearney
Alda_U_4	0.5335	at Grand Island	0.1371	at Grand Island
Alda_U_3	0.6686	at Grand Island	0.2705	at Kearney
Alda_U_2	0.7412	at Grand Island	0.3645	at Grand Island
Alda_U_1	0.9809	at Grand Island	0.8000	at Grand Island
Alda_D_3	0.6210	at Grand Island	0.3300	at Kearney
Alda_D_2	0.6213	at Grand Island	0.3106	at Kearney
Alda_D_1	0.6939	at Grand Island	0.2656	at Grand Island

more even split with the ΔGH at the Kearney gage (16 and 10 of the 28 wells respectively).

The question of why the well WSE and ΔWSE correlate best with the gage data at Grand Island may lie in the discussion of attenuation presented earlier. The broader peaks at Grand Island may mimic those in the wells to a greater extent than those at the other gages. Wells would be expected to rise and fall more slowly than surface waters. The surface water that rises and falls the slowest then gives the best fit to the well data. This may be particularly true for the wells that show the best fit between the WSE and GH. For example, the average r for the best correlations of any well WSE and the GH at the Grand Island gage is 0.67, while those that show the best correlations with the GH at the Kearney gage have an average r of 0.36.

An alternative explanation relates to the operation of the J2 return. This return is above the Overton gage. The other downstream gages are more distant and show its effects on flow to a lesser degree. The greater the distance the less the effects are shown and the more the gage represents a response to local precipitation and runoff. The Grand Island gage is the most distant and thus shows the effects of local precipitation and runoff the most. This condition would better represent a natural hydrograph and a better fit to the well response to local precipitation. The net result would be a better correlation with the well WSE than that of other gages.

At the other end of the spectrum of r-values, the WSE in the Alda upstream well nearest the river has an r of 0.98 (Table 22). The well could almost be used as a surrogate gage (see Figure 31 of Attachment A). As a gage it would have an estimated accuracy of 96 percent, which as gage performance is rated, would be considered good. However, this would be on a daily basis. On a smaller time step, the performance would likely be much less accurate.

The ΔWSE data have several "best correlations" that are nonsignificant. In addition to the Elm Creek well mentioned above, the Elm Creek upstream well second nearest the river (ElmC_U_2) does not correlate significantly with any of the gages (r = 0.1022; prob. = 0.213). The other well that does not correlate based on its ΔWSE is the upstream Alda well farthest from the river (r = 0.1371; p = 0.117). This well is located north of the Wood River, which could affect the well; the WSE in the well could not be affected by the Platte River. However, if the Wood River behaved enough like the Platte River, the significant correlation between WSE and GH could be explained.

There is a gage on the Wood River at Alda. The daily flow data for the gaging station were retrieved from the USGS Water Resources NWIS database. The data include the water years 1954 through 1994. These were correlated against the equivalent data from the Grand Island gage on the Platte River. The correlation was not particularly good (r = 0.212), but was statistically significant.

It has been noted elsewhere that there has been a long-term trend toward increasing flow in the Platte River near Grand Island during the summer months. Because of this trend, it might be that there is a change in the relationship between the flows at the 2 gages. The data were then broken down by decade and separate correlations were developed for each decade between the 1950's and the 1990's. These are superimposed on the hydrographs for the 2 gages on Figure 9. The r-values for these correlations range from a low of 0.0136 in the 1970's to 0.562 in both the 1960's and 1990's. It should be noted that the data for the 1990's only include the years through 1994.

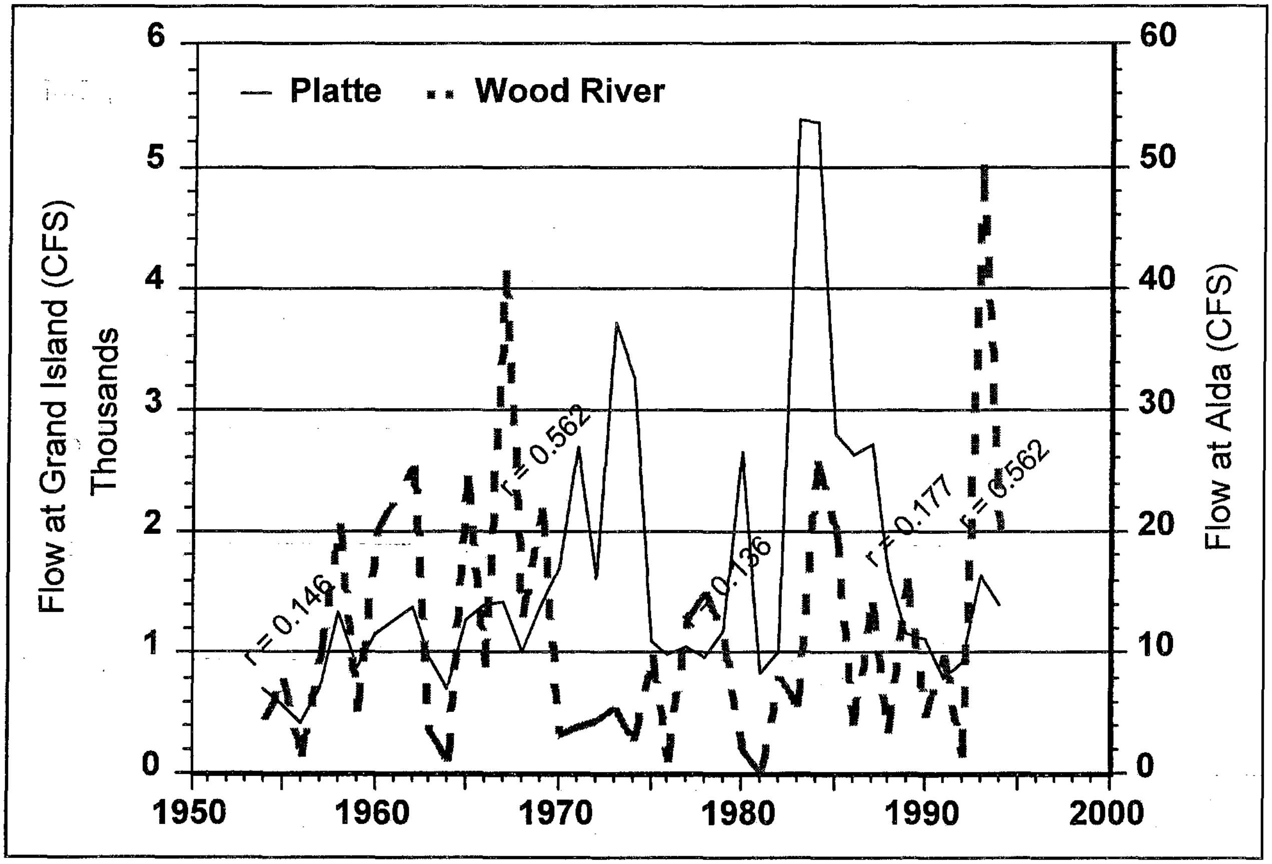


Figure 9: Hydrographs of the daily flows of the Platte River at Grand Island and the Wood River near Alda

The range in correlations for the different decades indicated a great deal of variation in the relationship between flows at the 2 gages. To further evaluate the variation, annual correlations were calculated. The r-values for these correlations are shown on Figure 10. Given the number of values for each correlation, an r of ±0.11 would be statistically significant in most cases and an r of ±0.2 is statistically significant in all cases. The correlations range from a minimum of -0.40 to a maximum of 0.86; both extremes are statistically significant at an α-level of < 0.000001. The minimum r-value was observed based on the 1976 data and the maximum was observed for 1978 (Figure 10). As

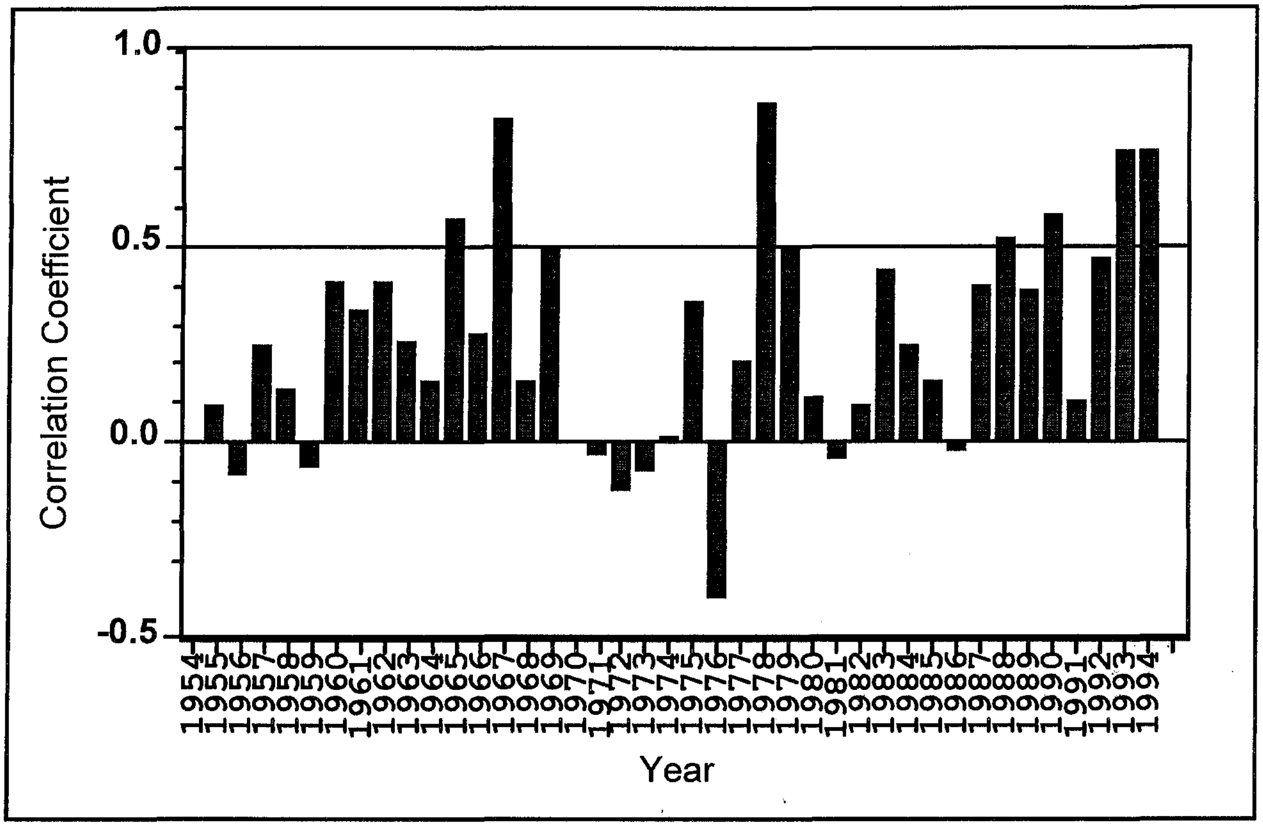


Figure 10: r-values for the annual correlations between the daily flows at the gages on the Wood River near Alda and Platte River at Grand Island

water years go, 1976 was a drought year and 1978 was a high flow year. To further evaluate this potential influence, the r-values were correlated with the mean annual flows at the 2 gages. The results showed no significant relationship to the Platte flow at Grand Island (r = -0.02), but there was a highly significant correlation with the flow of the Wood River near Alda (r = 0.62). This means that there is likely to be a relationship between the flows in the 2 rivers when there are high flows in the Wood River and no relationship between them when the flows in the Wood River are low. The possible relationship between the 2 gages during the study period was then investigated. Conditions within the study area were relatively wet during 1999, which would favor higher flows in the Wood River.

The Wood River gage height data were obtained from the Nebraska Natural Resources Commission. These data were correlated with wells in the Alda transect and the Platte River gage heights at Grand Island. The results are shown in Table 23.

There is no significant correlation between the Platte and Wood river gage heights (Table 23). The Wood River only correlates significantly with the WSE of 3 of the wells, and 2 of those correlations are inverse. The Wood River, with the exception of a few peaks or spikes in the hydrograph following storm events, shows a continuous decline

Table 23. Correlations of selected Alda wells with the Wood River at the Alda gage, the Platte River at the Grand Island gage, and other wells in the Alda transect

		Wood River	Alda_U_4	Alda_U_3	Alda_D_3	Alda_D_2
Platte River gage	r	0.121937	0.535722	0.672528	0.624701	0.624256
	Prob. > r	0.089478	< 0.000001	< 0.000001	< 0.000001	< 0.000001
	n	195	133	195	195	195
Wood River	r	——	0.105084	-0.173497	-0.240335	-0.446680
	Prob. > r	——	0.228672	0.015283	0.000714	< 0.000001
	n	195	133	195	195	195
Alda_U_4	r	0.105084	——	0.794939	0.888753	0.880419
	Prob. > r	0.228672	——	< 0.000001	< 0.000001	< 0.000001
	n	133	133	133	133	133
Alda_U_3	r	-0.173497	0.794939	——	0.973038	0.917198
	Prob. > r	0.015283	< 0.000001	——	< 0.000001	< 0.000001
	n	195	133	195	195	195
Alda_U_2	r	-0.077887	0.806640	0.968192	0.944247	0.887454
	Prob. > r	0.279126	< 0.000001	< 0.000001	< 0.000001	< 0.000001
	n	195	133	195	195	195
Alda_U_1	r	0.053319	0.566503	0.746479	0.686366	0.699068
	Prob. > r	0.459119	< 0.000001	< 0.000001	< 0.000001	< 0.000001
	n	195	133	195	195	195
Alda_D_3	r	-0.240335	0.888753	0.973038	——	0.936519
	Prob. > r	0.000714	< 0.000001	< 0.000001	——	< 0.000001
	n	195	133	195	195	195
Alda_D_2	r	-0.446680	0.880419	0.917198	0.936519	——
	Prob. > r	< 0.000001	< 0.000001	< 0.000001	< 0.000001	——
	n	195	133	195	195	195
Alda_D_1	r	0.262288	0.787215	0.794037	0.800443	0.900675
	Prob. > r	0.001744	< 0.000001	< 0.000001	< 0.000001	< 0.000001
	n	140	133	140	140	140

in gage height throughout the study period. Alternatively both of the wells with inverse correlations show an increase in WSE from the beginning of the study period in March to early July. This increase in WSE is great enough and long enough to produce the inverse correlation. Actually there is no evident relationship between the well and river water surface elevations. Based on the results in Table 23, the Wood River is not a significant source of recharge to the adjacent wells in the Alda transect. The Wood River gage height is the only variable in Table 23 that has any nonsignificant correlations. All of the well WSE's and the Platte River gage height are significantly correlated. The Wood River would appear somewhat hydrologically isolated based on the correlations. However, based on the flow, it appears to have a large base flow component and acts as a drain.

Table 24. Summary of precipitation correlations with gage data

A. Stage data	Overton	Kearney	Grand Island
Overall best r-value	0.201850	0.227761	0.211801
Overall minimum Prob > r	0.004991	0.001487	0.003268
Precipitation source	ElmC_U_4	Mndn_U_4	Mndn_U_4
Lag	3 days	3 days	4 days
B. Stage change data			
Overall best r-value	0.188229	0.334341	0.343438
Overall minimum Prob > r	0.008581	0.000002	0.000001
Precipitation source	Mndn_U_321	Ovtn_U_3/D_3	ElmC_U_4
Lag	1 day	1 day	1 day

Correlations of precipitation with various measures of well WSE were previously presented (see Table 2). However, there was no assessment of the relationship between the gage data and precipitation. The main reason for not evaluating the gage relationship was that there were numerous measures of precipitation throughout the study area. In light of the above results, correlations among each of the gages and all of the measures of precipitation were undertaken. The complete set of correlations is included in Attachment B (see pages B-35 through B-51). In addition, the well WSE and ΔWSE and the gage GH and ΔGH data were correlated with lagged precipitation (0-5 days for Overton and 0-4 days for the other 3 transects. These results are also included in Attachment B.

The correlations for the gage data are summarized in Table 24. The table presents the best r-value for the correlations of the gage data with precipitation, including all of the lags, the associated probability, the nearest well to the precipitation measurement, and the number of days the precipitation data were lagged. Although none of the r-values shown in Table 24 is particularly high, all are statistically significant.

The response of the river at a gage should reflect upstream precipitation. The Overton transect is the only one with measured precipitation that is located upstream from the Overton transect. As was the case with the WSE in the wells of the Overton transect, the precipitation at the wells does not correlate with the GH data at the Overton gage, but there is a significant correlation between the ΔGH and precipitation at each well with a 1-day lag (see Attachment B, pages B-35 through B-39). However, the best correlation with GH at Overton is with the precipitation at the farthest well (number 4) in the upstream transect of the Elm Creek transect. The ΔGH at the Overton gage correlates best with precipitation at the 3 nearest wells (all are within the same 2 square mile NEXRAD minium resolution) in the upstream Minden transect (Table 24). Neither of the "best correlations" reflect upstream precipitation at the Overton gage. This would indicate that the correlations are the result of coincidence, and a reflection of a high degree of correlation of the precipitation data across the study area. To effectively evaluate a relationship between the Overton gage and precipitation, NEXRAD data from an area farther west of the gage appears to be necessary.

Both the Kearney and Grand Island GH data correlate best with the precipitation at the Minden upstream well farthest from the river (Table 24). There is a 1-day difference between the lags in the 2 correlations. The "best correlations" between ΔWSE and precipitation for the Kearney and Grand Island gages are both with wells farthest from the river, Kearney with the Overton transect and Grand Island with the Elm Creek transect, both based on a 1-day lag. It is unclear why the correlations for wells farther from the river seem to show the better correlations, but it may be a reflection of the earlier stated relationship between distance from the river and higher precipitation. With the high degree of correlation among all measures of precipitation, the higher measures yield the better relationships to the change in stage.

The discussion of Table 2 indicated that there were only 4 statistically significant correlations between well WSE and precipitation. Measured and lagged precipitation estimates at each well were correlated with well WSE. The "best correlation" for each well is shown in Table 25. The wells are arranged in the table from nearest the river (Well 1) to farthest from the river. The table includes the r-value, the probability of a greater r, and the number of lags for the best correlation.

Table 25. Correlations of precipitation and lagged precipitation with well WSE

Transect	Segment	Statistic	Well 1	Well 2	Well 3	Well 4
Overton	Upstream	r	0.155241	0.077408	0.095756	
		Prob > r	0.151069	0.284617	0.272901	
		No. of lags	1	2	4	
	Downstream	r	0.161370	0.132796	0.212650	
		Prob > r	0.024963	0.065616	0.029413	
		No. of lags	1	1	1	
Elm Creek	Upstream	r	0.321281	0.069367	0.163143	-0.040436
		Prob > r	0.000005	0.395779	0.023033	0.643995
		No. of lags	1	4	1	None
	Downstream	r	0.510559	0.313876	0.052953	0.079524
		Prob > r	0.000002	0.000159	0.463376	0.272880
		No. of lags	None	1	1	3
Minden	Upstream	r	0.184956	0.203945	0.044671	0.085666
		Prob > r	0.033743	0.010162	0.539464	0.237427
		No. of lags	None	1	4	3
	Downstream	r	0.283473	0.208975	0.253109	
		Prob > r	0.000721	0.003627	0.000397	
		No. of lags	None	3	3	
Alda	Upstream	r	0.203406	0.143144	0.151604	0.135406
		Prob > r	0.004447	0.047622	0.034844	0.120184
		No. of lags	1	3	1	3
	Downstream	r	0.167011	0.084319	0.108384	
		Prob > r	0.048580	0.244910	0.134545	
		No. of lags	2	3	3	

15 of the 28 wells show statistically significant correlations (highlighted) between WSE and precipitation

The use of lagged data increased the number of significant correlations from 4 to a total of 15 (50 percent). Only 3 of the 15 significant "best correlations" were with unlagged precipitation data, the Elm Creek downstream nearest and the Minden upstream and downstream wells nearest the river (Table 25). The majority of the wells farthest from the river are not statistically significant. This is consistent with the earlier results showing that the wells less than 11,000 feet from the river showed better correlations than those farther away.

None of the correlations in Table 25 has a particularly large r-value. This is a reflection of the problem discussed earlier concerning the attempt to correlate WSE with precipitation, *i.e.* the WSE rises and falls slowly and tends to remain at a higher level after each recharge event, while precipitation is most often 0 before and after an event. For this reason correlations with the change in WSE were considered more appropriate for analysis. The correlations between ΔWSE and precipitation are shown in Table 26.

Table 26. Correlations of precipitation and lagged precipitation with well ΔWSE

Transect	Segment	Statistic	Well 1	Well 2	Well 3	Well 4
Overton	Upstream	r	0.246034	0.240391	0.086171	
		Prob > r	0.022403	0.000783	0.325883	
		No. of lags	1	None	1	
	Downstream	r	0.350802	0.329766	0.186697	
		Prob > r	0.000001	0.000003	0.057742	
		No. of lags	None	None	None	
Elm Creek	Upstream	r	0.396906	0.085464	0.483477	0.144287
		Prob > r	< 0.000001	0.298406	< 0.000001	0.098816
		No. of lags	None	4	None	2
	Downstream	r	0.545307	0.266938	0.329008	0.163098
		Prob > r	< 0.000001	0.001490	0.000003	0.023433
		No. of lags	3	None	1	None
Minden	Upstream	r	0.518812	0.427118	0.251187	0.200989
		Prob > r	< 0.000001	< 0.000001	0.000441	0.004953
		No. of lags	None	None	3	None
	Downstream	r	0.283473	0.208975	0.253109	
		Prob > r	0.000721	0.003627	0.000397	
		No. of lags	None	3	3	
Alda	Upstream	r	0.366401	0.415291	0.361836	0.115577
		Prob > r	< 0.000001	< 0.000001	< 0.000001	0.186942
		No. of lags	None	1	None	None
	Downstream	r	0.435777	0.309658	0.349123	
		Prob > r	< 0.000001	0.000011	0.000001	
		No. of lags	None	None	1	

23 of the 28 correlations between precipitation and the change in WSE are statistically significant (highlighted)

Lagging the precipitation data only increases the number of significant precipitation-ΔWSE correlations from 22 to 23. Most of the "best correlations" (17) are still with the unlagged data. In other words lagging the precipitation data has the effect of showing 1 additional correlation between precipitation and ΔWSE and 9 wells showed slightly improved correlations between precipitation and ΔWSE. The correlations indicate that local precipitation is a significant source of recharge to the wells. They also indicate that recharge is relatively rapid. None of the significant correlations shows more than a 3-day lag.

There are 5 wells with a ΔWSE that does not correlate significantly with precipitation. All but 1 of these wells is the well in its transect located farthest from the river. As was noted above, the farthest well in the Alda transect is located north of the Wood River and the well in the Elm Creek upstream transect is located in the "ground water mound" and south of the Phelps County Canal. There is nothing remarkable about the other well that shows a nonsignificant correlation in the Elm Creek upstream transect, other than the fact that it has a somewhat abbreviated period of record (April 18 to August 12). However, the 2 farthest wells in the Overton upstream and downstream transects are located north of Spring Creek. (There are also 2 irrigation ditches [the Berquist Lateral and the Beatty Ditch] located between the Platte River and the wells.) Spring Creek is a perennial stream that carries a fairly substantial flow at times. There is a USGS gage on Spring Creek that has operated since April 1996. The data for the period through the end of water year 1998 were retrieved and are plotted on Figure 11. The elevation of the Spring Creek gage is 2310 feet. The minimum elevations of the 2 wells in the Overton transect that are farthest from the river are approximately 2344.8 and 2338.9 feet in upstream and downstream transects respectively. The gage is located near the mouth of the creek. At the point at which the creek crosses the transects, its elevation is greater than the gage height. However, the contours on the

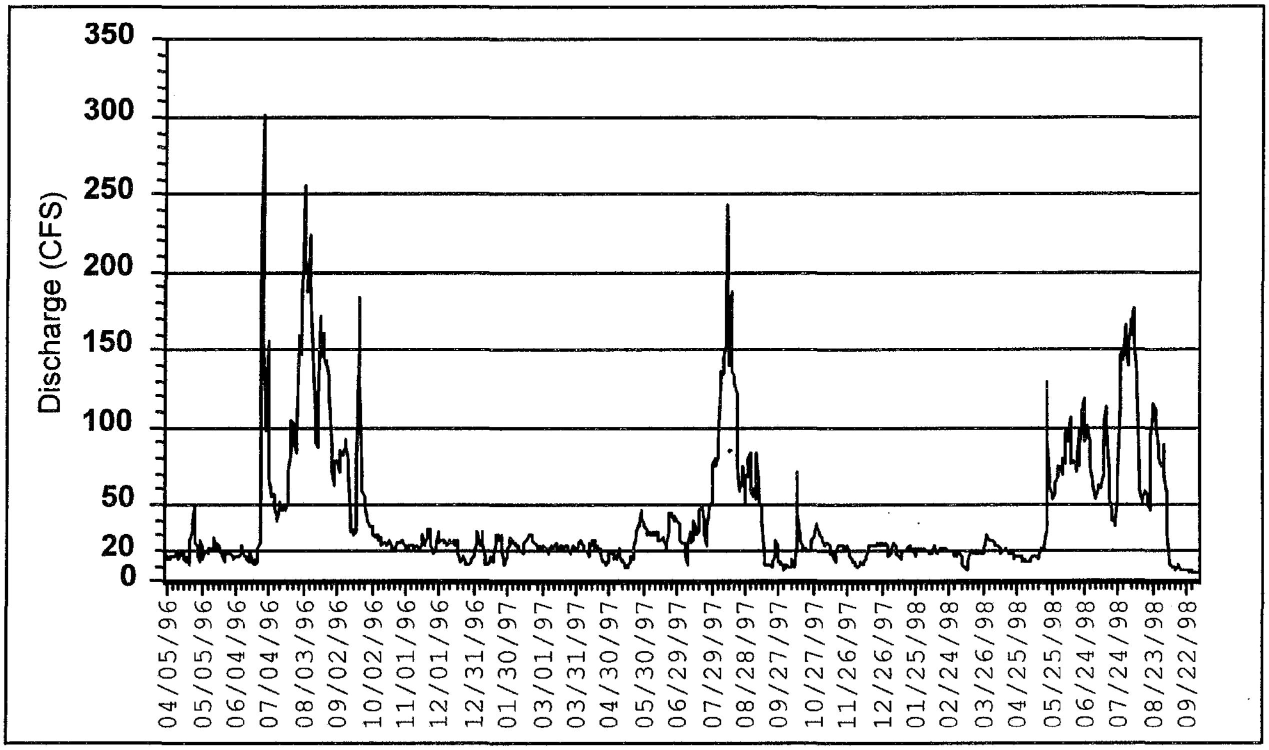


Figure 11: Hydrograph for Spring Creek gage near Overton

topographic maps that show the elevation are difficult to discern within the creek channel at that point because the channel is so narrow, but it appears to be between 2335 and 2340 feet..

The creek appears to have a base flow of between 10 and 20 ft³/s most of the time. The flow did fall below 10 ft³/s during September 1998 (Figure 11). What is interesting about Spring Creek is that the gage height shows a significant correlation with that of the Platte River near Overton (Table 27). This Spring Creek correlation has approximately the same r-value as the correlation between the number 3 well in the upstream segment of the transect (Ovtn_U_3). The correlation between the creek and the well to its south (Ovtn_ D_2) is much better than the correlation with the well to the north of the creek (Ovtn_U_3). The reason behind this is illustrated by the plots of WSE in figures 12 and 13. Figure 12 shows the hydrographs for the wells and the Spring Creek gage height, while Figure 13 shows scattergrams of the WSE's for the

Table 27. Correlations of the WSE of selected Overton wells with the Spring Creek and Overton gage heights, and other wells in the Overton transect

		Spring Creek	Ovtn_U_3	Ovtn_U_2	Ovtn_D_3	Ovtn_D_2
Overton gage	r	0.173382	0.518937	0.200455	0.409923	0.299435
	Prob. > r	0.015352	< 0.000001	0.005188	0.000014	0.000023
	n	195	132	193	105	193
Spring Creek	r	——	0.174316	0.857677	0.500060	0.856040
	Prob. > r	——	0.045605	< 0.000001	< 0.000001	< 0.000001
	n	195	132	193	105	193
Ovtn_U_3	r	0.174316	——	0.505652	0.856227	0.686732
	Prob. > r	0.045605	——	< 0.000001	< 0.000001	< 0.000001
	n	132	132	132	104	132
Ovtn_U_2	r	0.857677	0.505652	——	0.801887	0.949714
	Prob. > r	< 0.000001	< 0.000001	——	< 0.000001	< 0.000001
	n	193	132	193	105	193
Ovtn_U_1	r	0.883816	0.732469	0.939765	No Data	0.958584
	Prob. > r	< 0.000001	0.000014	< 0.000001	——	< 0.000001
	n	87	27	87	0	87
Ovtn_D_3	r	0.500060	0.856227	0.801887	——	0.877867
	Prob. > r	< 0.000001	< 0.000001	< 0.000001	——	< 0.000001
	n	105	104	105	105	105
Ovtn_D_2	r	0.856040	0.686732	0.949714	0.877867	——
	Prob. > r	< 0.000001	< 0.000001	< 0.000001	< 0.000001	——
	n	193	132	193	105	193
Ovtn_D_1	r	0.549973	0.786420	0.690417	0.930442	0.801650
	Prob. > r	< 0.000001	< 0.000001	< 0.000001	< 0.000001	< 0.000001
	n	193	132	193	105	193

wells plotted against the gage elevation of the creek. The well to the north of the creek shows a split in the ground water WSE's relative to the gage elevations at higher flows (Figure 13). The upper limb of the split (figure 13) reflects the coincidental peaks in June (Figure 12), while the lower limb of the split (Figure 13) reflects the lower WSE's in the well that coincide with the peak flows in August (Figure 12). Alternatively the well to the south of the creek tracks the peaks in gage elevation much better (Figure 12). There are deviations from the best fit line for the well to the south of the creek at both high and low flows (Figure 13). The deviations at the lower gage elevation reflect the early and late ground WSE's that plot well below the line of best fit (Figure 12). The deviations at high flow reflect the peak in the well WSE in early July (Figure 13). While these deviations are present, they are consistent rather than divergent.

The wells adjacent to Spring Creek in the Overton downstream transect show about the same thing as those in the upstream transect, although the correlation between the well to the north of the creek (Ovtn_D_3) is somewhat better than the one for the equivalent well in the upstream transect (Table 27). The WSE of the wells to the north of Spring Creek in each of the segments of the transect are 2 - 3 feet higher than those to the south. On the basis of a ground water contour map prepared by the USGS, ground water movement is generally from the north west to the southeast in this area. This would be generally parallel to the creek and not from well to well.

All of the correlations in Table 27 are statistically significant. Among the best of the correlations among the wells are those between the wells in the 2 transects located to the south of Spring Creek, with an r-value of 0.95. The best correlation of any ground WSE with the Spring Creek gage height is with the well nearest the Platte River in the upstream transect (Ovtn_U_1). The well is located adjacent to an unnamed intermittent tributary to the Platte River that may provide a similar influence to that of Spring Creek. The same well also shows the best correlation with another well of any in the data set (Ovtn_D_2), with an r-value of 0.96 (Table 27). The longer term hydrograph of Spring Creek flow (Figure 11) is flat during the nongrowing season. This would reflect a base flow condition when the creek flow is entirely composed of ground water discharge. In other words the creek is acting as a ground water drain at that time. The well hydrographs from 1999 only include a brief part of this period in March and April. As is shown in Figure 12, the ground water hydrograph is relatively flat at that time of the year as well. This may indicate that regional ground water flow is a controlling factor during this part of the year.

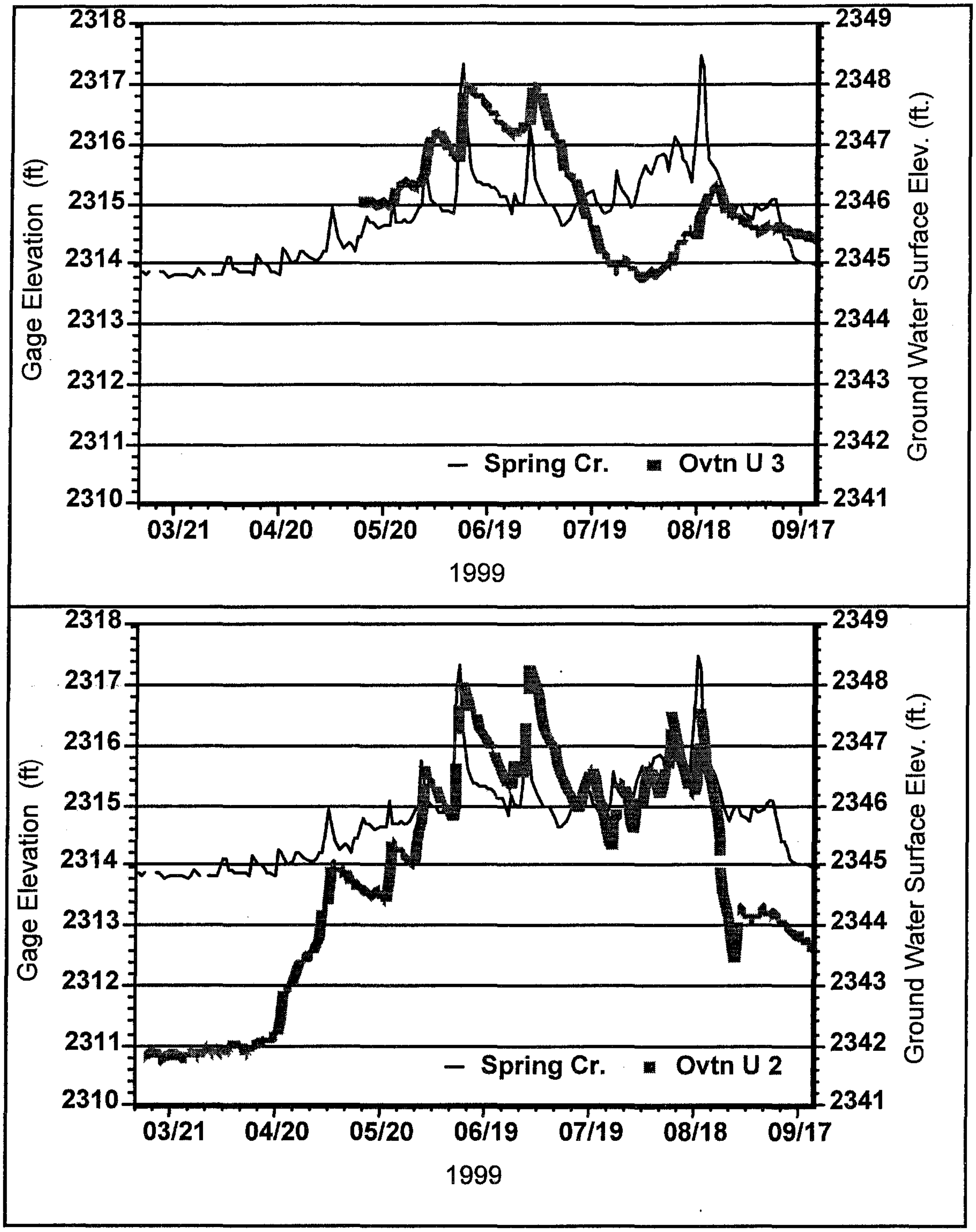


Figure 12: Water surface elevations in the wells in the Overton upstream wells adjacent to Spring Creek and in Spring Creek at the gage near Overton - NOTE the difference in elevation between the surface and ground water

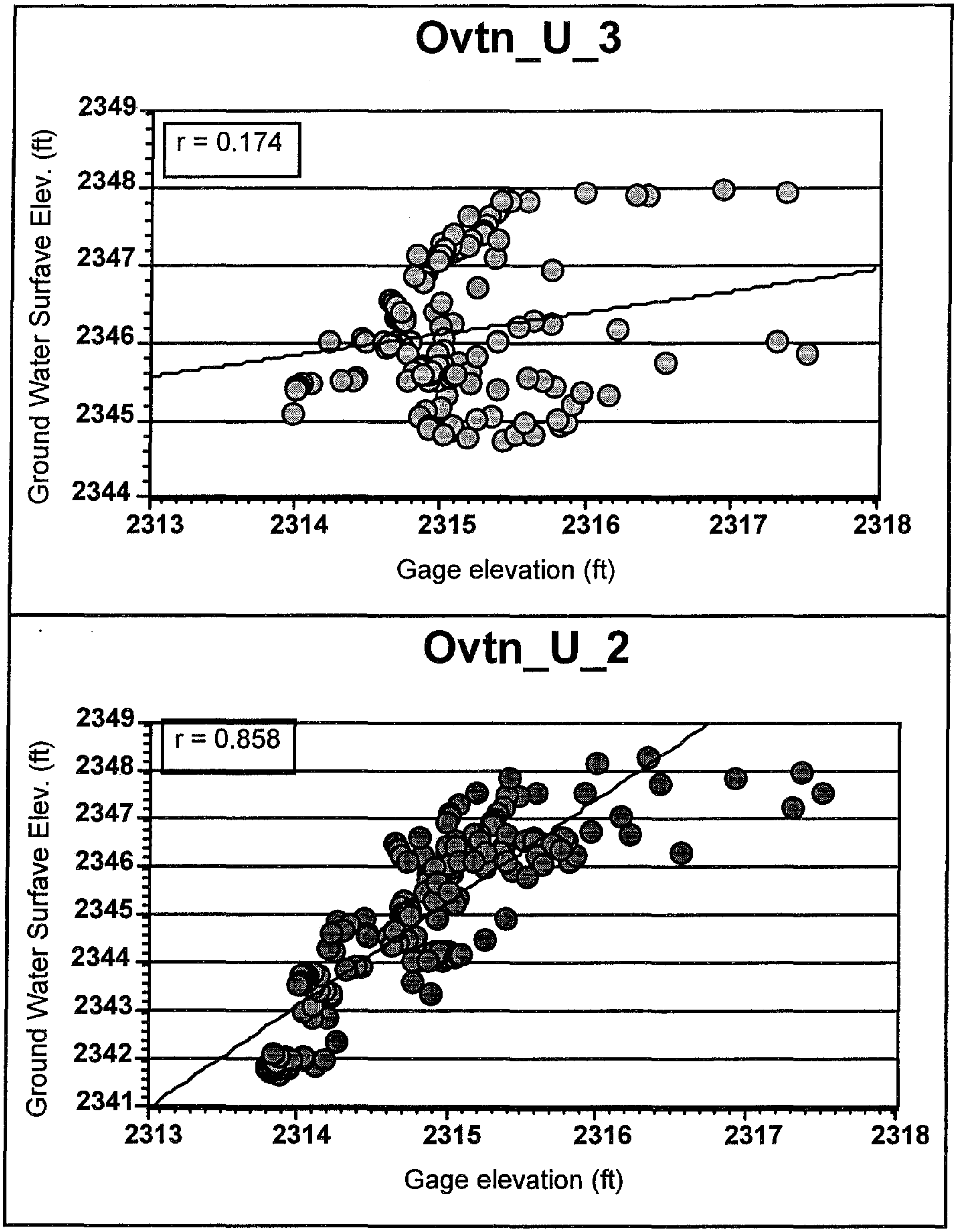


Figure 13: Scattergrams of ground water surface elevations in wells adjacent to Spring Creek in the Overton upstream transect

Precipitation variations

There are some missing data in the NEXRAD precipitation data set. An attempt was made to fill the gap in the data set by correlating with the precipitation record from the National Weather Service (NWS) precipitation data at Grand Island. The best r-values were between 0.85 and 0.86 with the precipitation at the Alda gage (Table 28), which would provide only a marginally useful precipitation estimate. For predictive purposes a minimum r^2-value of 0.75 is usually considered acceptable; at 0.86, the r^2-value is 0.74. What is rather interesting is that the r-values appear to decrease with distance from Grand Island (Table 28). The r-values for the Minden transect are around 0.6, those

Table 28. Correlation coefficients for the correlations of precipitation at each well with the NWS precipitation record at Grand Island and precipitation at other wells in the study area

Precip. at well(s)	GI Precip.	Ovtn_U3_D3	Ovtn_U21_D21	ElmC_U4	Elm_U321_D21
Ovtn_U3_D3	0.392913				
Ovtn_U21_D21	0.325240	0.934002			
ElmC_U4	0.547600	0.589537	0.518462		
Elm_U321_D21	0.394391	0.847127	0.902851	0.612071	
ElmC_D43	0.380992	0.833559	0.898536	0.602269	0.995874
Mndn_U4	0.568155	0.585127	0.501803	0.981108	0.611895
Mndn_U31	0.616779	0.600507	0.499636	0.949655	0.633697
Mndn_U2	0.614964	0.598953	0.499336	0.948639	0.632783
Mndn_D21	0.653706	0.634018	0.549168	0.890224	0.613979
Mndn_D3	0.603158	0.597603	0.514595	0.973743	0.623225
Alda_U4_D3	0.858743	0.508581	0.431194	0.783554	0.480435
Alda_U321	0.847841	0.501957	0.429269	0.754785	0.480515
Alda_D21	0.860931	0.496381	0.421072	0.735599	0.482358
	ElmC_D43	Mndn_U4	Mndn_U31	Mndn_U2	Mndn_D21
Mndn_U4	0.600608				
Mndn_U31	0.623352	0.963180			
Mndn_U2	0.622652	0.963686	0.998512		
Mndn_D21	0.600995	0.906647	0.932002	0.930554	
Mndn_D3	0.610790	0.990508	0.972398	0.972550	0.941608
Alda_U4_D3	0.464707	0.802076	0.822259	0.819539	0.862772
Alda_U321	0.463712	0.772831	0.811313	0.808238	0.847837
Alda_D21	0.464842	0.750420	0.815139	0.812198	0.836933
	Mndn_D3	Alda_U4_D3	Alda_U321		
Alda_U4_D3	0.831433				
Alda_U321	0.809374	0.989634			
Alda_D21	0.787151	0.965910	0.984453		

All except Ovtn_U21_D21 with Grand Island precipitation (p = 0.000011) have probabilities of a greater r-value that is < 0.000001; in all cases, n = 175 with Elm Creek and Overton transect precipitation are between 0.3 and 0.5 Because of this trend, it was decided to look at the correlations among all of the precipitation measurements.

As was described earlier, the NEXRAD data are based on 2-mile square polygons. The polygons are large enough to include as many as 5 wells. These are included in the identifiers used in Table 28. For example, 5 of the 8 wells in the Elm Creek transect are in the same NEXRAD polygon. Only the wells farthest from the river are in different polygons.

Table 28 shows the correlations among precipitation measurements in all of the NEXRAD polygons. The r-values for measurements in adjacent transects or within a transect tend to be between 0.8 and 0.9. When transects farther away are correlated, the r-values drop off by about 0.2 per transect. Nevertheless, all of the correlations are highly significant (probability of a > r < 0.000001); so this does not contradict the earlier references to the highly correlated precipitation over the study area.

It was noted earlier that there was an indication that the precipitation varied with distance from the river. This was investigated, but no relationship to any of the physical variables could be identified. One variable that had not been looked at is the potential for a difference between north and south bank transects. A summary of precipitation data for that variable is shown in Table 29. As can be seen there is a highly significant difference in precipitation between polygons in the north bank transects and those in the south bank transect, which is limited to the Elm Creek transect. This result indicates that in addition to the east-west variation in precipitation, there was also a north-south variation. However, the results appear to be even more complex than this.

Table 29. Comparison of precipitation on the North and south banks of the Platte River in the ground water study area

Bank	North	South
N of cases	20	8
Minimum	12.8	17.19
Maximum	20.54	20.31
Median	17.32	19.58
Mean	16.53	19.35
C.V.[1]	0.15	0.06
t-test	t =	-4.109297
	Prob =	0.000371
	df =	25.1

[1] C.V. = Coefficient of Variation

Polygons to the south of the river received a total of 19.4 inches of precipitation on the average during the monitoring period, while those to the north received only 16.5 inches on the average. Recall from the discussion of Table 16 that the Minden transect received significantly lower precipitation by about 4 inches than any of the other transects. This is part of the set of north bank transects, and appears to have affected the overall average for the set of north bank polygons. Nevertheless, the results in Table 16 indicated that the polygons in the Elm Creek transect received significantly more precipitation than those in either the Overton or the Minden transects. The Overton transect received the second highest precipitation total among the transects. The Overton and Elm Creek transects are the westernmost of the four. This appears to account for the transect effect on precipitation which shows it to be higher in the west than to the east. The real result is that there is a high degree of local variation in the amounts of precipitation over the study area when precipitation events occur.

The above result would imply that wells in the polygons receiving greater amounts of precipitation would also receive more recharge. Whether this would affect the statistical results is unknown. Based on the statistical techniques used, most of the results are a reflection of patterns. For example, the correlations show mostly low r-values that would indicate only that there may be a relationship. Because the r-values are low, definitive relationships would be difficult to impossible to determine. There is also the high probability that the correlations among the WSE in the wells are a reflection of a common response to precipitation. There is as much variation in the r-values among the well WSE as there is in the correlations for precipitation among NEXRAD polygons. In this respect, the results could be a reflection of the effect of precipitation and its variability.

Relationships of surface and ground water to flooding

The purpose of this analysis was to attempt to discern if the statistical relationships evaluated would help in drawing conclusions concerning ground water/surface water relationships and if those relationships could be used to evaluate the potential for flooding due to activities of the program. The analysis in this report has included a variety of correlations among the various hydrologic measurements. The main one for evaluating the ground water/surface water interrelationships are those between the gage and well WSE. As was noted earlier, correlations do not define cause and effect, only whether there is a common response in 2 variables. Regression, which is a related statistical procedure, can be used to define the numerical response of a dependent variable to an independent variable. The measure of the usefulness of a regression equation is its regression coefficient of r^2-value. For predictive purposes a regression equation should have an r^2-value of at least 0.75. The r^2-value estimates the fraction (or percentage if multiplied by 100) of variation in the dependent variable that is explained by the independent.

Regression analysis of the WSE - GH data is summarized in Table 30. The regressions are shown in the table running from the farthest upstream transect to the one farthest downstream. The r^2-values range from a high of 0.96, the earlier mentioned relationship between the gage and Alda upstream well nearest the river WSE, to 0.03, the regression between the gage and Elm Creek well next to the riverside well.

To illustrate what the regression relationships represent, the data and the line defined by the regression equations for the 4 best and the 4 poorest regressions are plotted on figures 14 and 15 respectively. Of the 4 best regressions, there are only 3 that have an r^2-value greater than 0.75 (Figure 14). The 2 top graphs on Figure 14 (wells Alda_U_1 and Mndn_D_1) have an r^2-value of 0.95 or more; each has a very tight grouping of points along the regression line. It is obvious that there is a very strong relationship between the two variables, which is what the high r^2-value represents. In both cases there appears to be a cause and effect relationship. Well Alda_U_1 is located 50 feet from the river; its WSE is usually below that of the river (Figure 16). These conditions are what would be expected for the river to influence the WSE of the well. The other well (Mndn_D_1) is located 100 feet from the river; its WSE is even farther below that of the river than was the case for the Alda well (Figure 16).

The 2 regressions on the lower half of Figure 14 show a significant drop-off in the r^2-values from those in the upper half. Time series plots of those WSE data are shown on Figure 17. The Minden upstream well 1 is located 700 feet from the river; its WSE is well below that of the river most of the time. There are 4 occasions when spikes of a few days in the WSE in the well that extend above the WSE of the river (Figure 17). These do not coincide with spikes in the river, indicating that there is an influence on

Table 30. Summary of regressions of well WSE on gage WSE

Well	Regression				Constant			Slope		
	r^2	n	F-ratio	P > F	Coefficient	t	P(2 Tail)	Coefficient	t	P(2 Tail)
Ovtn U 3	0.2693	132	47.91	< 0.000001	1188.44	7.105	< 0.00001	0.4956	6.922	< 0.00001
Ovtn U 2	0.0402	193	8.00	0.005188	1334.49	3.735	0.00025	0.4325	2.828	0.00519
Ovtn U 1	0.2229	87	24.38	0.000004	446.59	1.165	0.24745	0.8106	4.938	< 0.00001
Ovtn D 3	0.1680	105	20.80	0.000014	1330.50	6.009	< 0.00001	0.4334	4.561	0.00001
Ovtn D 2	0.0897	193	18.81	0.000023	1106.40	3.899	0.00013	0.5283	4.337	0.00002
Ovtn D 1	0.1567	193	35.50	< 0.000001	1192.52	6.226	< 0.00001	0.4898	5.959	< 0.00001
ElmC U 4	0.2104	133	34.91	< 0.000001	-2462.33	-3.039	0.00287	2.0895	5.908	< 0.00001
ElmC U 3	0.3322	194	95.50	< 0.000001	1371.42	14.571	< 0.00001	0.4015	9.773	< 0.00001
ElmC U 2	0.0344	151	5.31	0.022610	1368.64	3.414	0.00082	0.4031	2.304	0.02261
ElmC U 1	0.5727	194	257.37	< 0.000001	1703.36	46.885	< 0.00001	0.2544	16.043	< 0.00001
ElmC D 4	0.3341	194	96.33	< 0.000001	-246.10	-0.932	0.35255	1.1348	9.815	< 0.00001
ElmC D 3	0.1239	194	27.16	< 0.000001	932.73	3.480	0.00062	0.6115	5.212	< 0.00001
ElmC D 2	0.2914	140	56.76	< 0.000001	1436.23	12.758	< 0.00001	0.3713	7.534	< 0.00001
ElmC D 1	0.2085	80	20.55	0.000021	1409.98	7.365	< 0.00001	0.3799	4.533	0.00002
Mndn U 4	0.0390	195	7.84	< 0.000001	1591.02	9.207	< 0.00001	0.2331	2.800	0.00563
Mndn U 3	0.2135	195	52.39	< 0.000001	939.01	5.974	< 0.00001	0.5480	7.238	< 0.00001
Mndn U 2	0.4244	158	115.03	< 0.000001	-66.21	-0.332	0.74048	1.0309	10.725	< 0.00001
Mndn U 1	0.7844	132	472.97	< 0.000001	171.92	1.964	0.05167	0.9170	21.748	< 0.00001
Mndn D 3	0.0737	195	15.36	0.000123	1232.06	5.772	< 0.00001	0.4043	3.919	0.00012
Mndn D 2	0.3298	195	94.98	< 0.000001	759.64	5.658	< 0.00001	0.6324	9.746	< 0.00001
Mndn D 1	0.9510	140	2678.77	< 0.000001	-261.18	-5.803	< 0.00001	1.1258	51.757	< 0.00001
Alda U 4	0.2870	133	52.73	< 0.000001	359.57	1.703	0.09092	0.8049	7.262	< 0.00001
Alda U 3	0.4523	195	159.38	< 0.000001	-640.22	-3.183	0.0017	1.3332	12.625	< 0.00001
Alda U 2	0.5539	195	239.61	< 0.000001	-694.30	-4.137	0.00005	1.3639	15.479	< 0.00001
Alda U 1	0.9633	195	5060.57	< 0.000001	-19.66	-0.727	0.46810	1.0103	71.138	< 0.00001
Alda D 3	0.3903	195	123.52	< 0.000001	-6.49	-0.038	0.96965	0.9989	11.114	< 0.00001
Alda D 2	0.3897	195	123.24	< 0.000001	-434.48	-2.072	0.03959	1.2273	11.101	< 0.00001
Alda D 1	0.4828	140	128.84	< 0.000001	669.61	6.195	< 0.00001	0.6468	11.351	< 0.00001

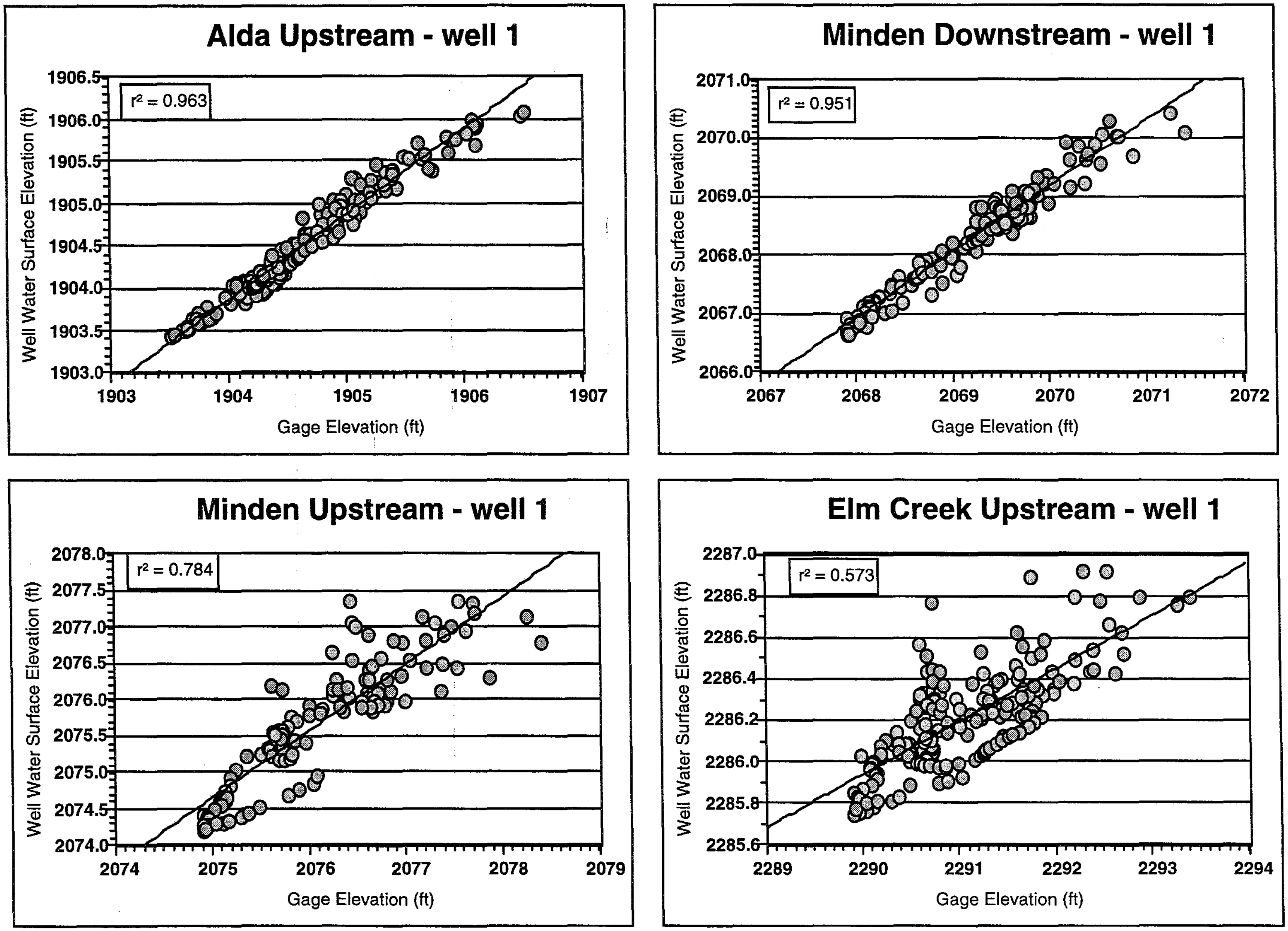


Figure 14: The best regressions of well WSE on gage WSE in the Platte River ground water study

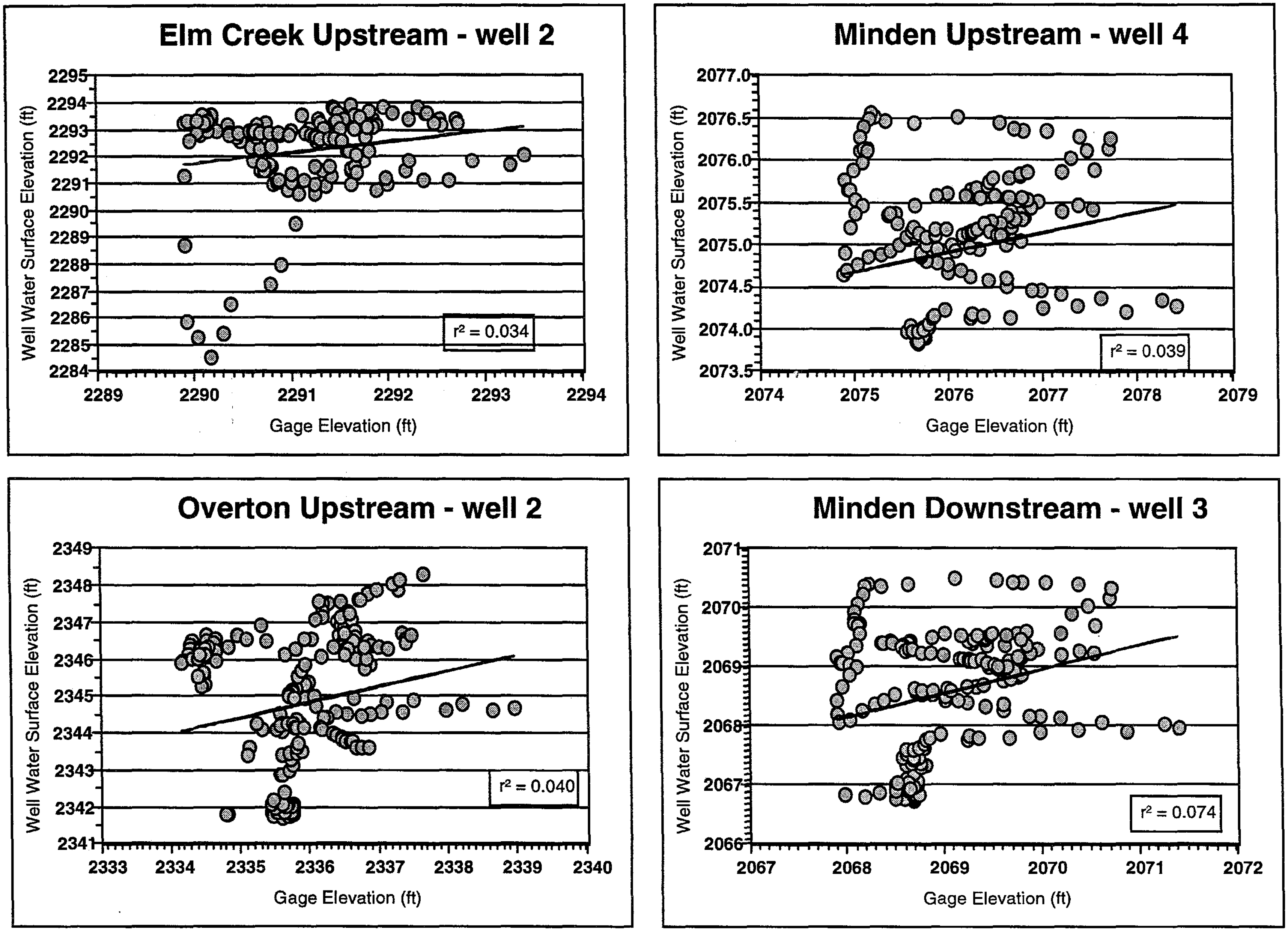
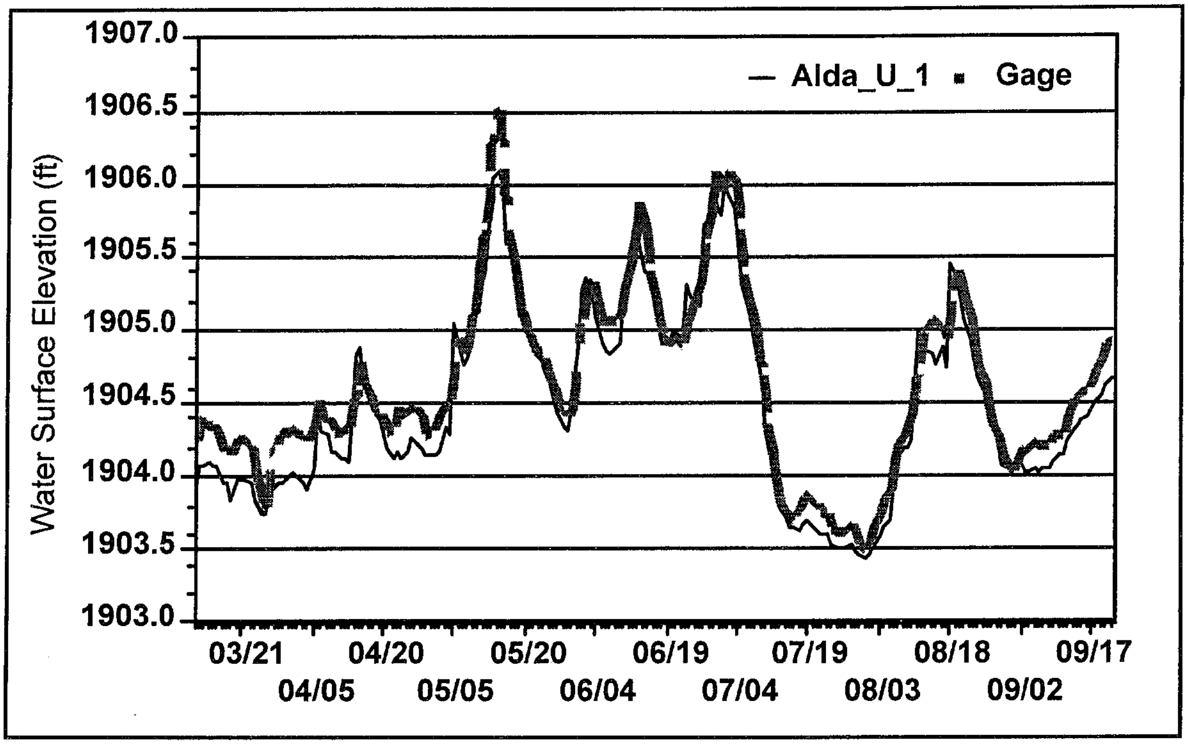


Figure 15: The poorest regressions of well WSE on gage WSE in the Platte River ground water study



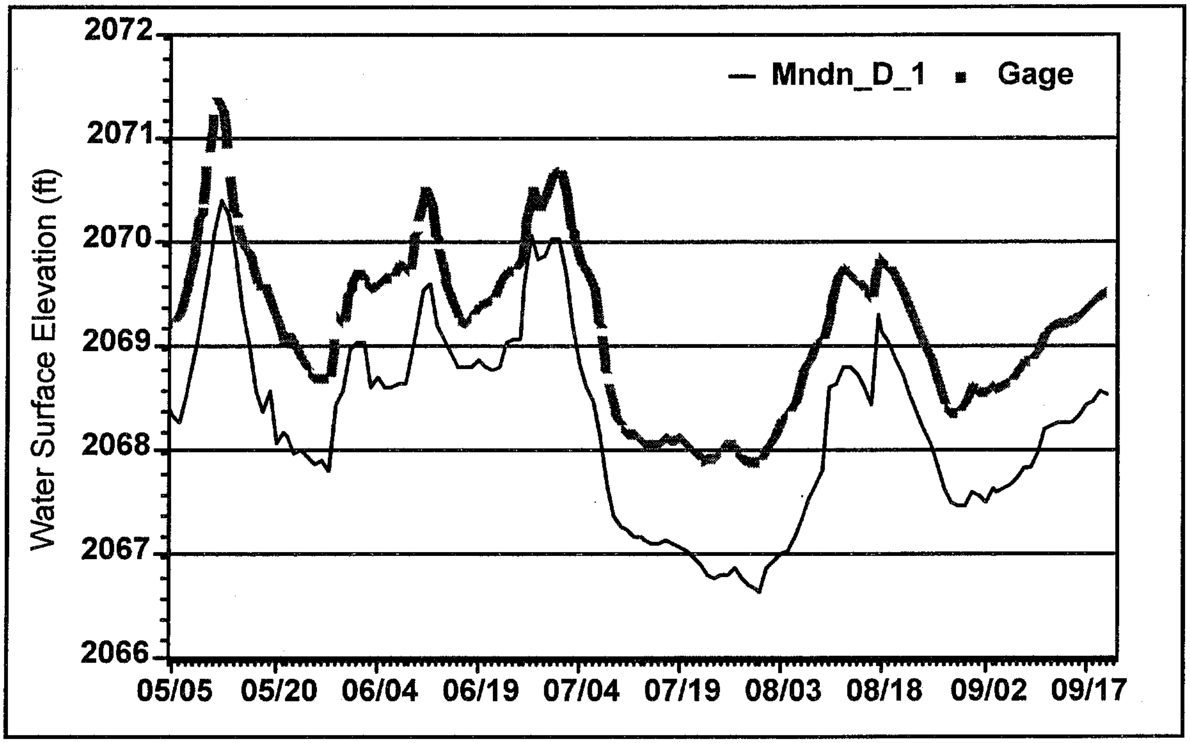
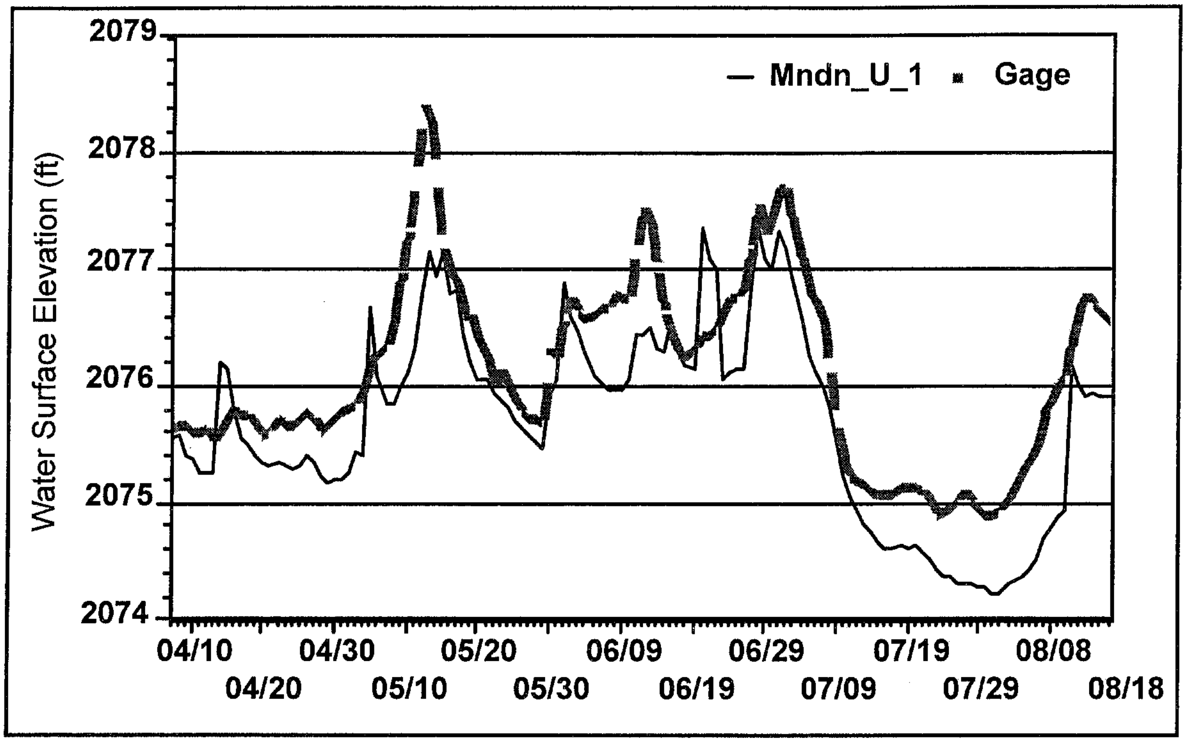


Figure 16: Time series plot of well and adjacent river water surface elevations for the two best regressions in the Platte River ground water - surface water study area



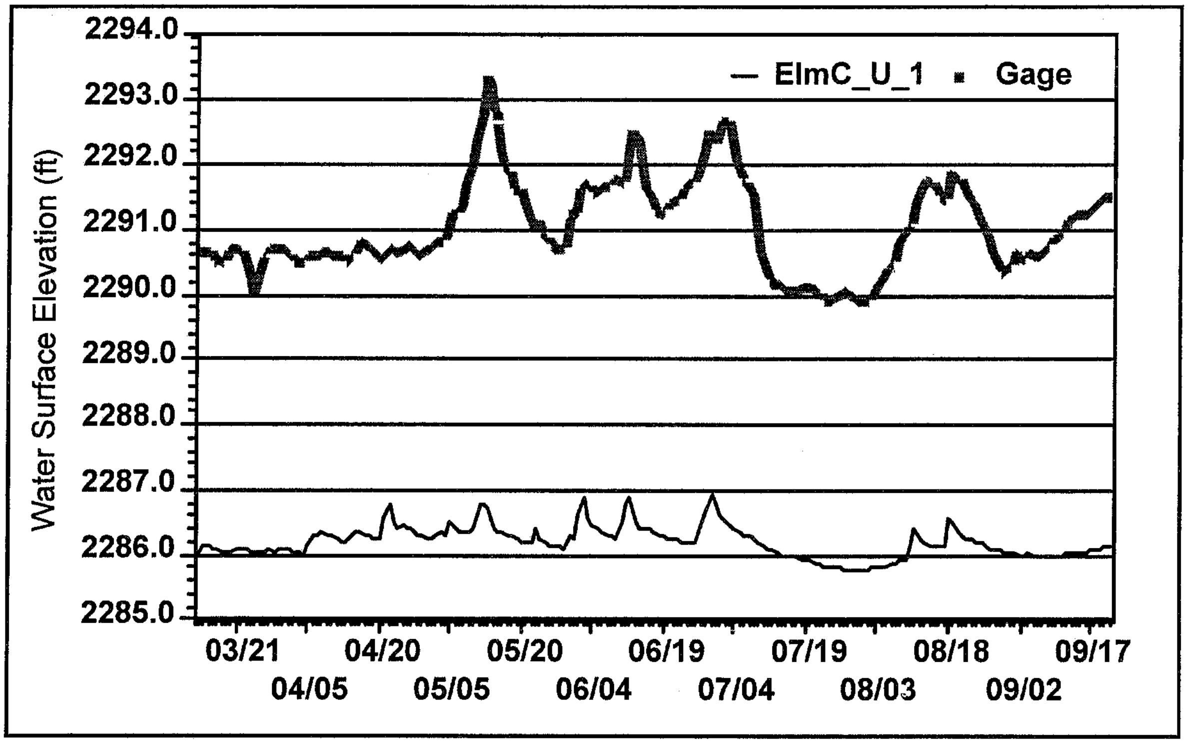


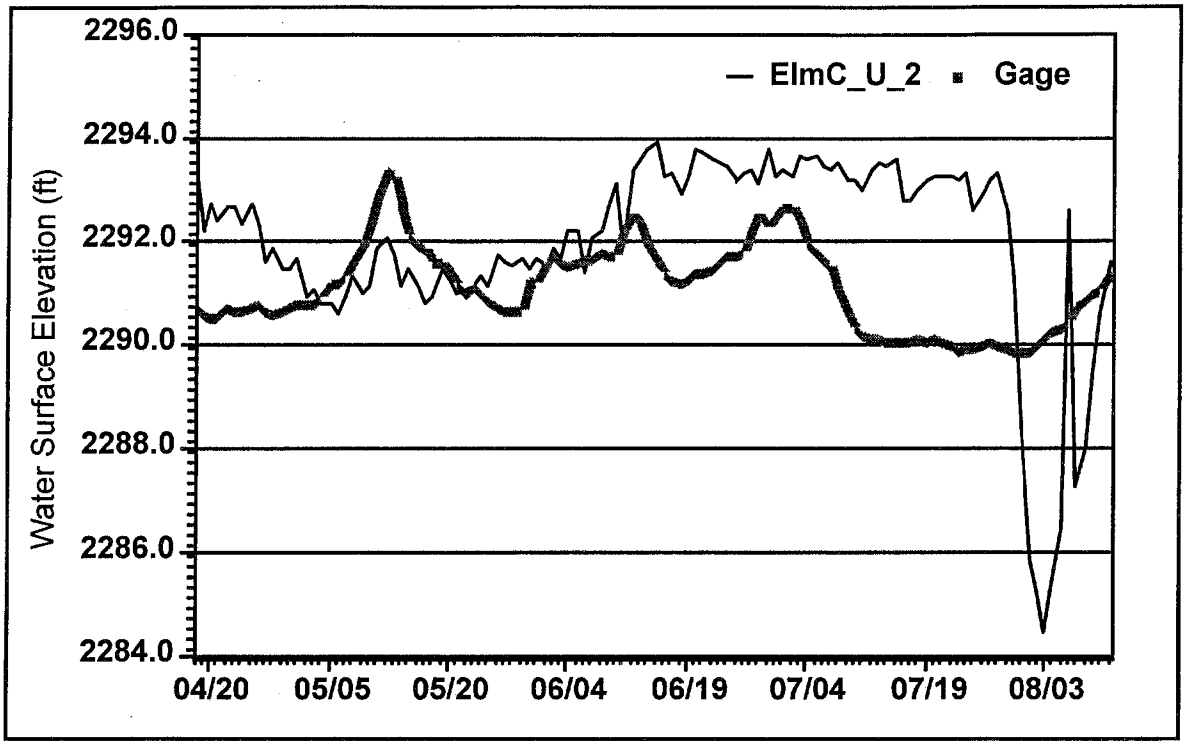
Figure 17: Time series plot of well and adjacent river water surface elevations for the wells showing the third and fourth best regressions in the Platte River ground water - surface water study area

the well that is independent of the river. Figure 17 also shows a time series plot of the WSE of the Elm Creek well 1 in the upstream segment of the transect. As is obvious, the WSE in the well is at least 4 feet below that of the river throughout the period of record. The peaks in the two plots coincide, but those in the well tend to be muted. The peaks in the WSE in the well tend to rise to the same elevation (about 2287 feet), no matter how high the peak stage is in the river (Figure 18). The well, like Mndn_D_1, is only 100 feet from the river. Nevertheless something is influencing the magnitude of the peaks. This could be a case of attenuation in the very short distance from the river. There are also some small peaks early in the record that do not appear in the gage WSE plot. One of these peaks appears to coincide with one of the peaks in the MNDN_U_1 plot that also did not coincide with a peak in the river.

Figure 15 shows scattergrams of the 4 poorest regressions between well and gage WSE. The r^2–values show that the regression explains 3 to 4 percent of the variation in the dependent variable (well WSE). Figure 18 shows time series plots of the well and gage WSE for the 2 wells with the poorest regressions. These tend to show even less of a relationship than the scattergrams. These are examples of the fit of correlations with r–values of about 0.2 and illustrate the type of relationship for that level of correlation. Other than a few coincident peaks, the correlations are difficult to discern. The scattergrams about the regression lines indicate that the WSE in a well can be anywhere in a range of 5 or 6 feet at any given gage elevation. Consequently the error bars about any estimate would be somewhere around 5 or 6 feet. In the case of the wells in Figure 15, the WSE of the wells and gages do not appear to have any relationship. It should be noted that 3 of the 4 wells on Figure 15 are more than 11,000 feet from the river, while the remaining well (ElmC_U_2) is 1500 feet from the river.

So far the evaluation has focused on a comparison of the observed and the predicted values from the regressions. The slope of the regression line can be thought of as the is the rise in the well WSE that would accompany a 1-foot rise in the river. However, there is another aspect to the predicted values that needs to be considered before a regression is applied. This is the confidence interval about the estimate. Each slope coefficient in Table 30 above also has an error bar around it, *i.e.* the standard error of the coefficient. The actual slope of the line is the coefficient ± the standard error. These error coefficients and the upper and lower limits about the slope are shown in Table 31. The table shows the equations in order of decreasing r^2-values. The other statistic to note in Table 31 is the percent relative error column. This is the ratio of the standard error to the slope coefficient. What this shows is that the error about the slope generally increases as the r^2-value decreases.

The standard errors of the slope coefficients appear to be small. When they are translated into a percentage the poorest regression has an error of more than 40 percent (Table 31). An example of how this affects the predictive capability of the regression equation is illustrated in Figure16. Figure 16 shows the confidence interval



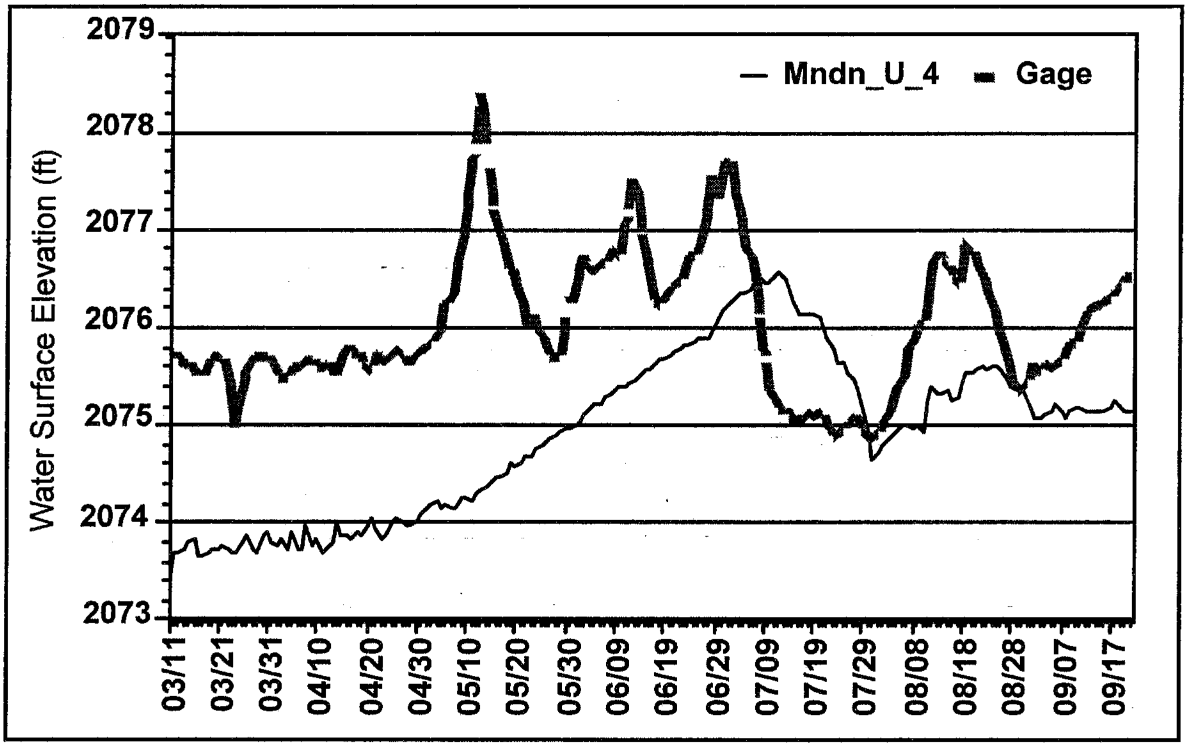
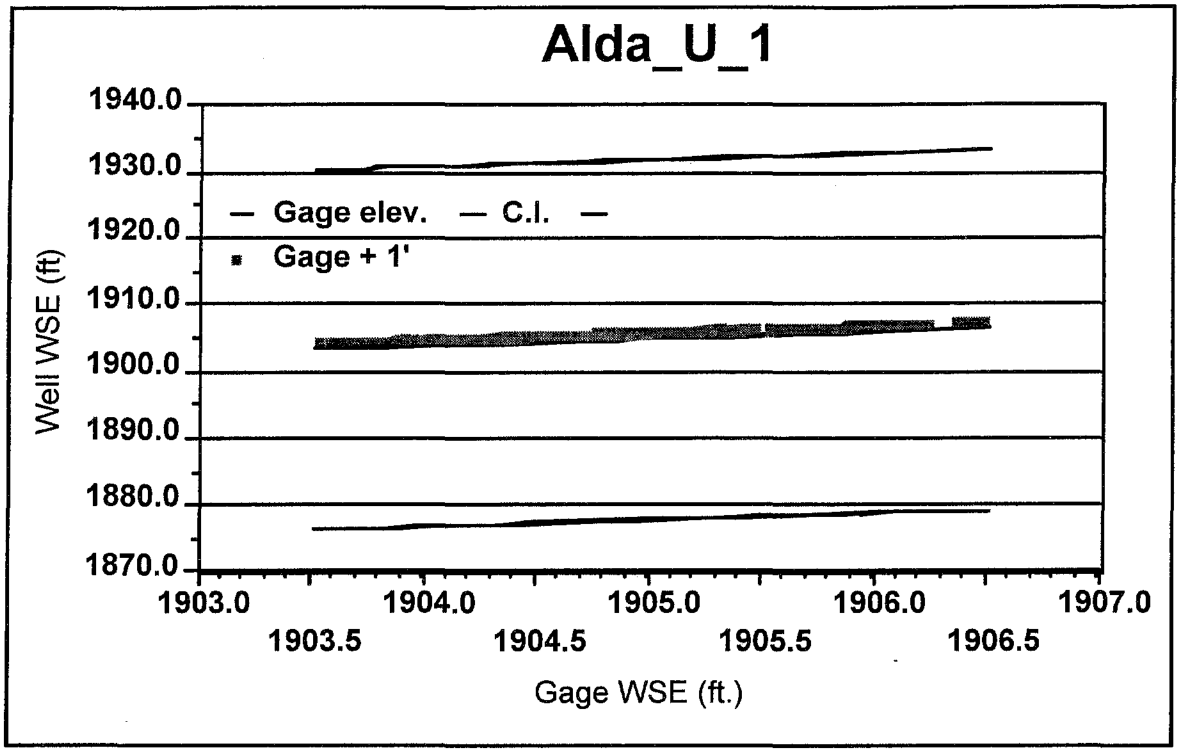


Figure 18: Time series plot of well and adjacent river water surface elevations for the two poorest regressions in the Platte River ground water - surface water study area

Table 31. Regression equations with confidence interval for the slope

		Slope		Percent	Confidence Interval		Constant
Well	r^2	Coef.	Std Error	Rel. Error	Lower	Upper	Coef.
Alda_U_1	0.9633	1.0103	0.0142	1.406	0.9961	1.0245	-19.66
Mndn_D_1	0.9510	1.1258	0.0218	1.932	1.1040	1.1475	-261.18
Mndn_U_1	0.7844	0.9170	0.0422	4.598	0.8748	0.9591	171.92
ElmC_U_1	0.5727	0.2544	0.0159	6.233	0.2385	0.2703	1703.36
Alda_U_2	0.5539	1.3639	0.0881	6.460	1.2758	1.4521	-694.30
Alda_D_1	0.4828	0.6468	0.0570	8.810	0.5899	0.7038	669.61
Alda_U_3	0.4523	1.3332	0.1056	7.921	1.2276	1.4388	-640.22
Mndn_U_2	0.4244	1.0309	0.0961	9.324	0.9348	1.1271	-66.21
Alda_D_3	0.3903	0.9989	0.0899	8.998	0.9090	1.0888	-6.49
Alda_D_2	0.3897	1.2273	0.1106	9.008	1.1168	1.3379	-434.48
ElmC_D_4	0.3341	1.1348	0.1156	10.189	1.0192	1.2504	-246.10
ElmC_U_3	0.3322	0.4015	0.0411	10.233	0.3604	0.4425	1371.42
Mndn_D_2	0.3298	0.6324	0.0649	10.261	0.5675	0.6973	759.64
ElmC_D_2	0.2914	0.3713	0.0493	13.273	0.3220	0.4206	1436.23
Alda_U_4	0.2870	0.8049	0.1108	13.771	0.6941	0.9157	359.57
Ovtn_U_3	0.2693	0.4956	0.0716	14.447	0.4240	0.5672	1188.44
Ovtn_U_1	0.2229	0.8106	0.1642	20.253	0.6464	0.9747	446.59
Mndn_U_3	0.2135	0.5480	0.0757	13.816	0.4723	0.6238	939.01
ElmC_U_4	0.2104	2.0895	0.3537	16.926	1.7358	2.4431	-2462.33
ElmC_D_1	0.2085	0.3799	0.0838	22.060	0.2961	0.4638	1409.98
Ovtn_D_3	0.1680	0.4334	0.0950	21.924	0.3384	0.5285	1330.50
Ovtn_D_1	0.1567	0.4898	0.0822	16.783	0.4076	0.5720	1192.52
ElmC_D_3	0.1239	0.6115	0.1173	19.187	0.4942	0.7288	932.73
Ovtn_D_2	0.0897	0.5283	0.1218	23.056	0.4065	0.6500	1106.40
Mndn_D_3	0.0737	0.4043	0.1032	25.515	0.3011	0.5075	1232.06
Ovtn_U_2	0.0402	0.4325	0.1530	35.364	0.2796	0.5855	1334.49
Mndn_U_4	0.0390	0.2331	0.0832	35.712	0.1498	0.3163	1591.02
ElmC_U_2	0.0344	0.4031	0.1750	43.405	0.2281	0.5781	1368.64



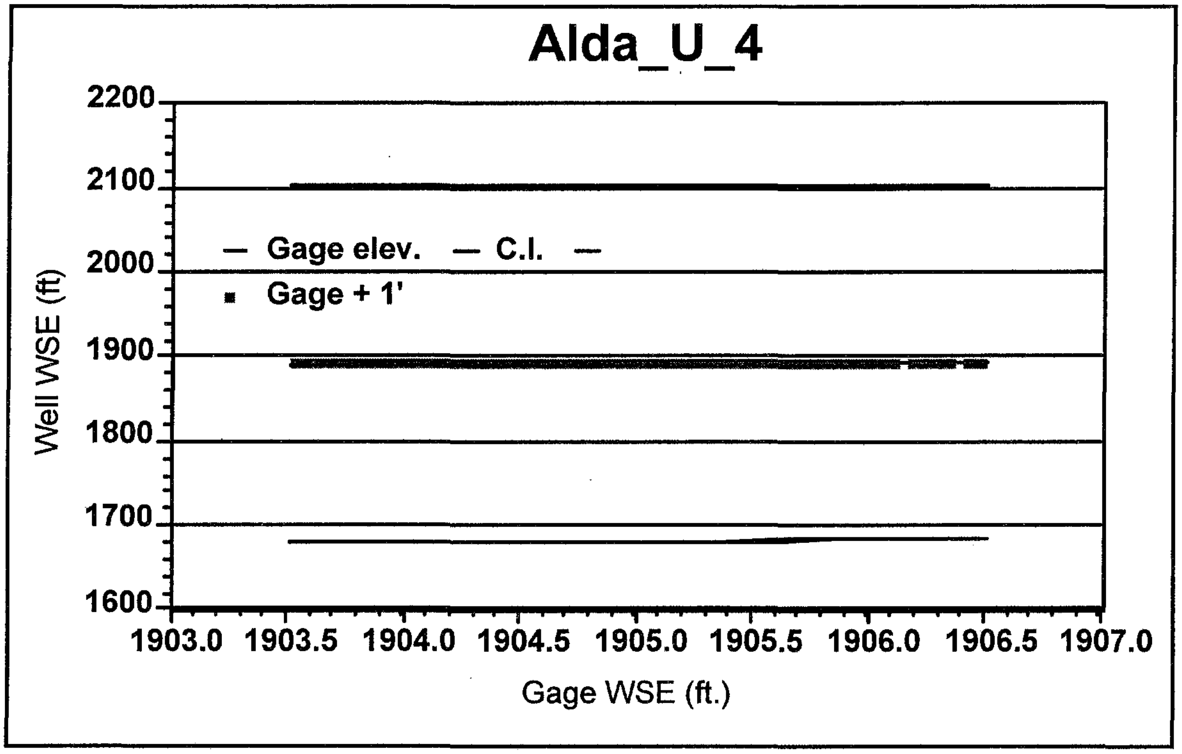


Figure 19: Projected water surface elevations in 2 wells in the river plus the 95 percent confidence interval about the projection and the projected water surface elevation in the well with an across-the board 1-foot rise in the river

about the slope for the best overall regression. It also shows that the error band about the estimate when it is translated into feet of elevation is about ± 25 feet for the Alda upstream well number 1 near the river. The second plot shows a similar plot for the well in the same transect that is farthest from the river. This regression has an r^2-value of 0.287 (Table 31). The error band about the estimate is ± 200+ feet (Figure 16). What this says is that the projection will most likely fall along the regression line, but it could actually be anywhere within the band and the regression prediction would be correct.

Figure 20 shows the effect of a 1-foot rise in the water surface elevation of the river on each of the wells based on the regressions. In the Overton transect the projected rise would be about ½ foot in most of the wells; the exception would be the well nearest the river in the upstream transect, which shows a projected rise of 0.8 foot. The greatest projected rise in ground water elevation in the Elm Creek transect is in the wells farthest from the river (Figure 20). All 3 wells (upstream transect number 4 and downstream transect wells 3 and 4) are located in the ground water mound and would not likely show any change whatsoever due to a rise in the river. Each shows a difference in elevation from the river that ranges from a low of 32 feet to as much as 68 feet higher (Table 8). Despite the correlation with the river, the elevations are controlled by the factors that control the mound. The wells in the Elm Creek transect nearer the river show a projected rise that would range from about 0.2 to 0.6 foot (2.4 to 7.2 inches).

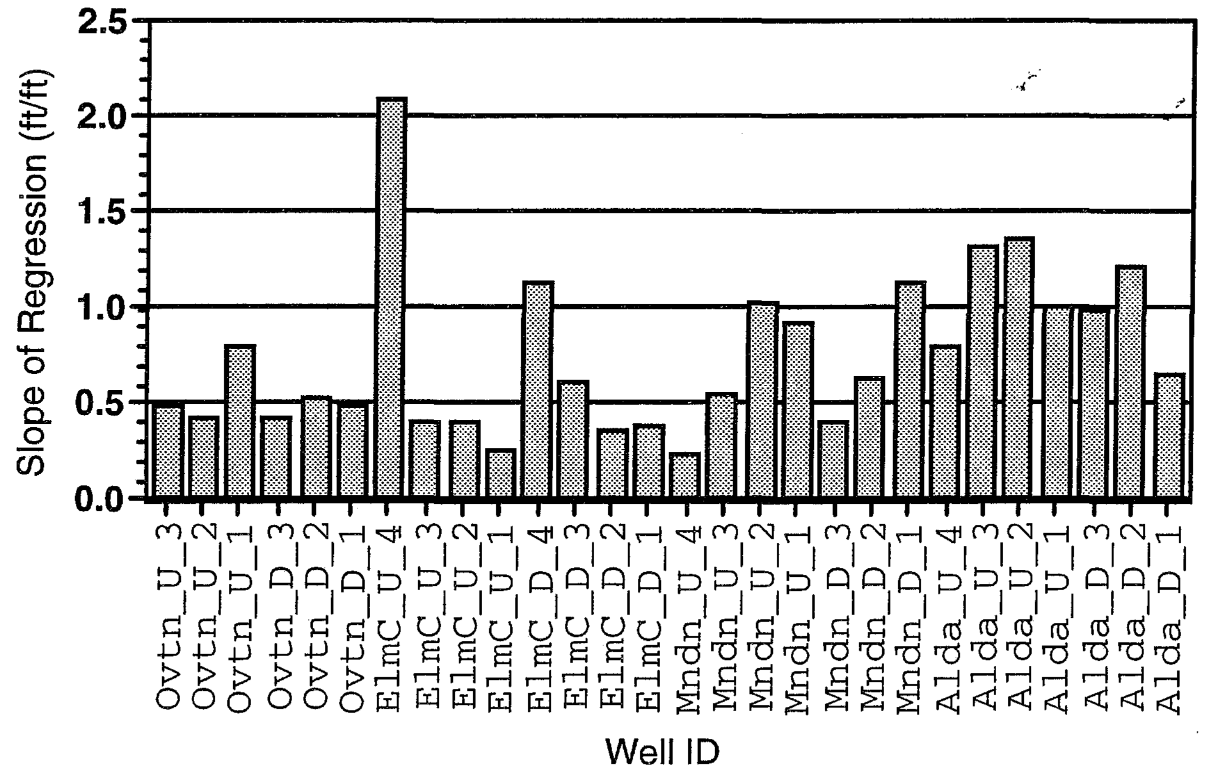


Figure 20: Possible rise in well water surface elevation with a 1 foot rise in the river

The wells in the Minden transect show a more reasonable projection in that the largest rise would be near the river, with smaller rises occurring with increasing distance from the river (Figure 20). The ground water rise would be about 1 foot near the river, decreasing to about 0.2 to 0.4 feet in the farthest wells. The Alda wells show the oddest result of all, with the greatest increase projected in the wells of intermediate distance from the river (Figure 20) and a smaller increase in wells near the river and farthest away. The increase near the river is projected at about 1 foot, while that in the farthest wells is 0.3-0.4 foot or 4-5 inches.

Are these projections remotely meaningful? For 23 of the 28 regressions shown in tables 30 and 31, the r^2-value is less than 0.5. This means that the regression equation can at best explain less than 50 percent of the variation in the well water surface. In the case of the above noted regressions for the wells in the ground water mound, the r^2-values are 0.2-0.3, which means that 70-80 percent of the variation in well WSE is due to some factor or factors other than the equation. Since the water in the mound is between 30 and 70 feet higher in the wells, any correlation between the well WSE and the river WSE is due to coincidence. It would be physically impossible to have the river create a 1 to 2 foot rise on a water table that is so much greater in elevation. Alternatively, the regressions with the greatest r^2-values that are adjacent to the river, *i.e.* the first 4 in Table 31, are probably realistic. For the most part, these wells are within 100 feet of the river. With the exception of the well in the Elm Creek transect (¼-foot), the regressions project an approximate 1-foot rise in the wells with a 1-foot rise in the river. Since ground water in the Elm Creek transect appears to be controlled by the ground water mound to the south, the regressions developed for that transect do not appear to provide useful projections.

In an earlier section, the effect of the distance to the river on the significance of the well and gage WSE was evaluated using cluster analysis and discriminant analysis based on well distances greater or less than 10,000 feet from the river. Because the wells very near the river appear to show an even greater difference from others within 10,000 feet, the first group was further split into 2 based on a 1000-foot distance between the well and the river. The comparison is based on a Oneway ANOVA and Fisher's Least Significant Difference (LSD) Test. The results are shown in Table 32.

The average r-value for the correlations between WSE and GH for the distance less than 1000 feet is 0.9 (Table 32); it decreases to 0.5 between 1000 and 10,000 feet from the river and decreases further to 0.4 beyond 10,000 feet from the river. All of these values are significantly different from one another. If these are translated to an r^2-value, the resulting values are 0.81, 0.29, and 0.16 for the 3 respective groups. In other words, there is little potential for a significant degree of control for the ground water by the river beyond a distance of 1000 feet. Based on the actual data, the maximum distance would really be at 700 feet or less, but there are no data between 700 and 1200 feet to further refine the distance limit.

Table 32. Effects of distance to the river on the significance of correlations

A. Analysis of Variance - distance to river

Correlation	Between Group Means			ANOVA	
	< 1000’	< 10,000’	≥10,000’	F	Prob. > F
r WSE GH	0.898	0.539	0.397	18.1282	0.000014
r WSERAIN	0.146	0.112	0.045	1.9608	0.161803
r ΔWSE ΔGH	0.649	0.201	0.163	21.9101	0.000003
r ΔWSE RAIN	0.391	0.323	0.141	5.2873	0.012162

B. Group Comparisons - Fisher’s LSD

Correlation	Between Group MSE			Between Group Probablilities		
	Grp 1 & 2	Grp 1 & 3	Grp 2 & 3	Grp 1 & 2	Grp 1 & 3	Grp 2 & 3
r WSE GH	-0.359	-0.502	-0.143	0.000177	0.000003	< 0.000001
r WSE RAIN	-0.034	-0.101	-0.067	0.571998	0.104402	0.121609
r ΔWSE ΔGH	-0.448	-0.486	-0.038	0.000003	0.000001	0.482313
r ΔWSE RAIN	-0.069	-0.250	-0.181	0.463053	0.013572	0.011041

Table 32 also evaluates the correlations between ΔWSE and ΔGH. These also show a significant drop in the r-values between the wells less 1000 feet and those farther away. However, there is no significant difference between the two groups of wells farther from the river than 1000 feet. The average r-value between ΔWSE and ΔGH for the wells less than 1000 feet from the river is much smaller than was the case for the WSE-GH correlations. These would not provide reasonably predictive regressions and indicate that the differences between the ΔWSE and ΔGH are not proportional. This is what would be expected if the distance from the river is the major factor moderating the peak changes in WSE in the wells that are influenced by the river.

Table 32 also shows the effect on relationships of WSE and ΔWSE with rainfall. There were very poor r-values in general for the WSE-precipitation correlations, and there is no significant difference with distance from the river. Alternatively, the ΔWSE-precipitation correlations do show a difference between wells less than 10,000 feet from the river and the group of wells farther away. The break between wells less than 1000 feet from the river and the group between 1000 and 10,000 feet is not significant in the case of the correlations between ΔWSE and precipitation.

The lagged correlations that were discussed previously also support the hypothesis that the ground water and surface water in most cases are moving in concert due to an outside influence. The “best correlations” in the majority of cases are between a given well’s WSE and the stage at the Grand Island gage. If any of these could improve its r^2-value beyond 0.75, it would be worthy of further review to evaluate the potential for an interaction with the river. Table 33 shows the “best correlation” and an r^2-value, along with a review of the number of lags that went into the correlation and the distance to the river. As can be seen in Table 33, only the same 3 wells as above show an r^2-value greater than 0.75. However, 2 of the 3 now show a better correlation with the Grand

Island gage than with the nearest gage. These include the two wells from the Minden transect (U_1 and D_1). The Grand Island gage is the nearest for the third well in the group, Alda_U_1.

Table 18 showed the correlations among the 3 active Platte River gages within the study area. The table shows a very good correlation among the gages. Logic would dictate that the flows at Grand Island cannot affect those at either the gage at Kearney or the one at Overton. Water rarely flows up hill. Alternatively, the gage at Overton will affect both the one at Kearney and the one at Grand Island, since most of the water at the lower gage will originate from water passing the upper gage. The same is true of wells. If a well is continuously greater in elevation than the river, the river's effect on the well will be minimal. Just as the Grand Island gage will not affect the upstream gages, it will not affect the upgradient (or upstream) wells. It is just that the stage at the Grand Island gage better mimics the WSE of the wells and therefore produces a better correlation with the well WSE, even for a well that shows a very good correlation with an adjacent gage, such as the 2 Minden wells nearest the river.

Table 33. Best correlation summary for each well with Platte River gage

Well	r-value	Gage	r^2-value	Distance to river	No. of Lags
Ovtn_U_3	0.6509	at Grand Island	0.4237	15,500	1
Ovtn_U_2	0.3963	at Kearney	0.1571	11,200	0
Ovtn_U_1	0.6909	at Kearney	0.4773	5,000	5
Ovtn_D_3	0.6639	at Grand Island	0.4408	17,500	0
Ovtn_D_2	0.4732	at Kearney	0.2239	11,000	0
Ovtn_D_1	0.5634	at Grand Island	0.3174	6,000	1
ElmC_U_4	0.5424	at Grand Island	0.2942	17,300	0
ElmC_U_3	0.6570	at Grand Island	0.4316	6,300	0
ElmC_U_2	0.2253	at Grand Island	0.0508	1,500	0
ElmC_U_1	0.8119	at Grand Island	0.6592	100	1
ElmC_D_4	0.6578	at Grand Island	0.4327	17,400	0
ElmC_D_3	0.3546	at Kearney	0.1258	12,100	0
ElmC_D_2	0.6078	at Grand Island	0.3694	6,900	1
ElmC_D_1	0.6228	at Grand Island	0.3878	2,700	3
Mndn_U_4	0.1962	at Kearney	0.0385	14,200	0
Mndn_U_3	0.5040	at Grand Island	0.2540	9,000	0
Mndn_U_2	0.7370	at Grand Island	0.5431	3,800	0
Mndn_U_1	0.9318	at Grand Island	0.8682	700	0
Mndn_D_3	0.2703	at Kearney	0.0730	13,000	1
Mndn_D_2	0.6057	at Grand Island	0.3669	7,700	0
Mndn_D_1	0.9790	at Grand Island	0.9584	100	0
Alda U 4	0.5335	at Grand Island	0.2847	23,300	0
Alda U 3	0.6686	at Grand Island	0.4471	8,000	0
Alda U 2	0.7412	at Grand Island	0.5494	3,000	0
Alda U 1	0.9809	at Grand Island	0.9621	50	0
Alda D 3	0.6210	at Grand Island	0.3857	11,000	0
Alda D 2	0.6213	at Grand Island	0.3860	6,500	0
Alda D 1	0.6939	at Grand Island	0.4815	1,200	0

Conclusions

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.
- 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 a 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.

Conclusions related to the precipitation analysis include the following:

- Precipitation amounts varied greatly over the study area.
- 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.

ATTACHMENT A

Contents -

1. Plots of ground water surface elevation, precipitation, and Platte River gage height during April 1999: pages A-1 through A-9
2. Plots of ground water surface elevation, precipitation, and Platte River gage height from March 11 through September 21, 1999: pages A-10 through A-37

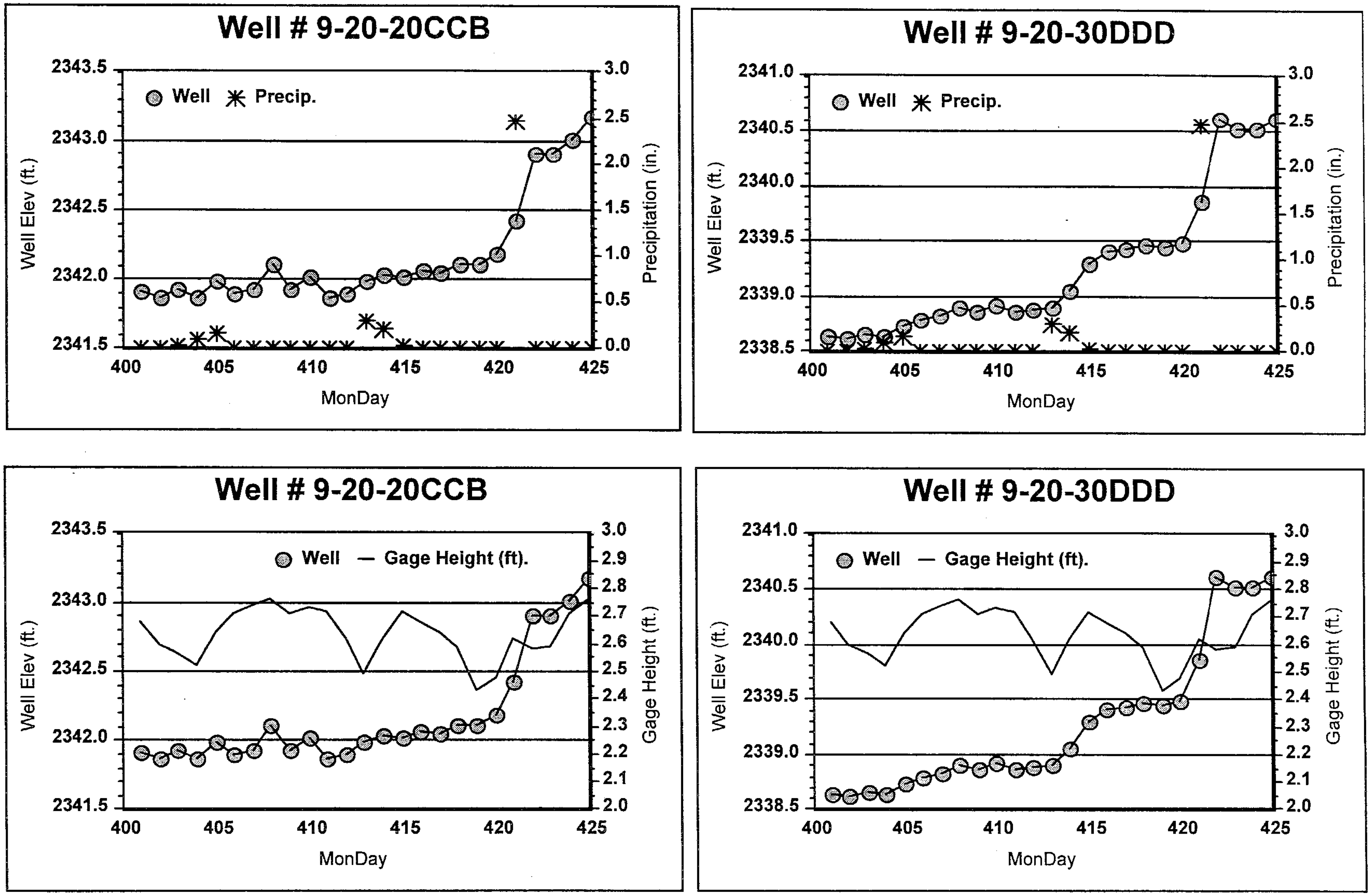


Figure 1: Overton Upstream Wells

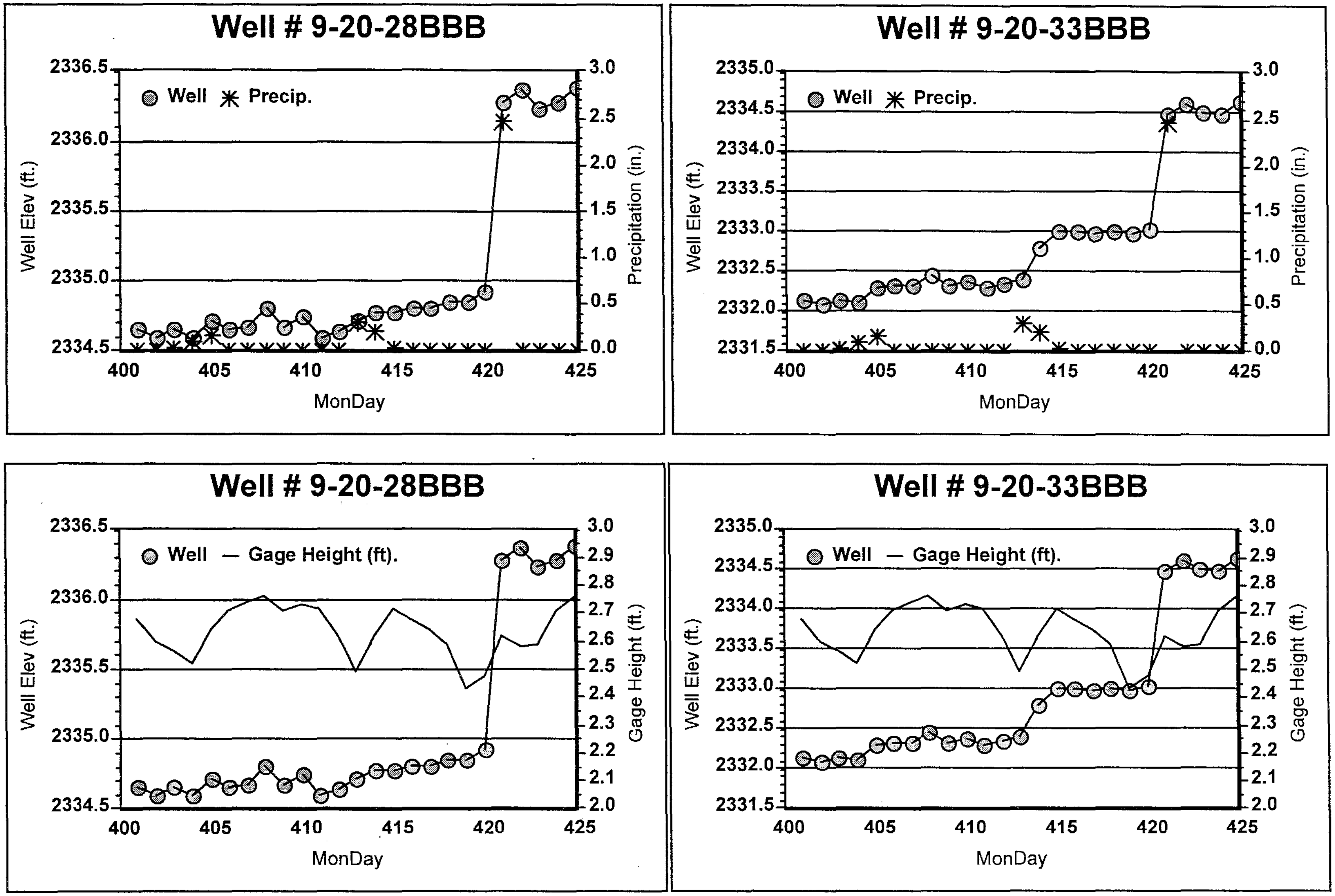


Figure 2: Overton Downstream Wells

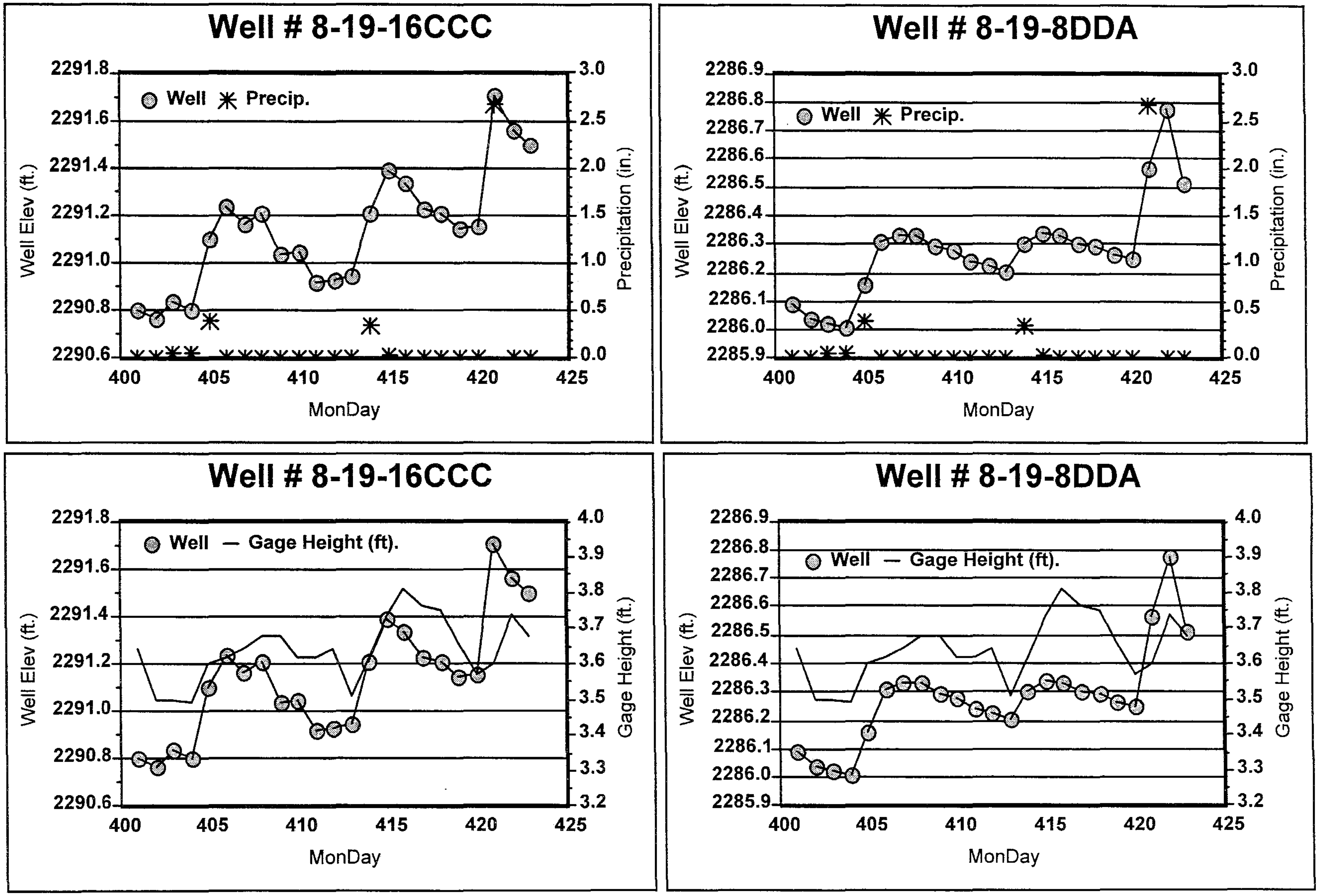


Figure 3: Elm Creek Upstream Wells

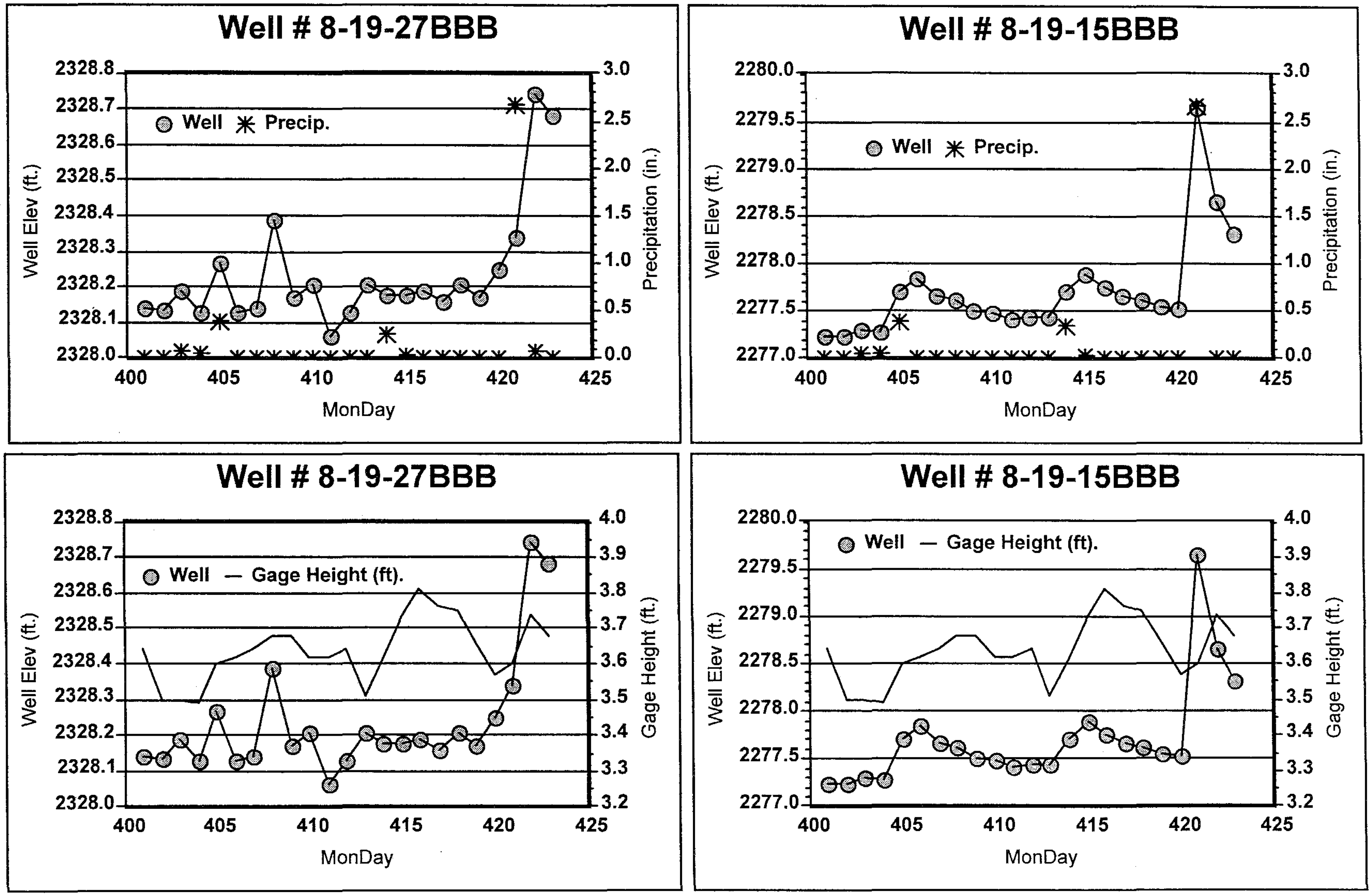


Figure 4: Elm Creek Downstream Wells

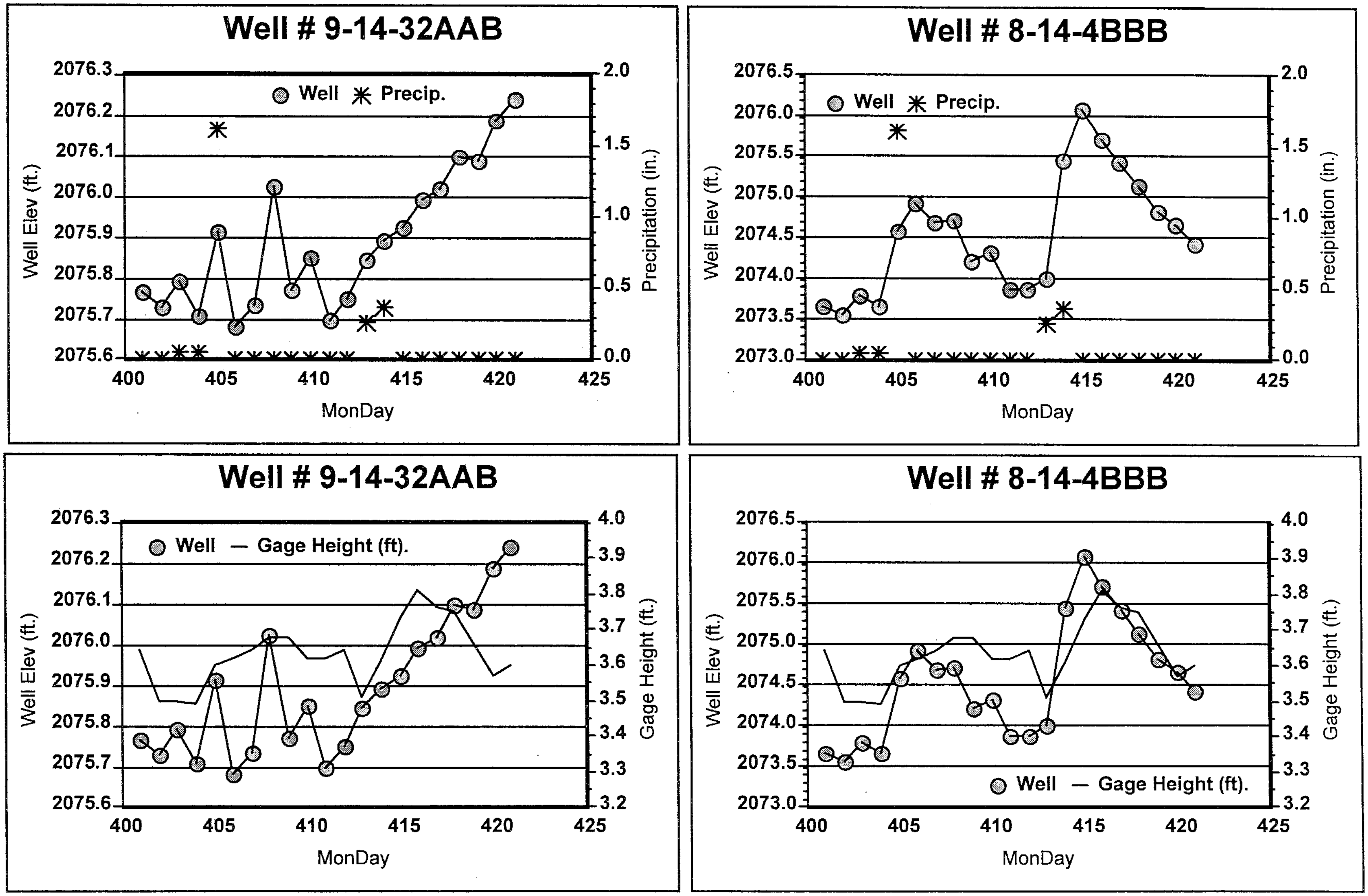


Figure 5: Minden Upstream Wells

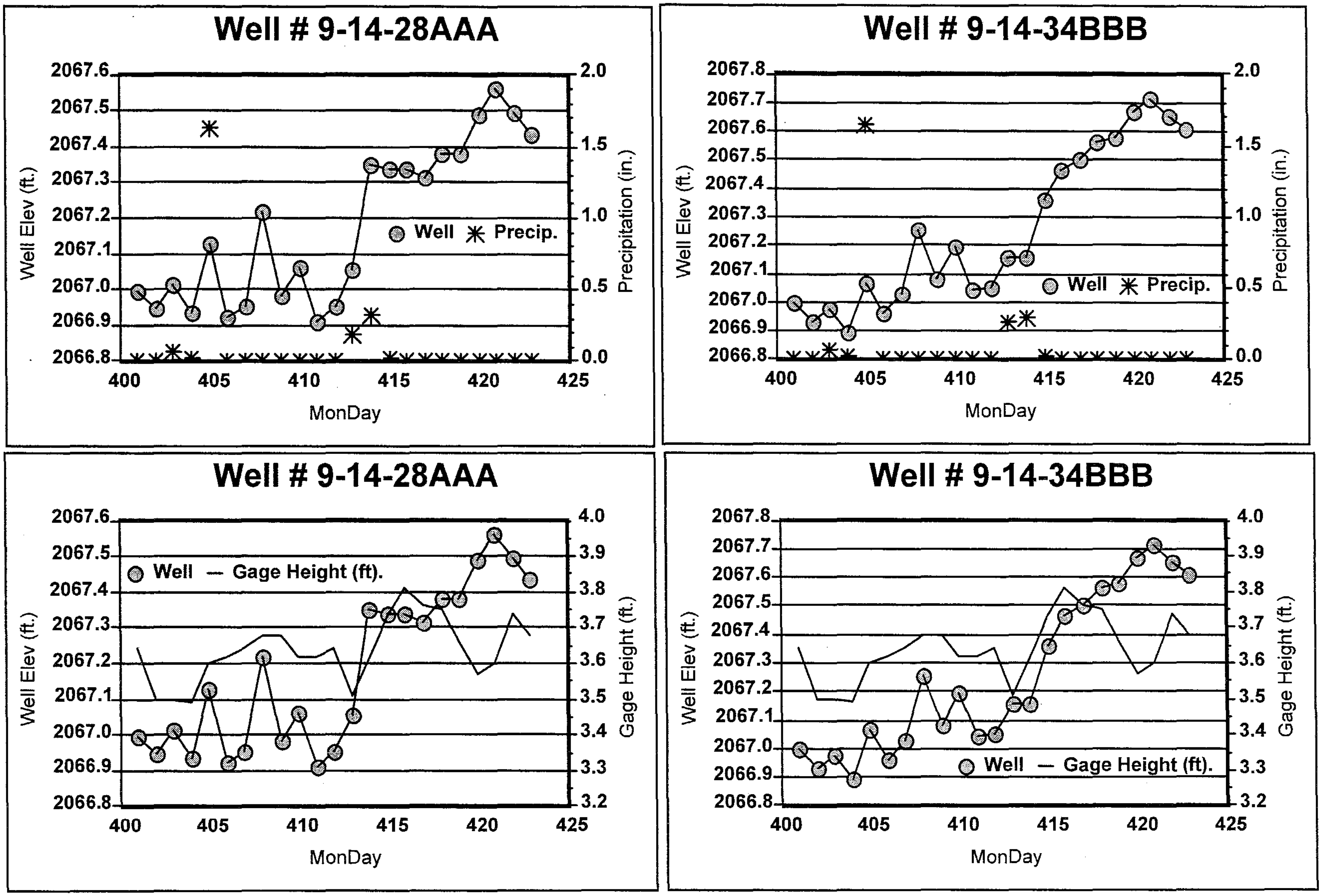


Figure 6: Minden Downstream Wells

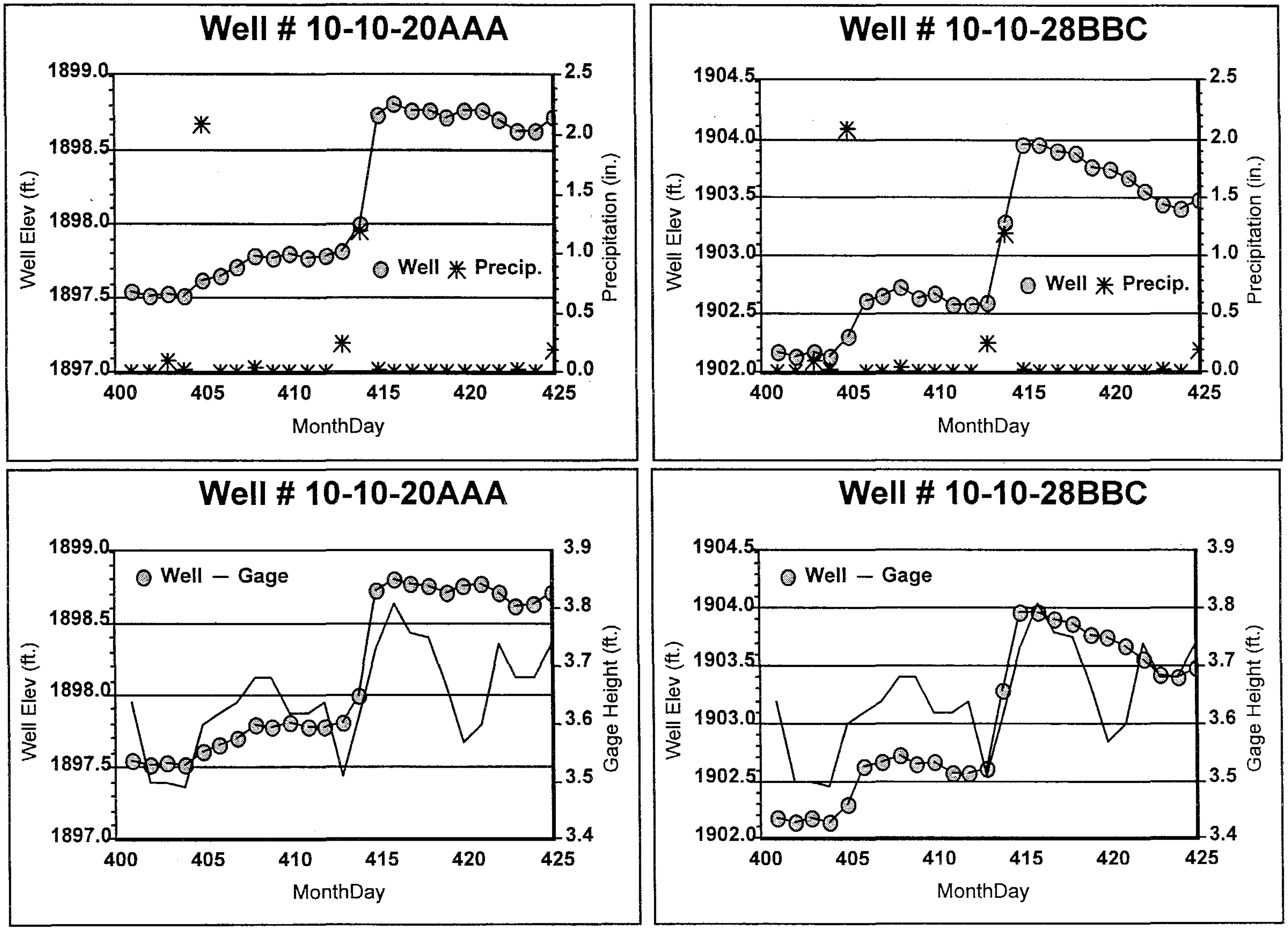


Figure 7: Alda Upstream Wells

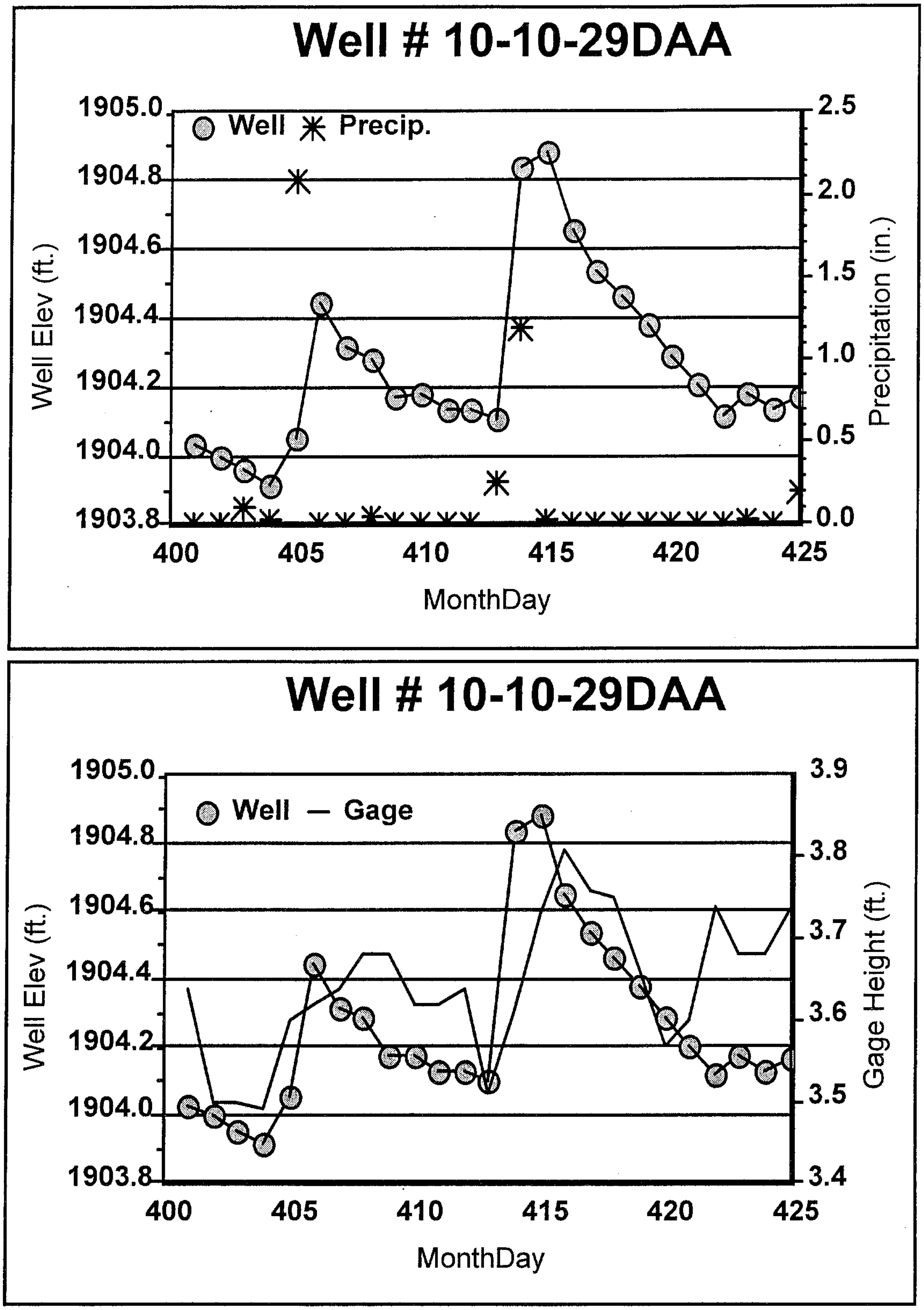


Figure 8: Alda Upstream Wells (continued)

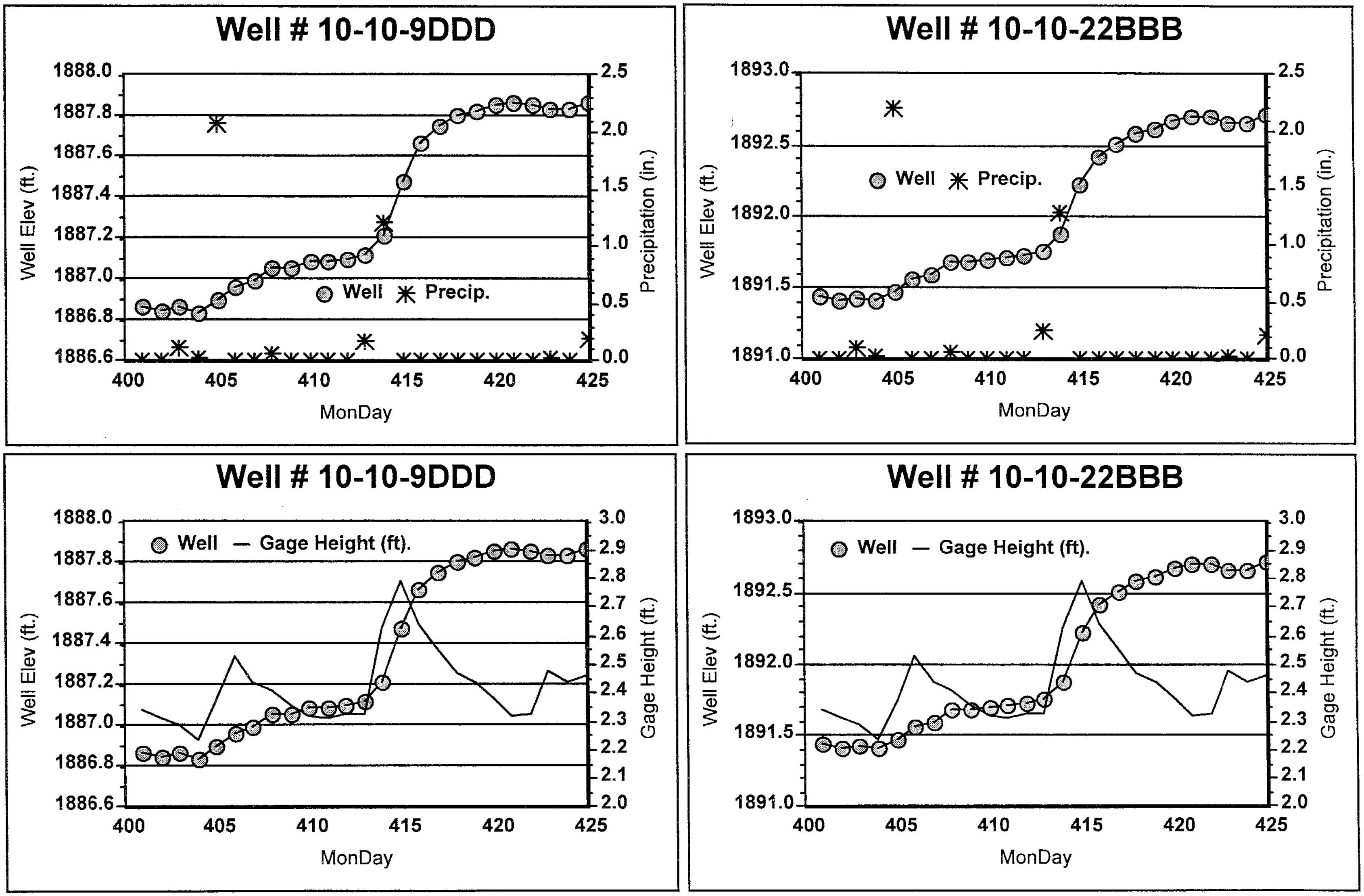


Figure 9: Alda Downstream Wells

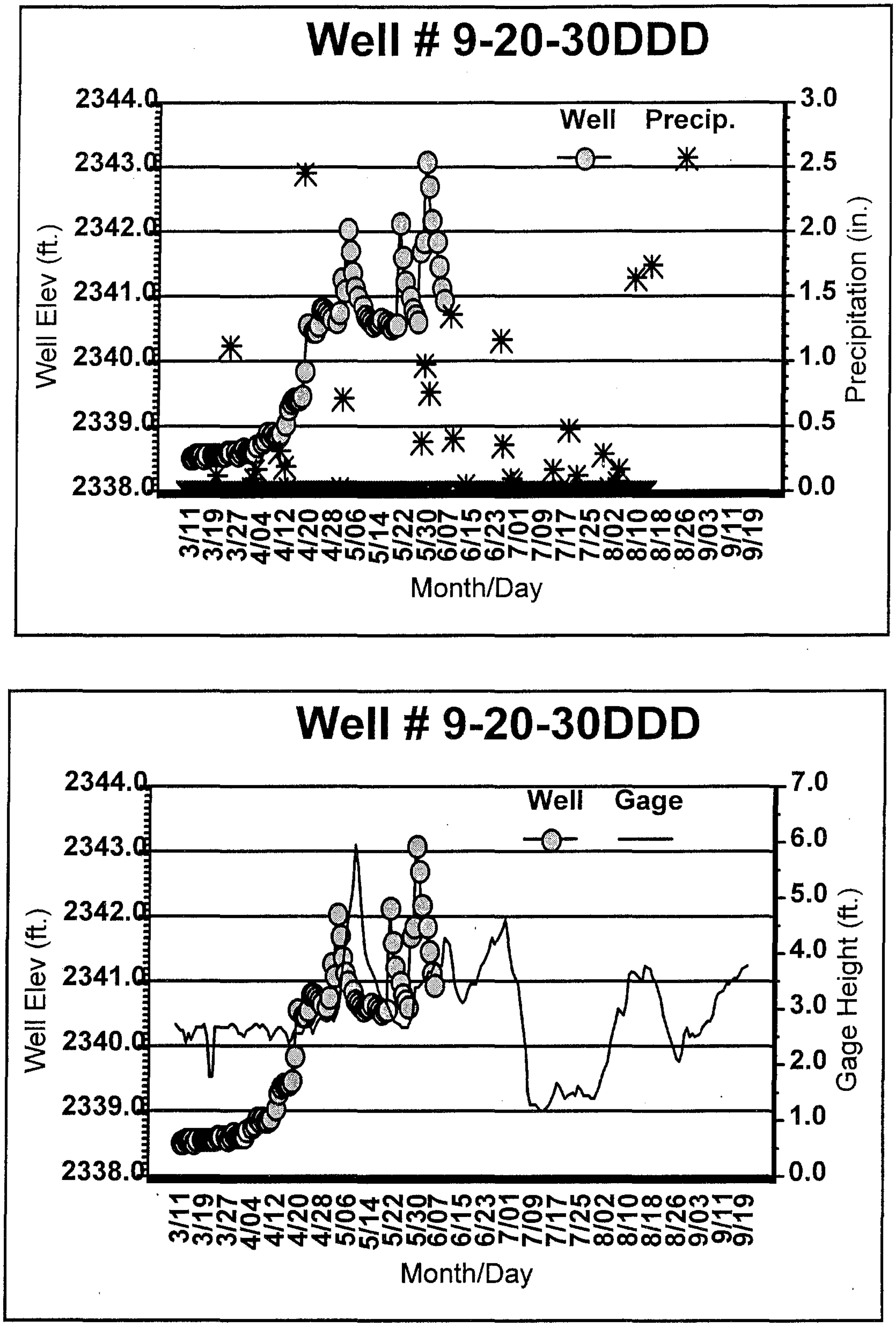
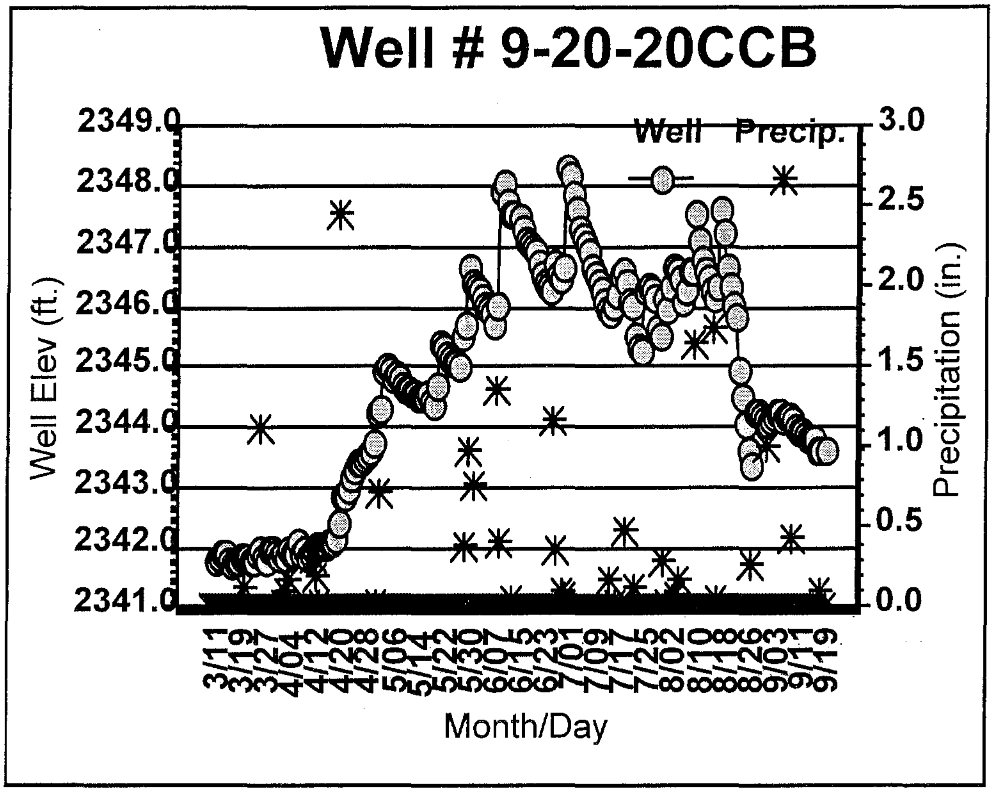


Figure 10: Overton upstream well number 1



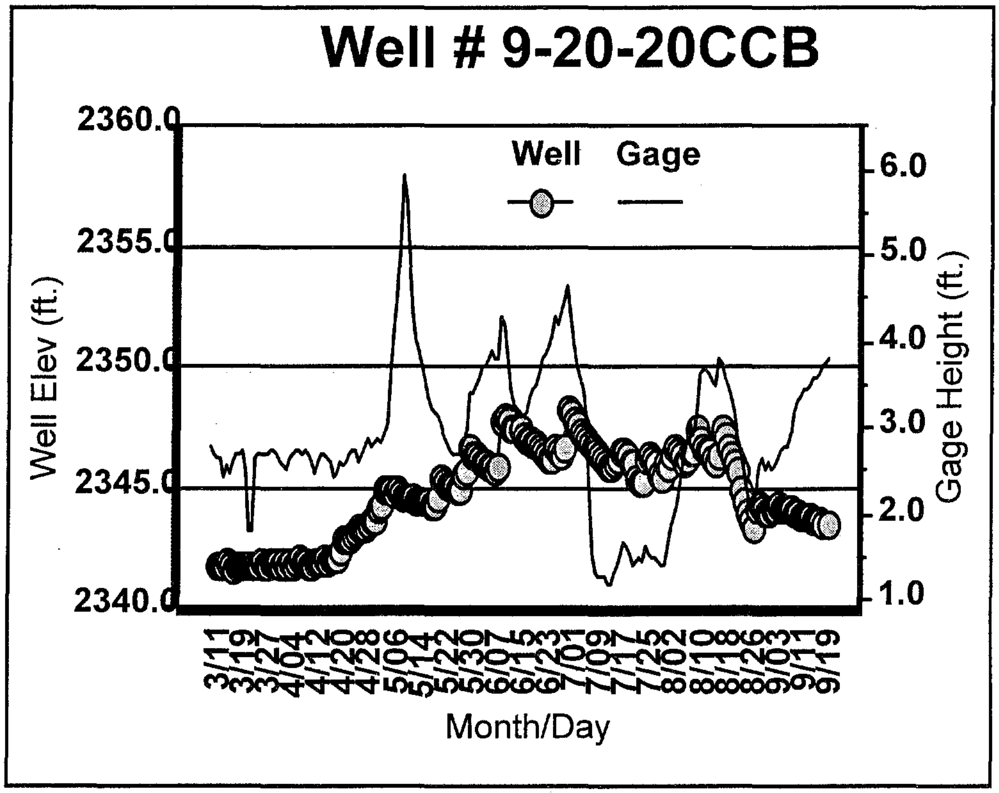
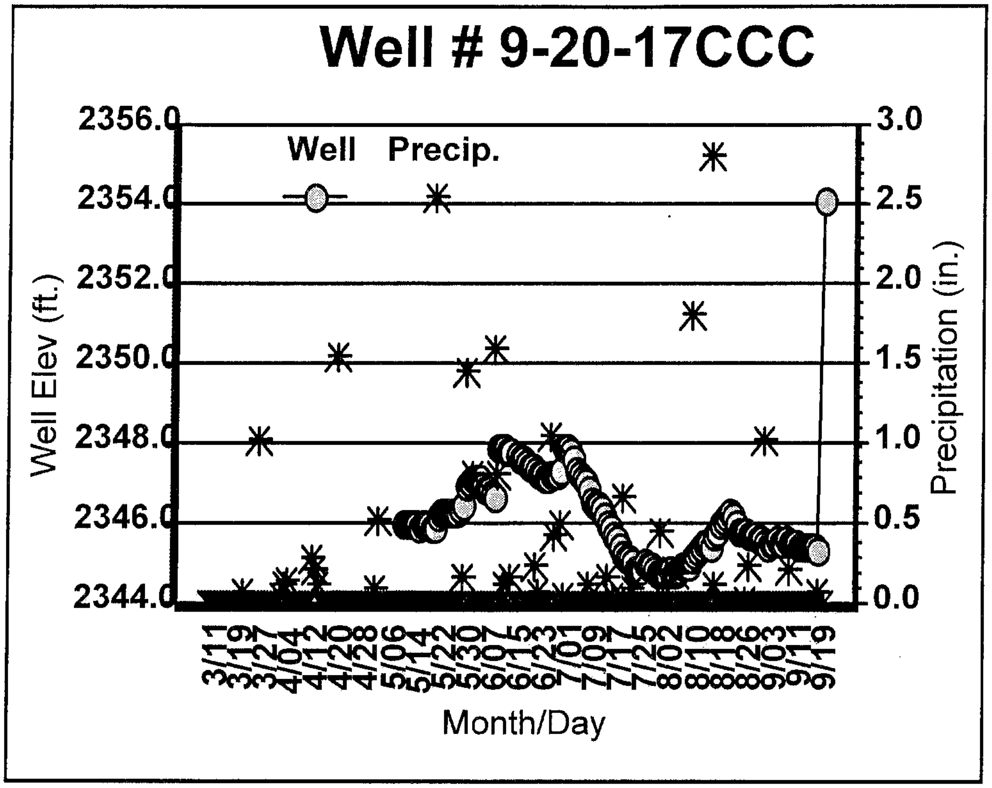


Figure 11: Overton upstream well number 2



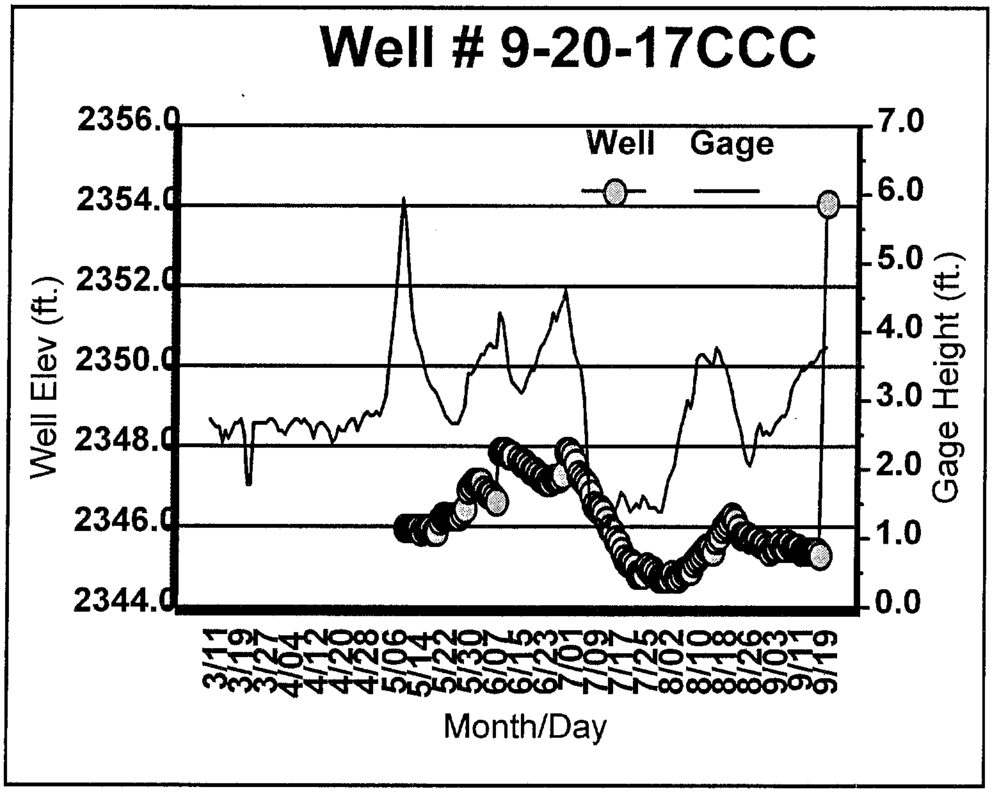


Figure 12: Overton upstream well number 3

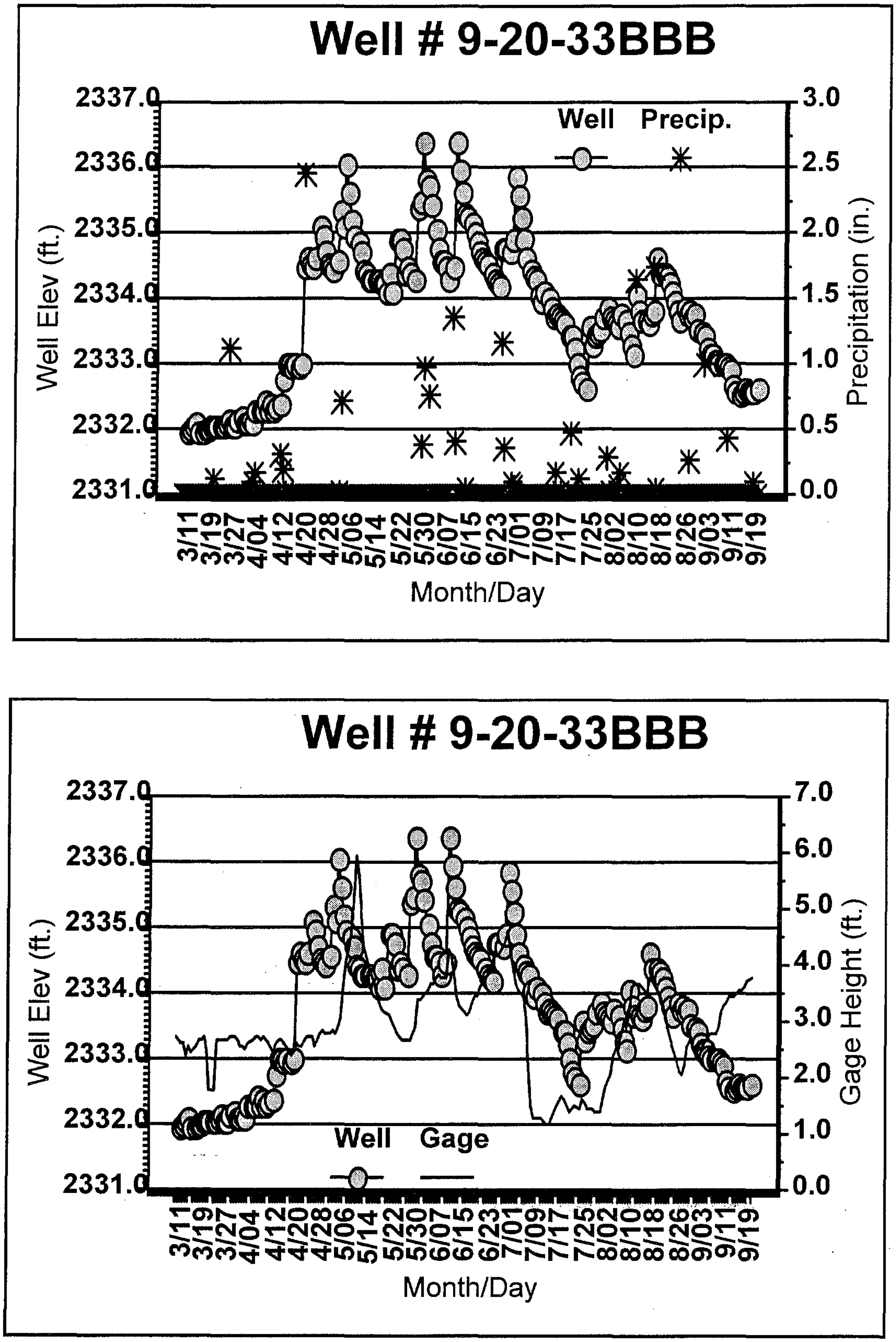


Figure 13: Overton downstream well number 1

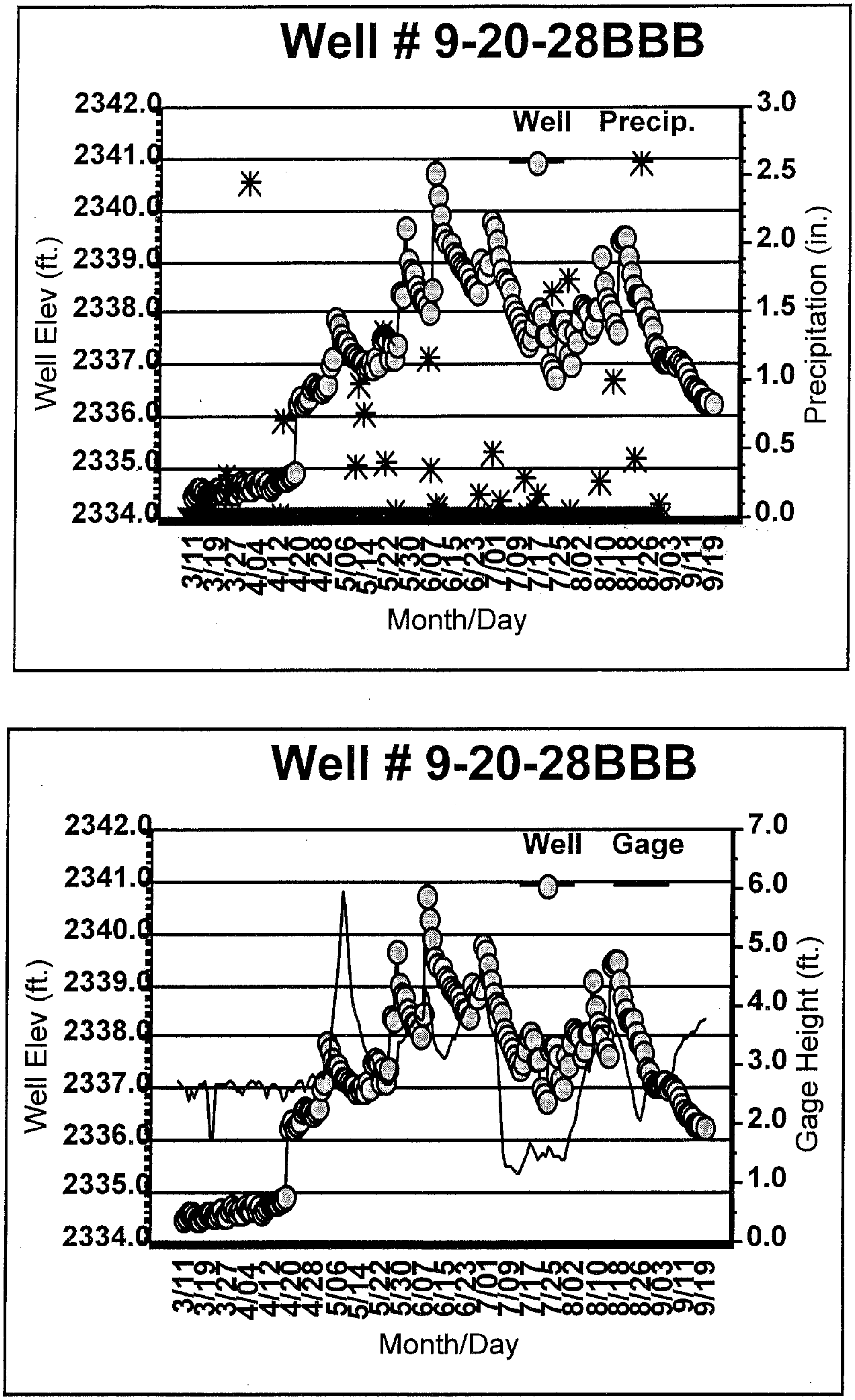


Figure 14: Overton downstream well number 2

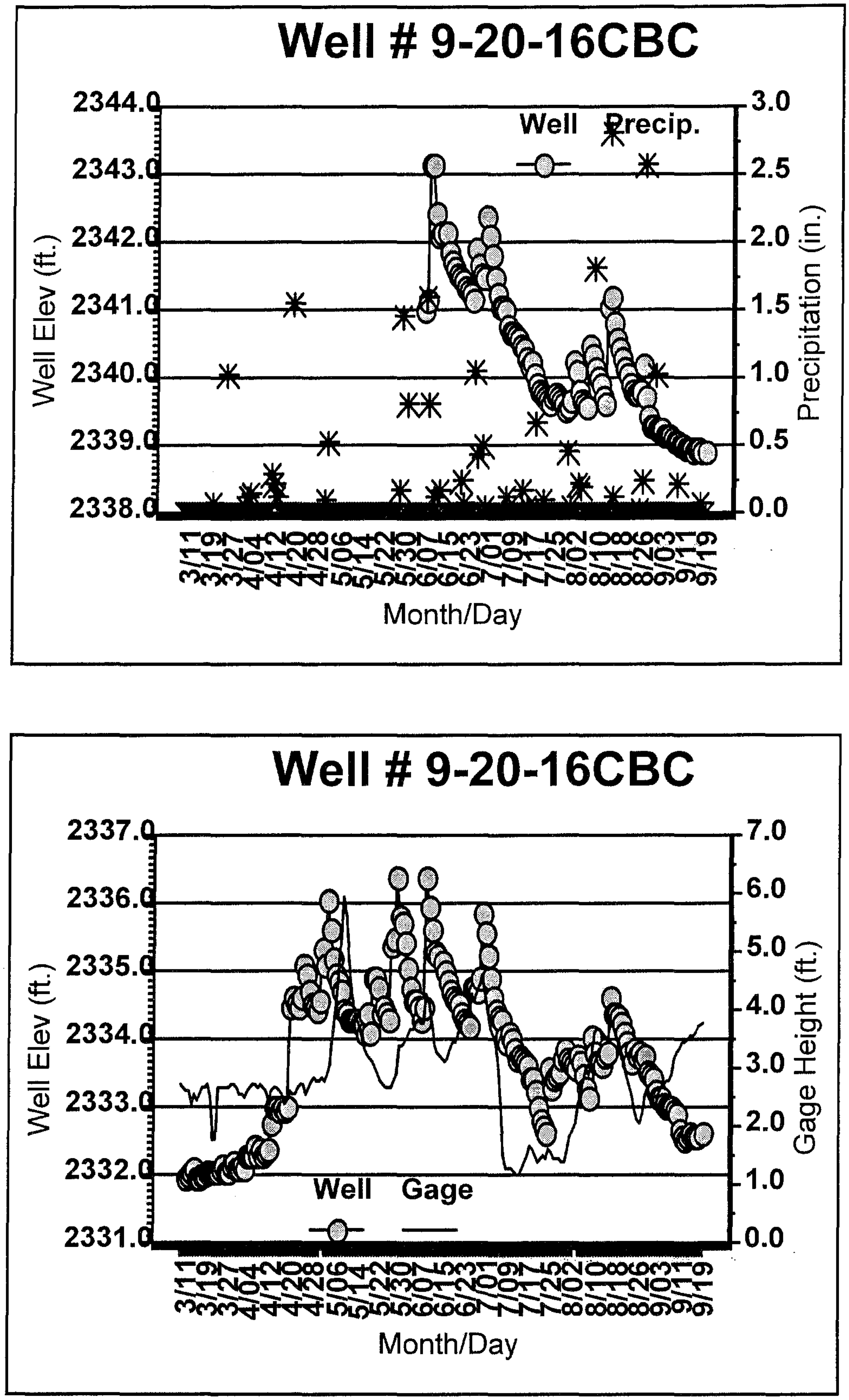


Figure 15: Overton downstream well number 3

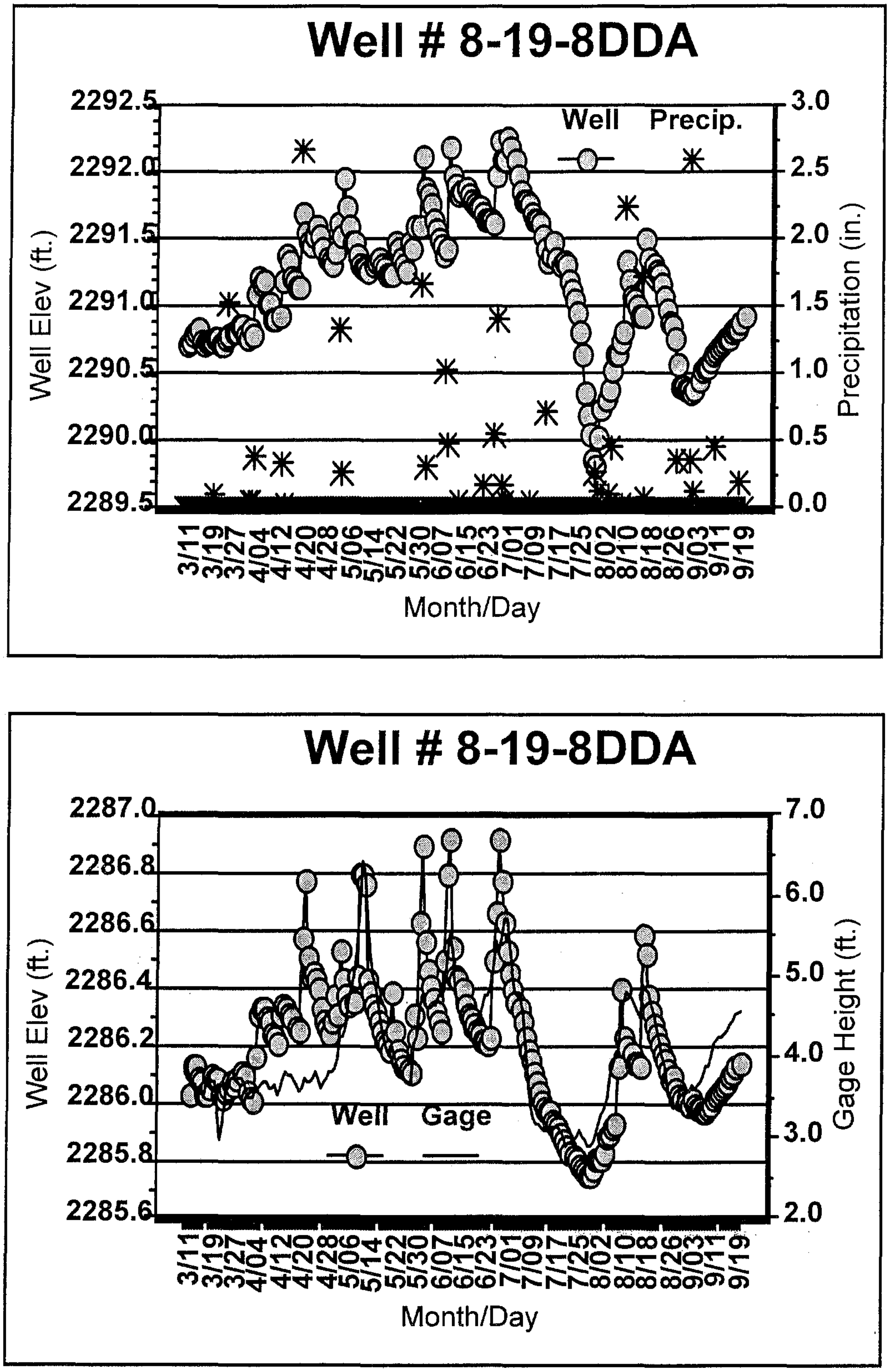


Figure 16: Elm Creek upstream well number 1

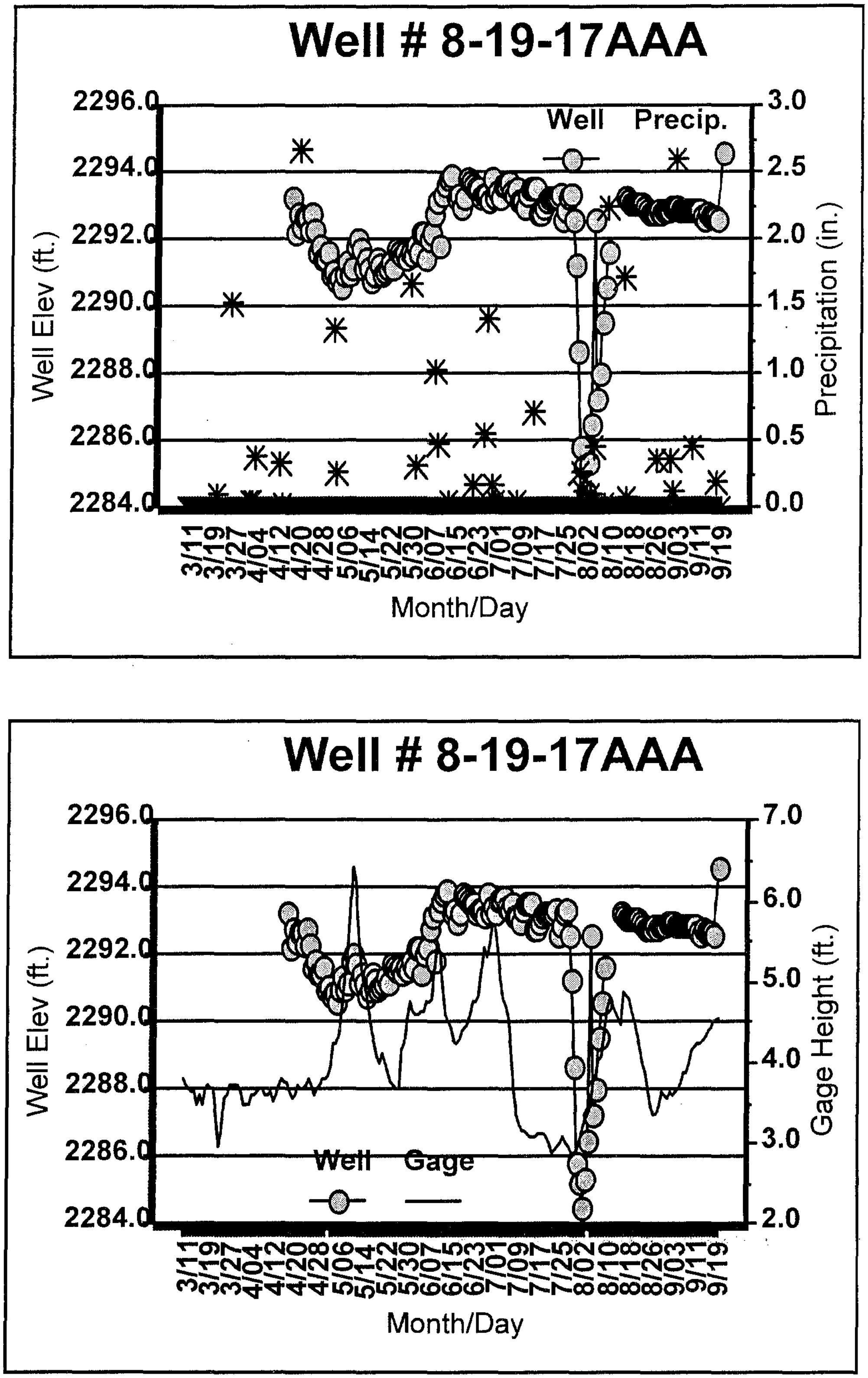
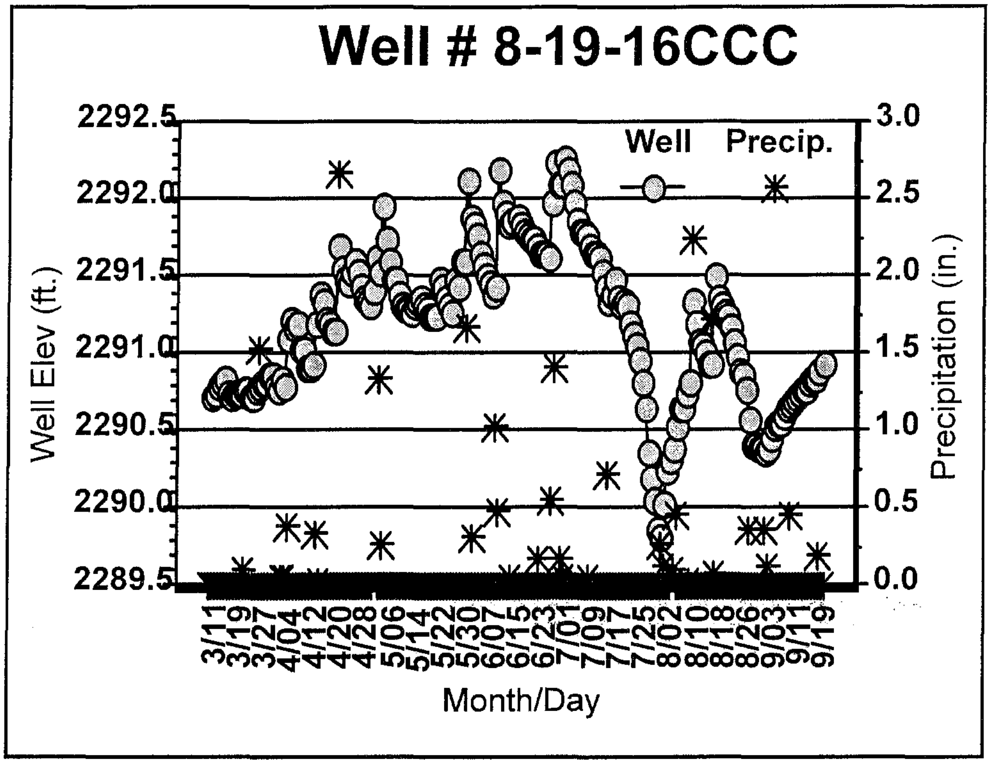


Figure 17: Elm Creek upstream well number 2



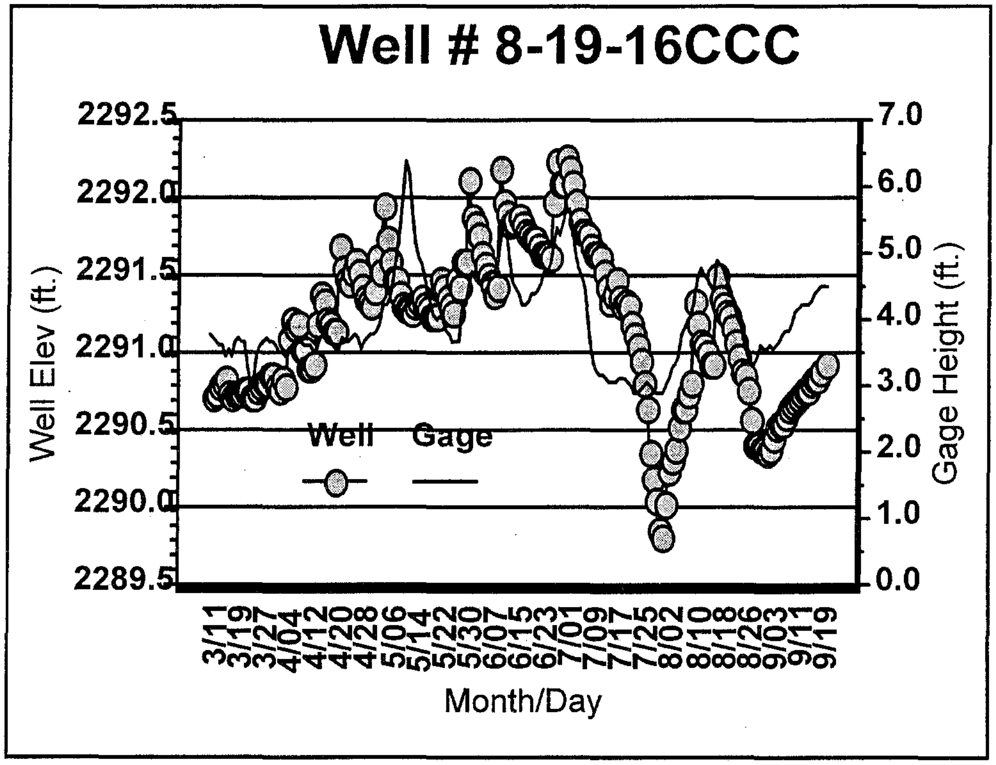


Figure 18: Elm Creek upstream well number 3

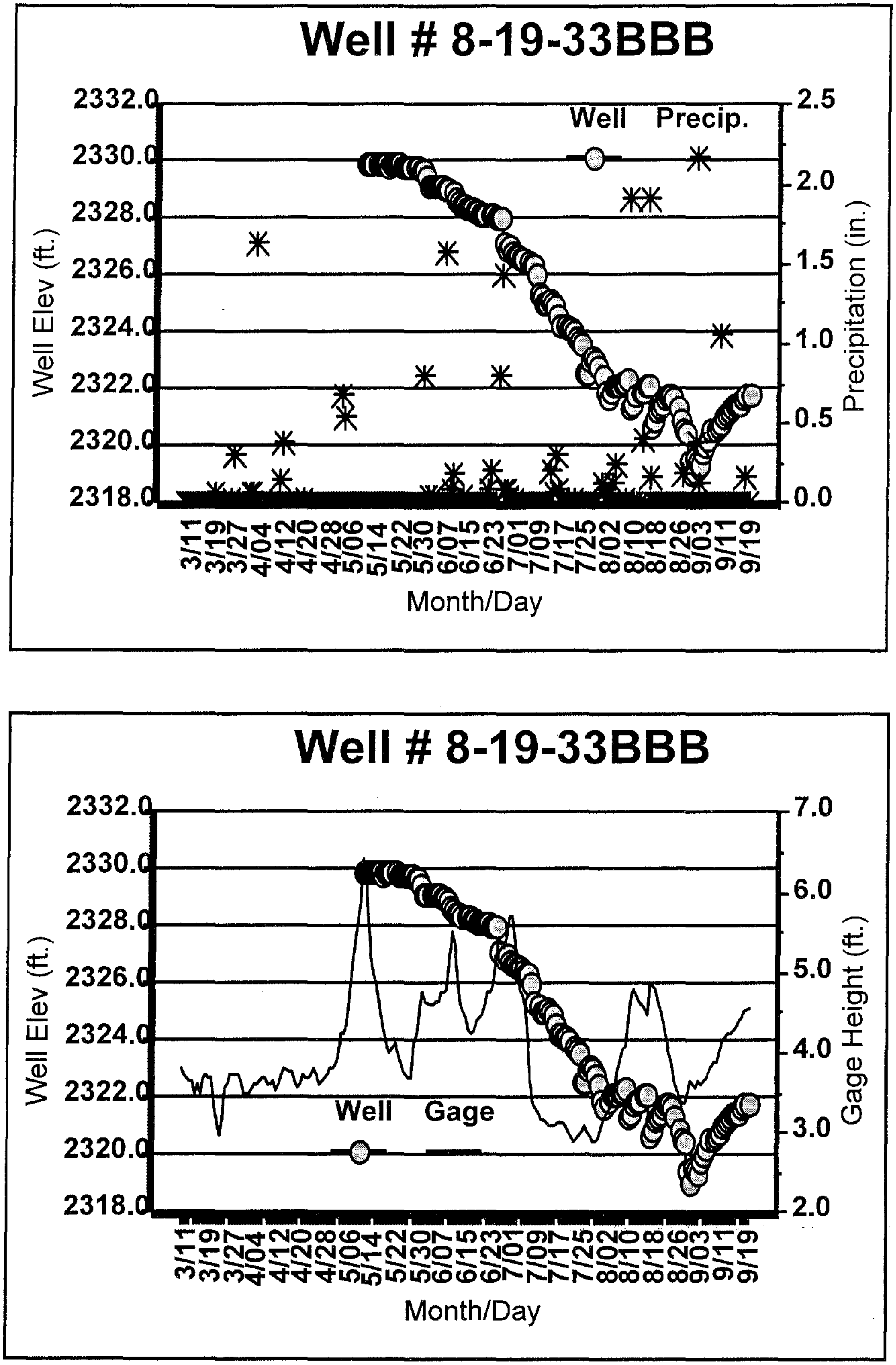
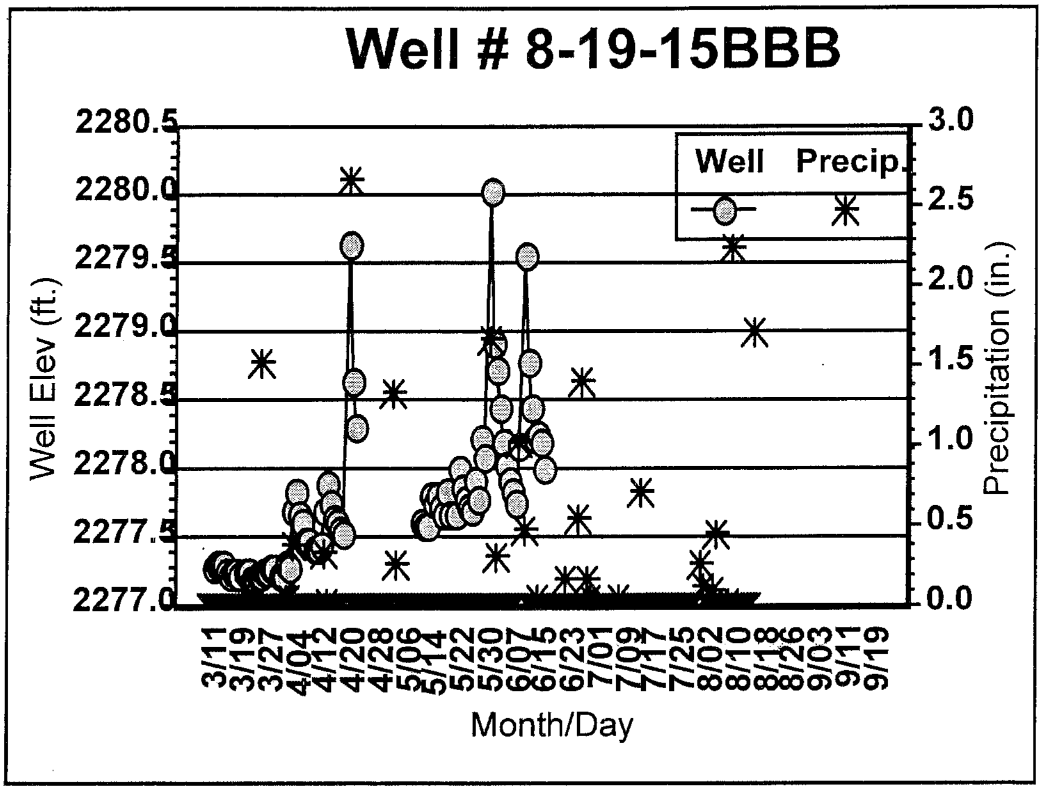


Figure 19: Elm Creek upstream well number 4



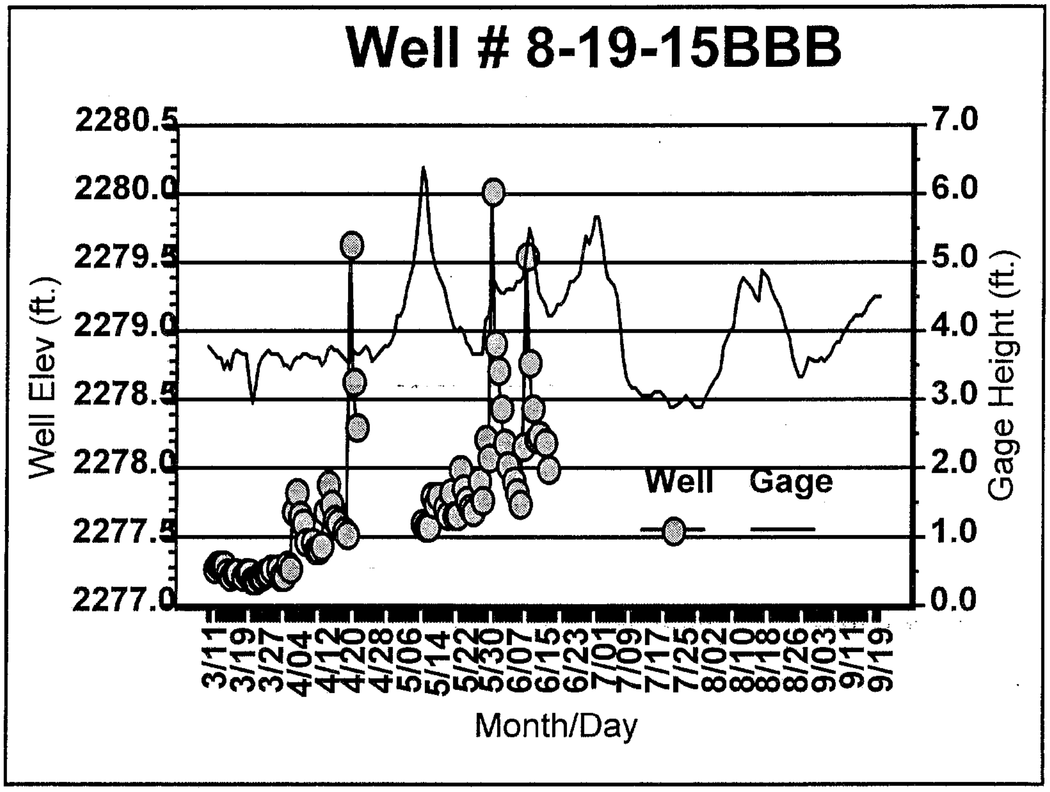


Figure 20: Elm Creek downstream well number 1

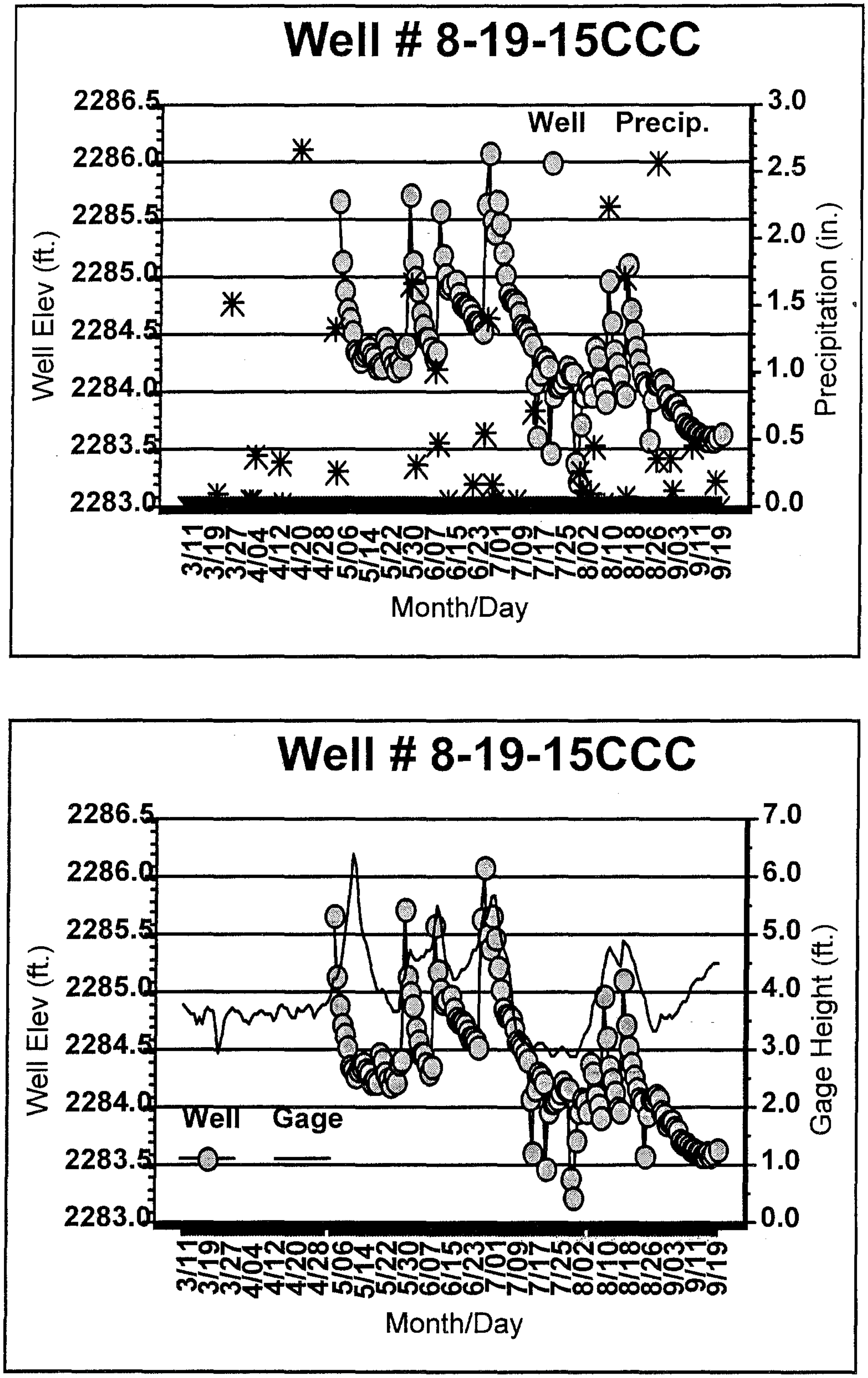
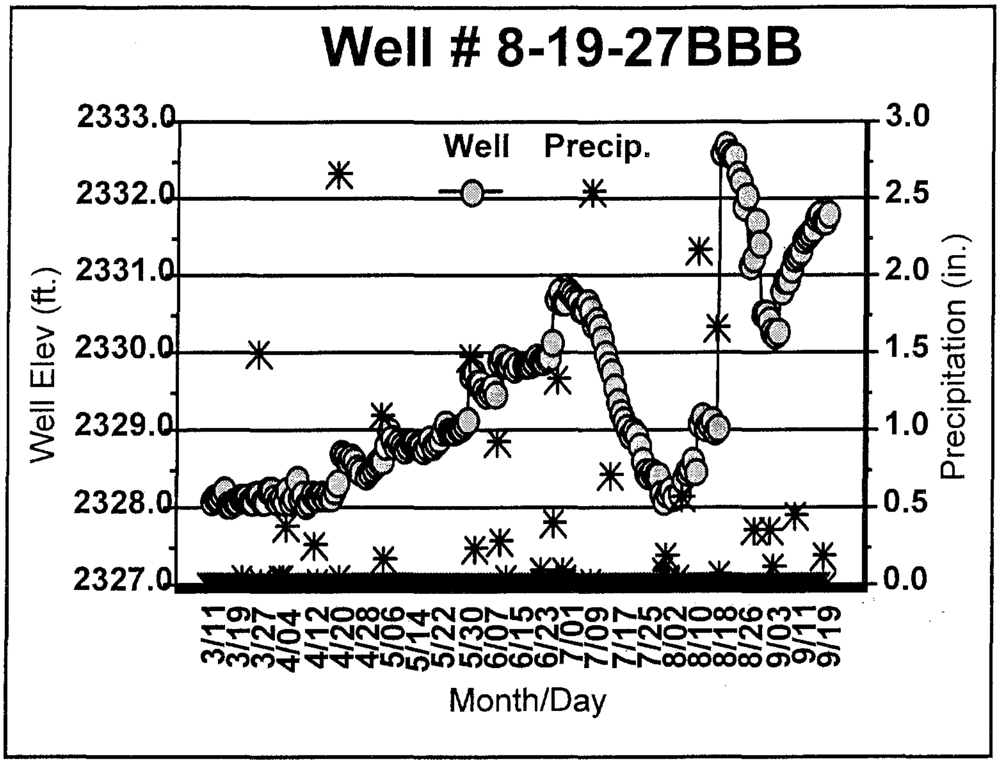


Figure 21: Elm Creek downstream well number 2



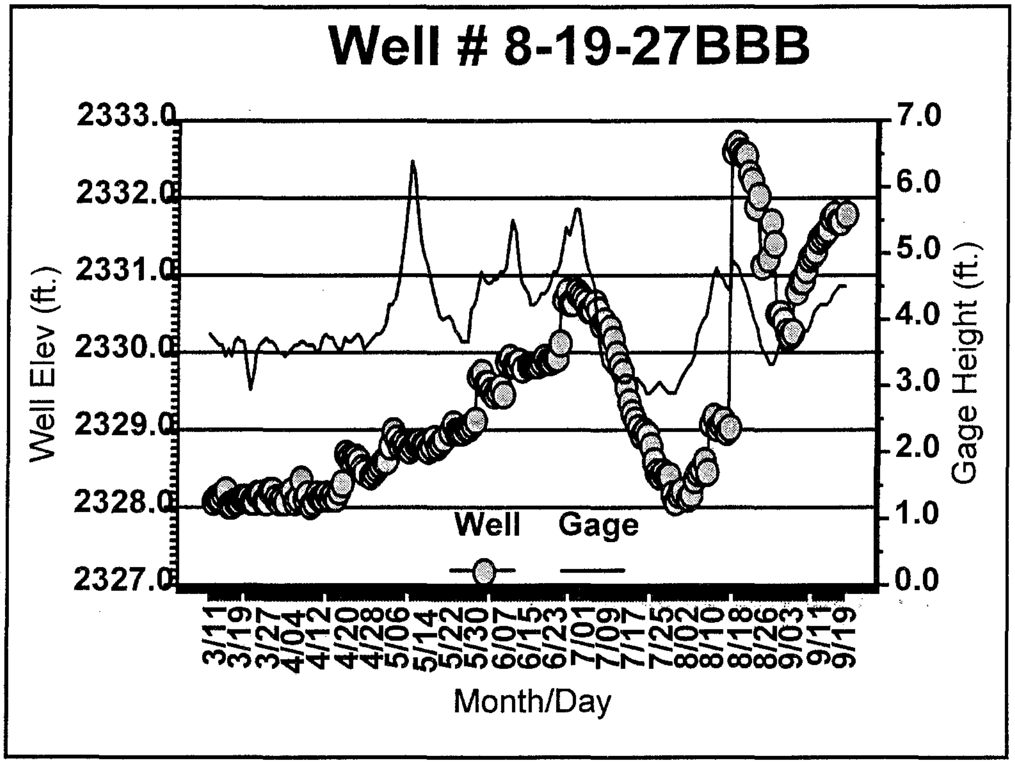


Figure 22: Elm Creek downstream well number 3

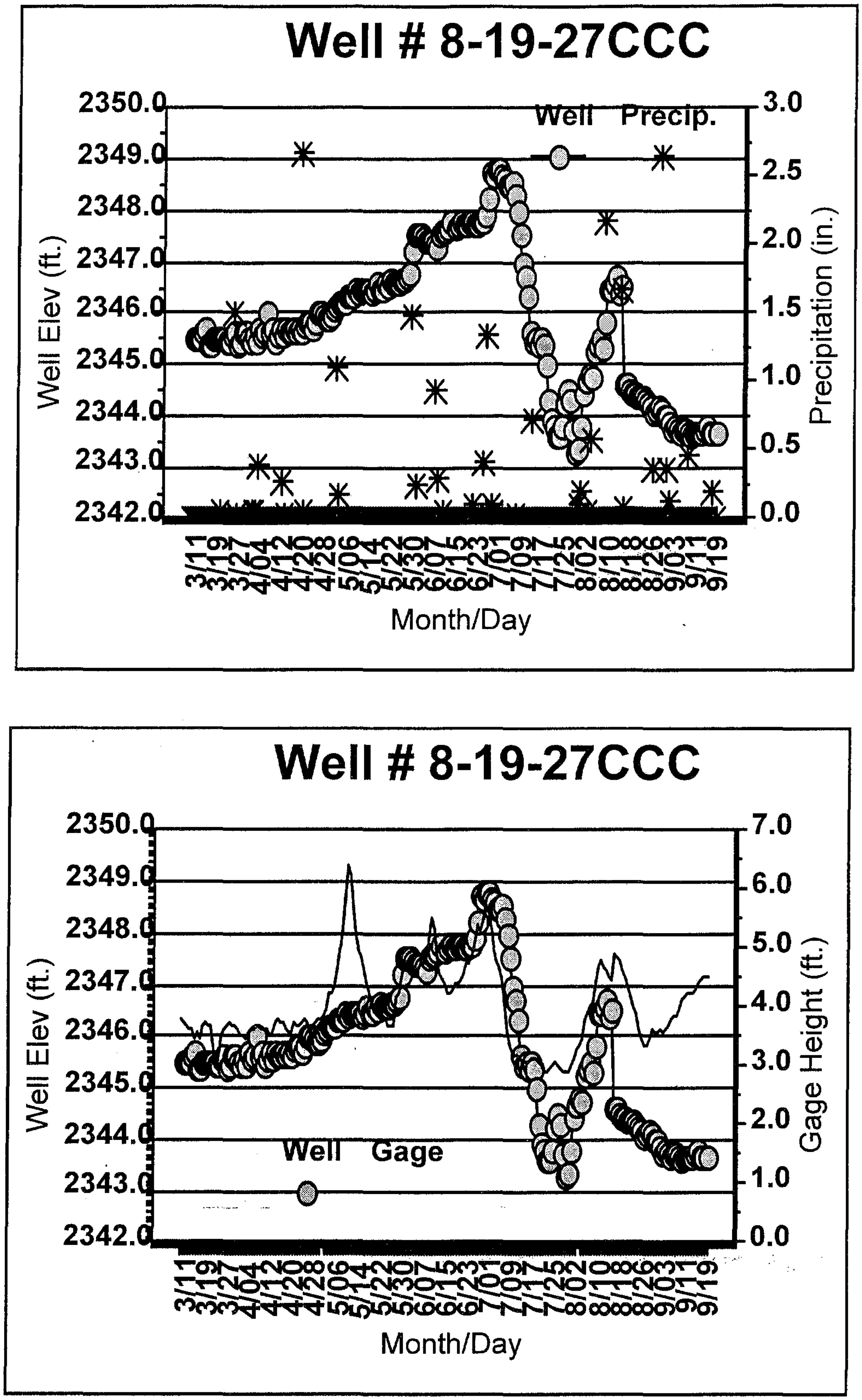
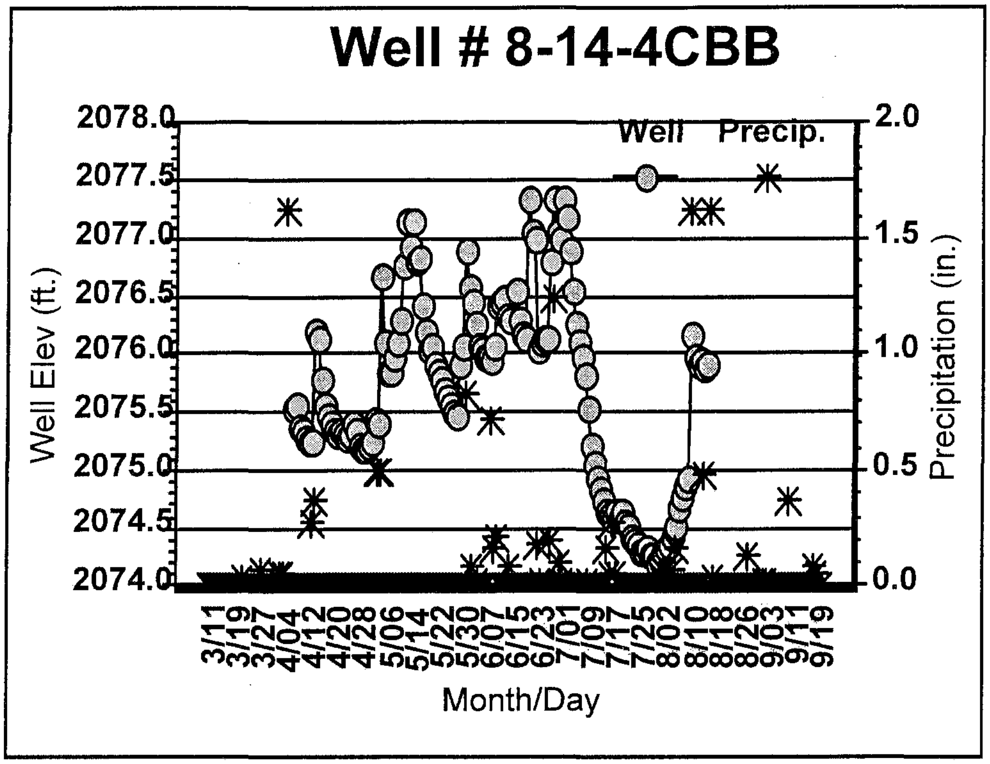


Figure 23: Elm Creek downstream well number 4



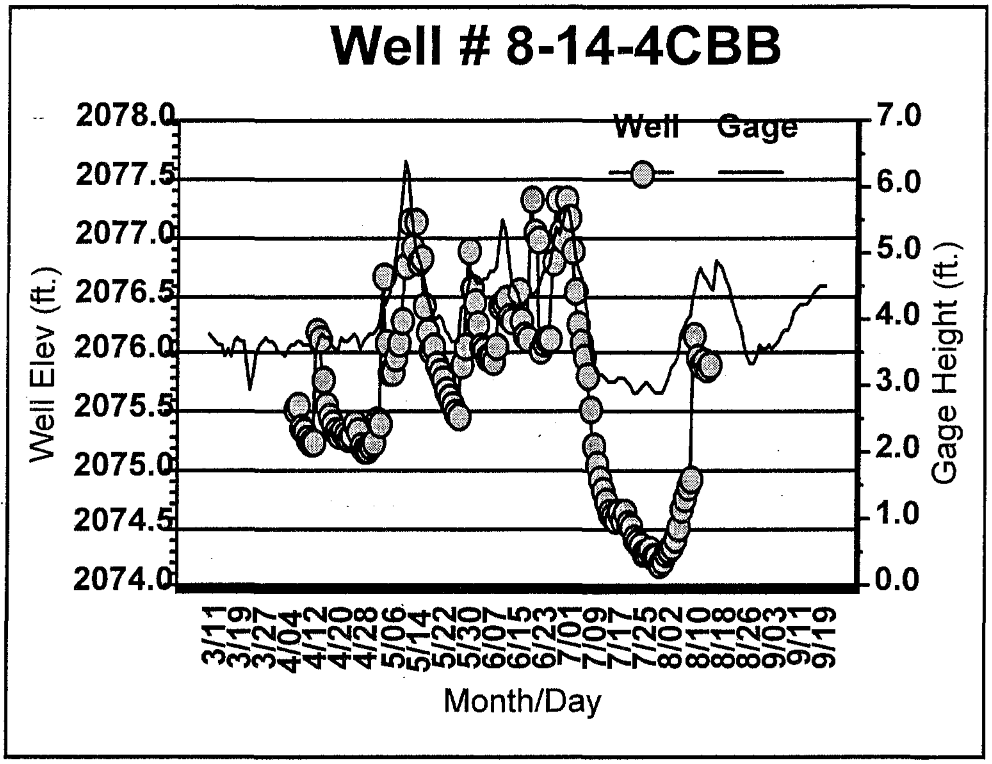
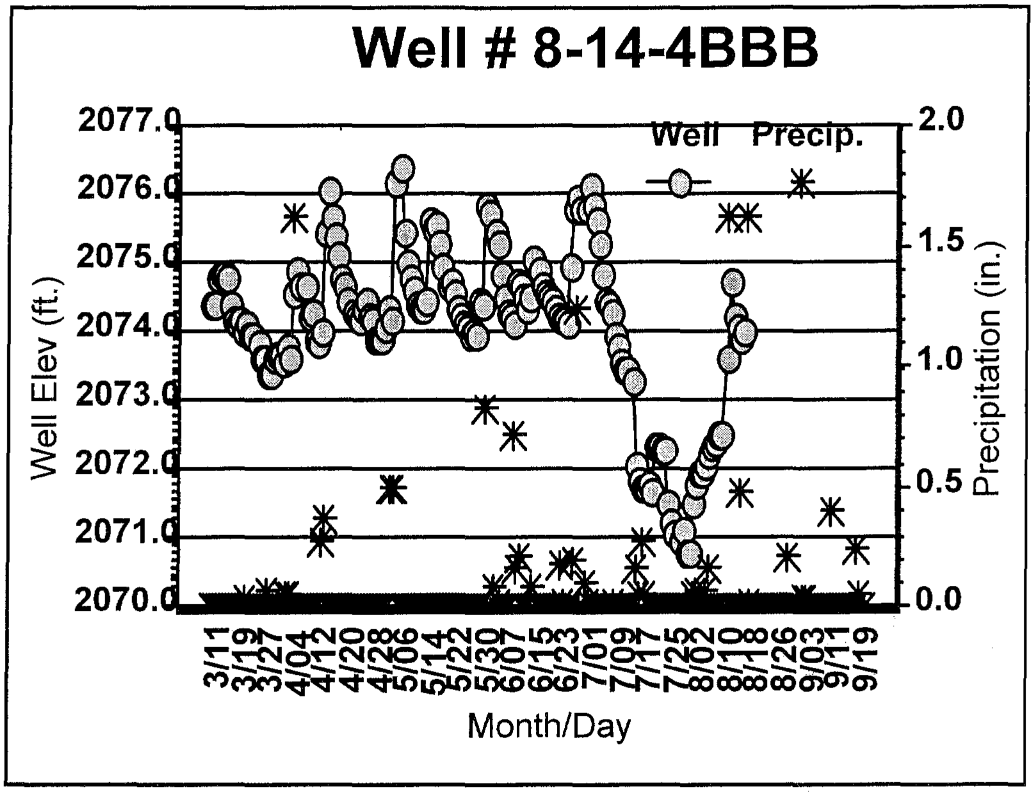


Figure 24: Minden upstream well number 1



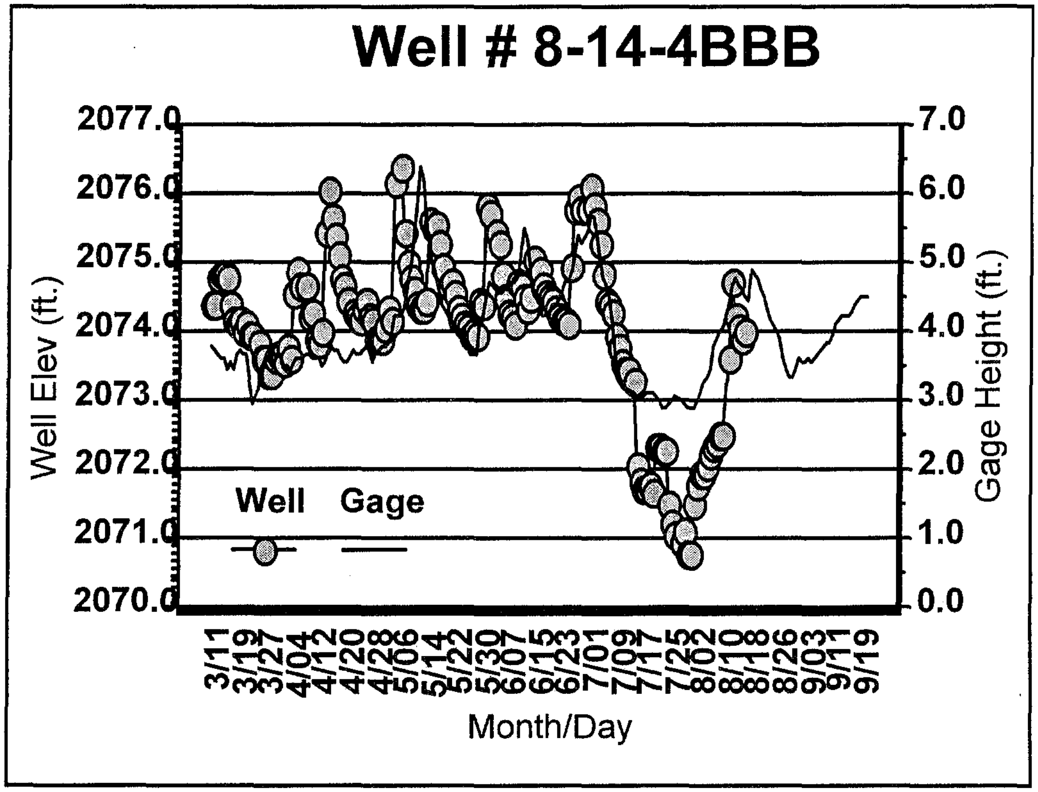


Figure 25: Minden upstream well number 2

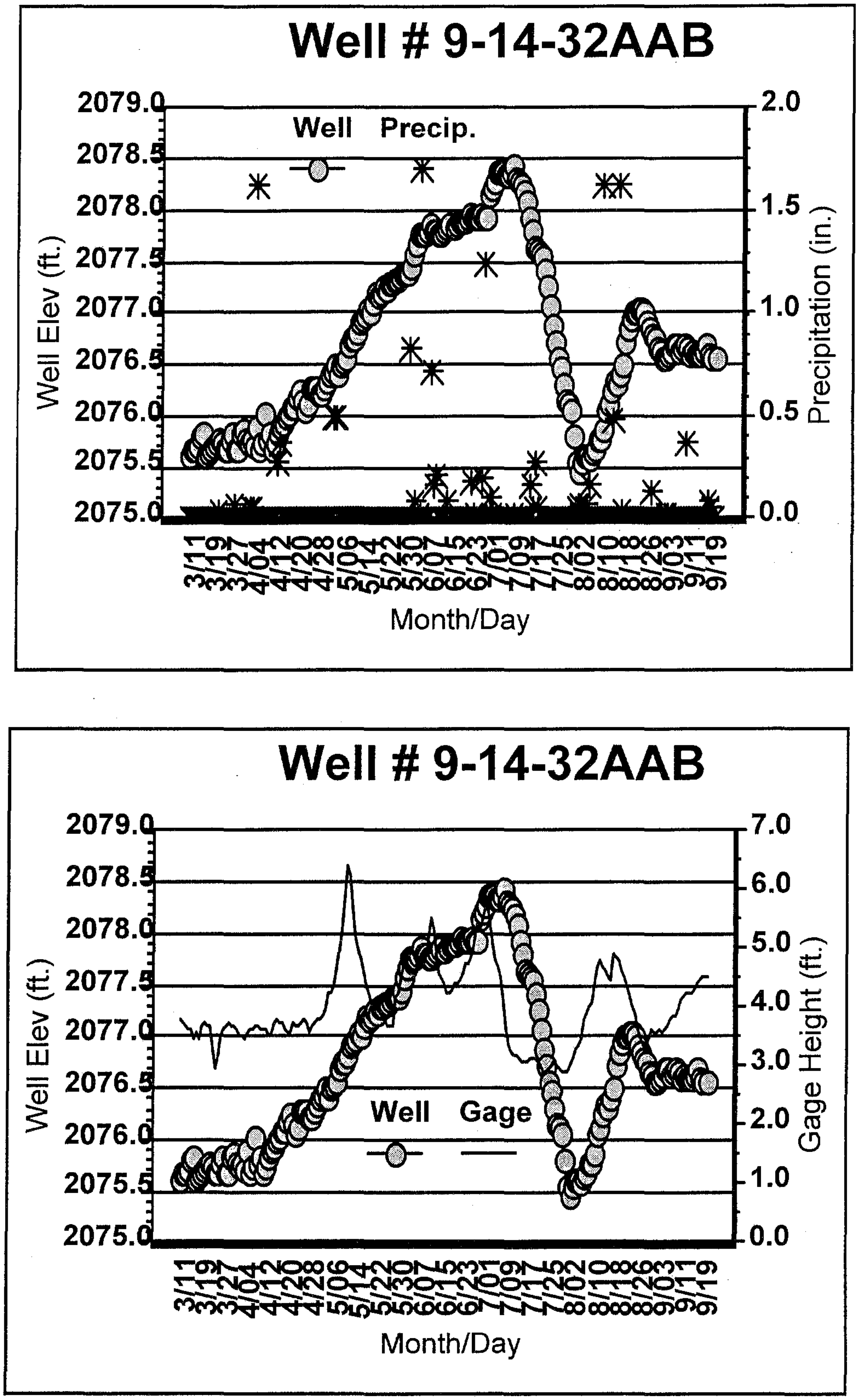


Figure 26: Minden upstream well number 3

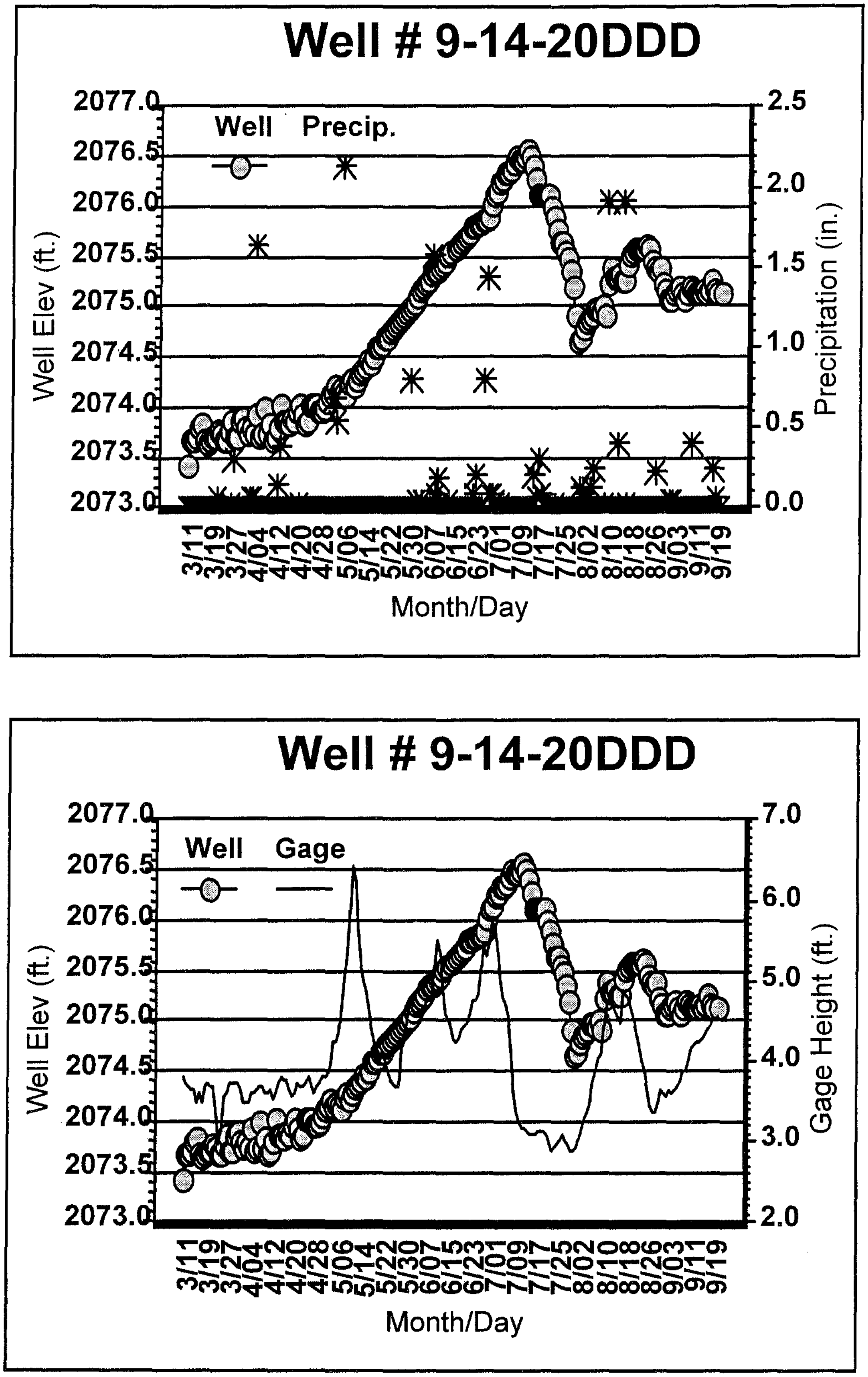


Figure 27: Minden upstream well number 4

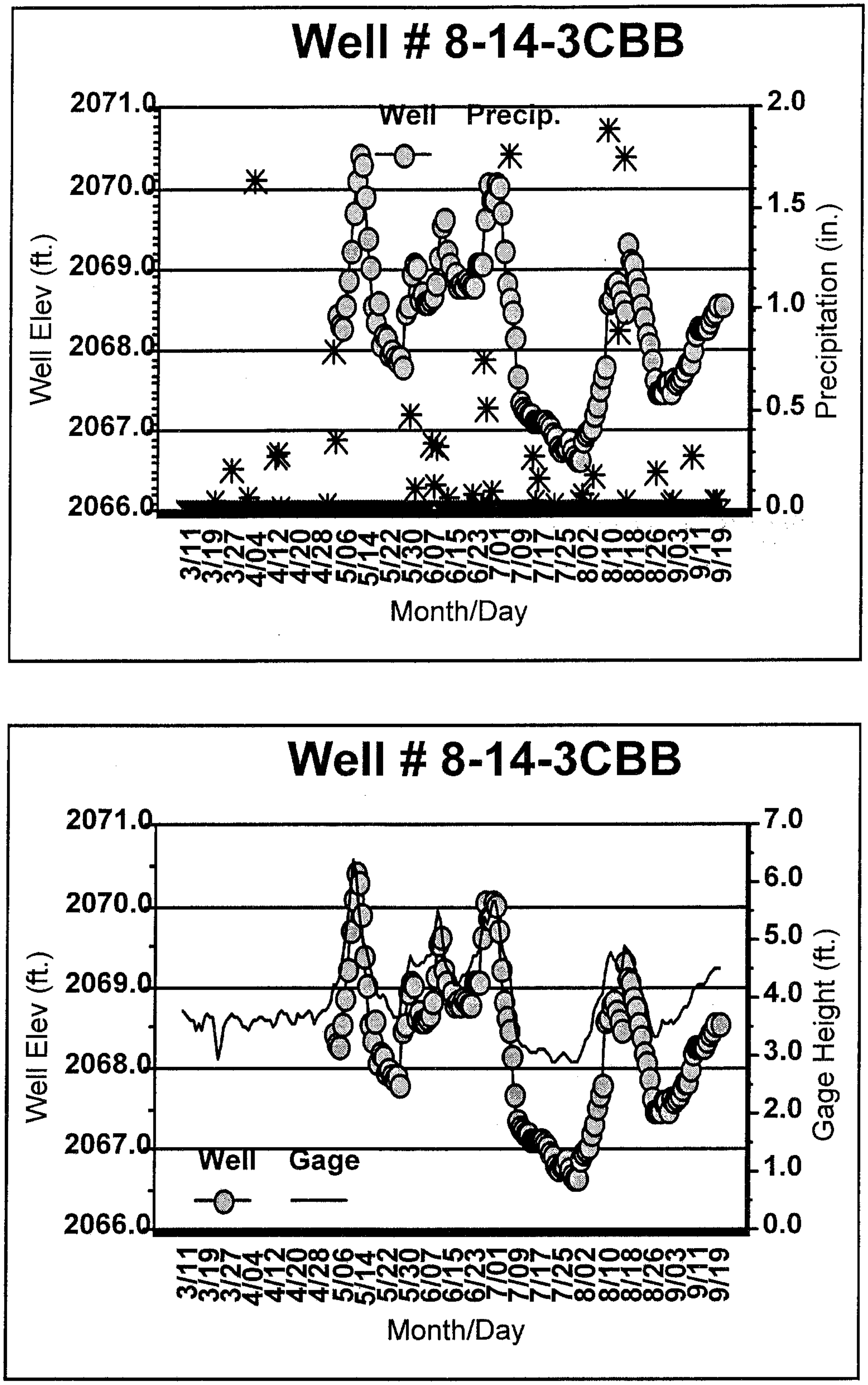


Figure 28: Minden downstream well number 1

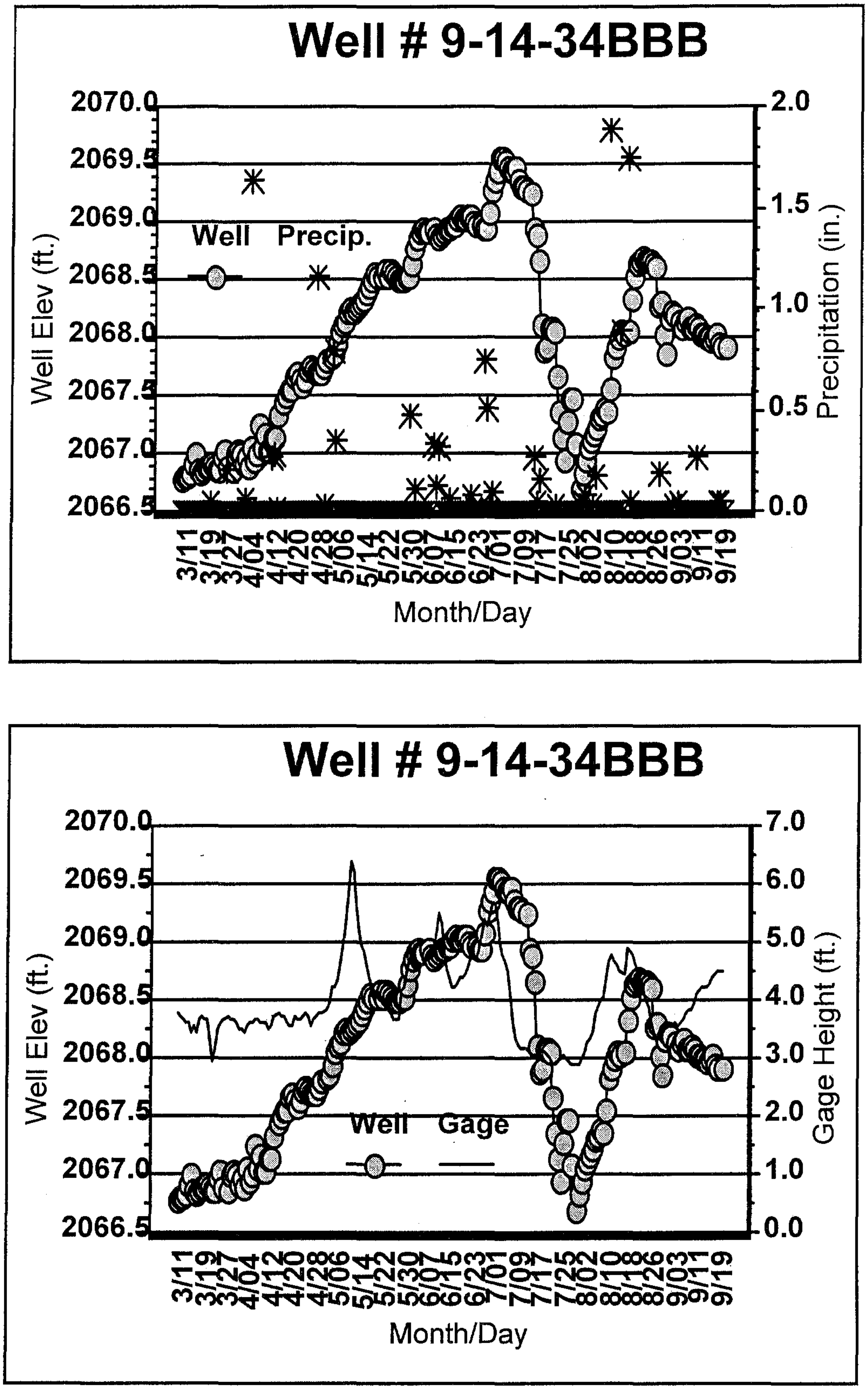


Figure 29: Minden downstream well number 2

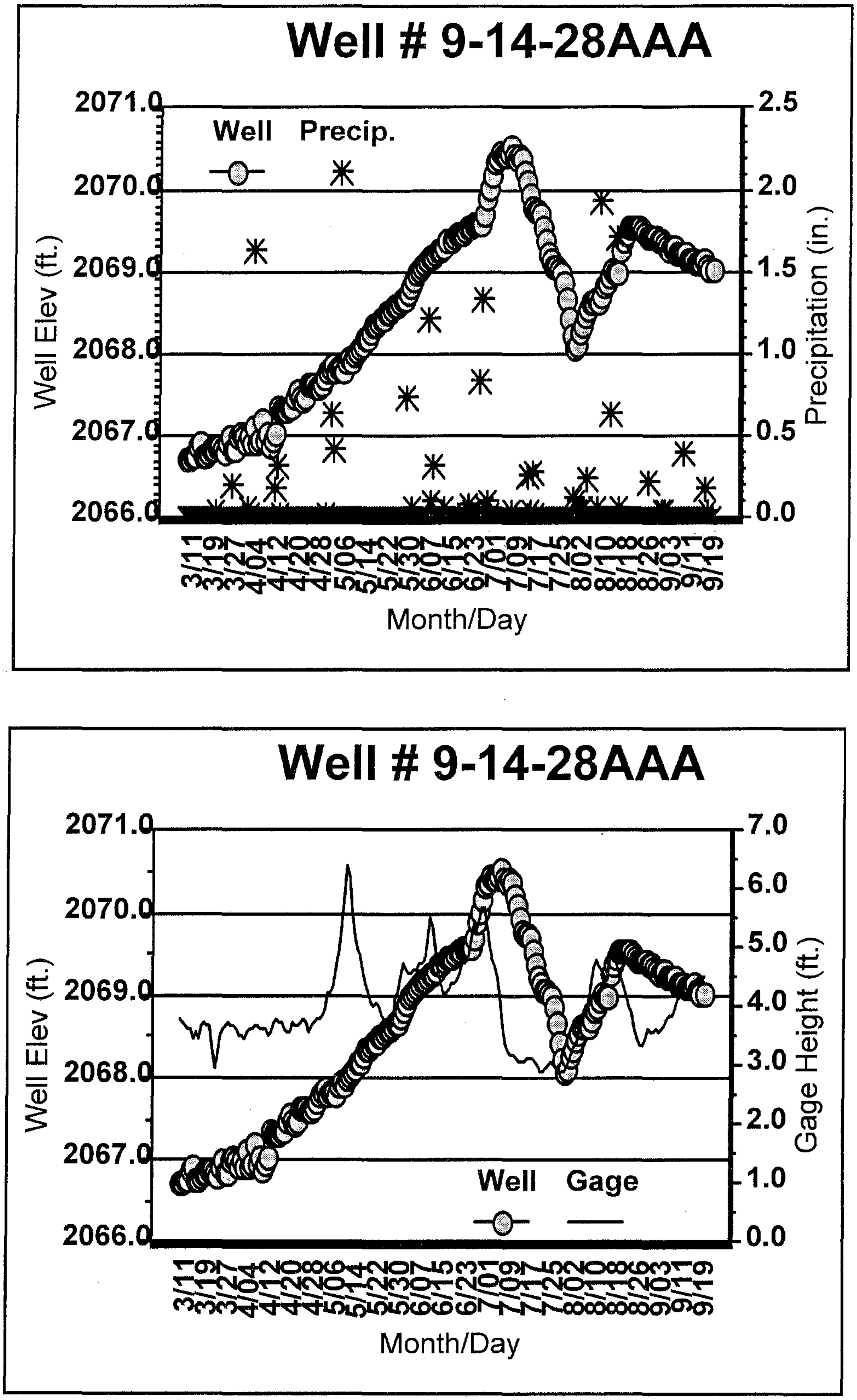


Figure 30: Minden downstream well number 3

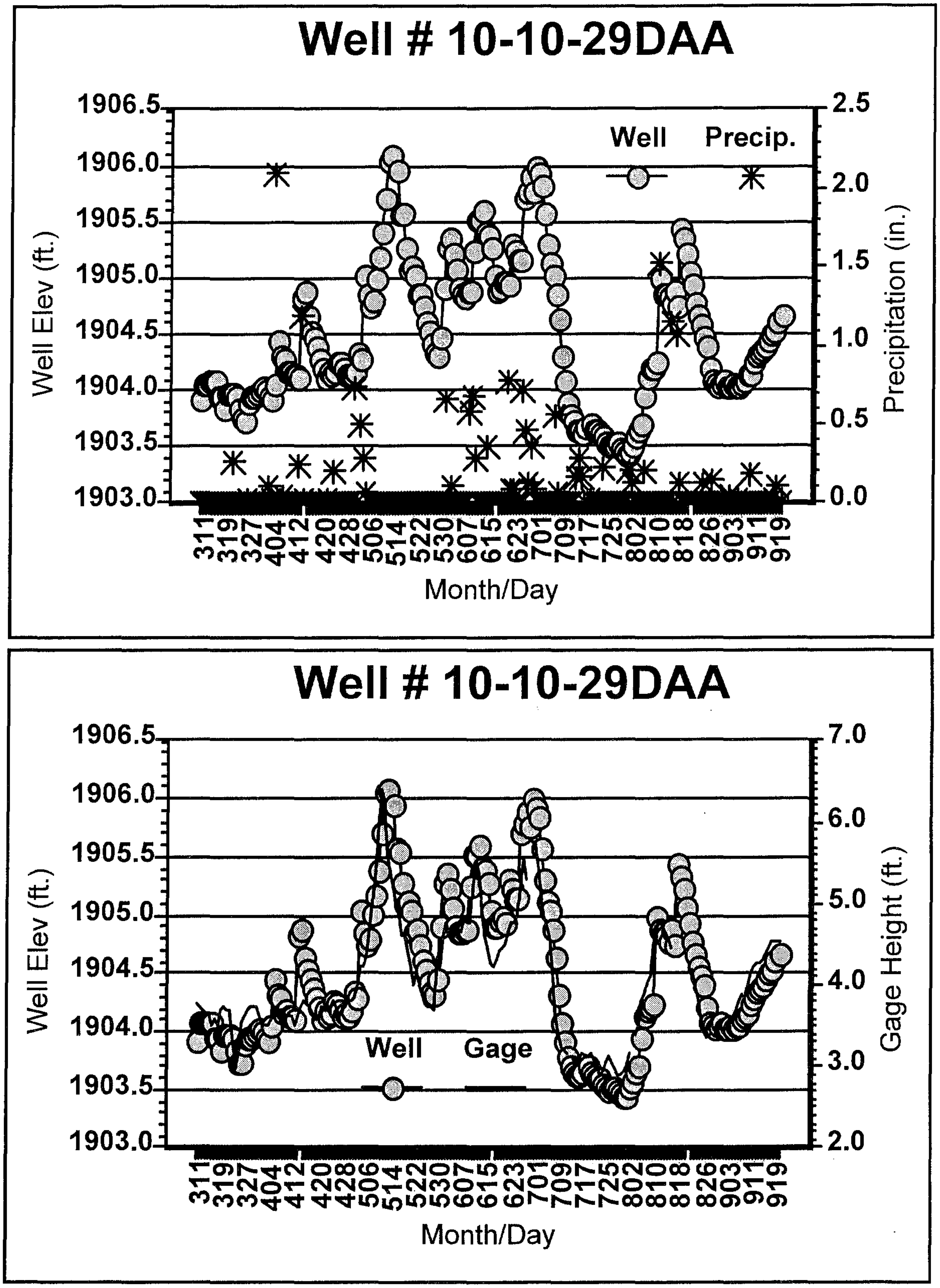


Figure 31: Alda upstream well number 1

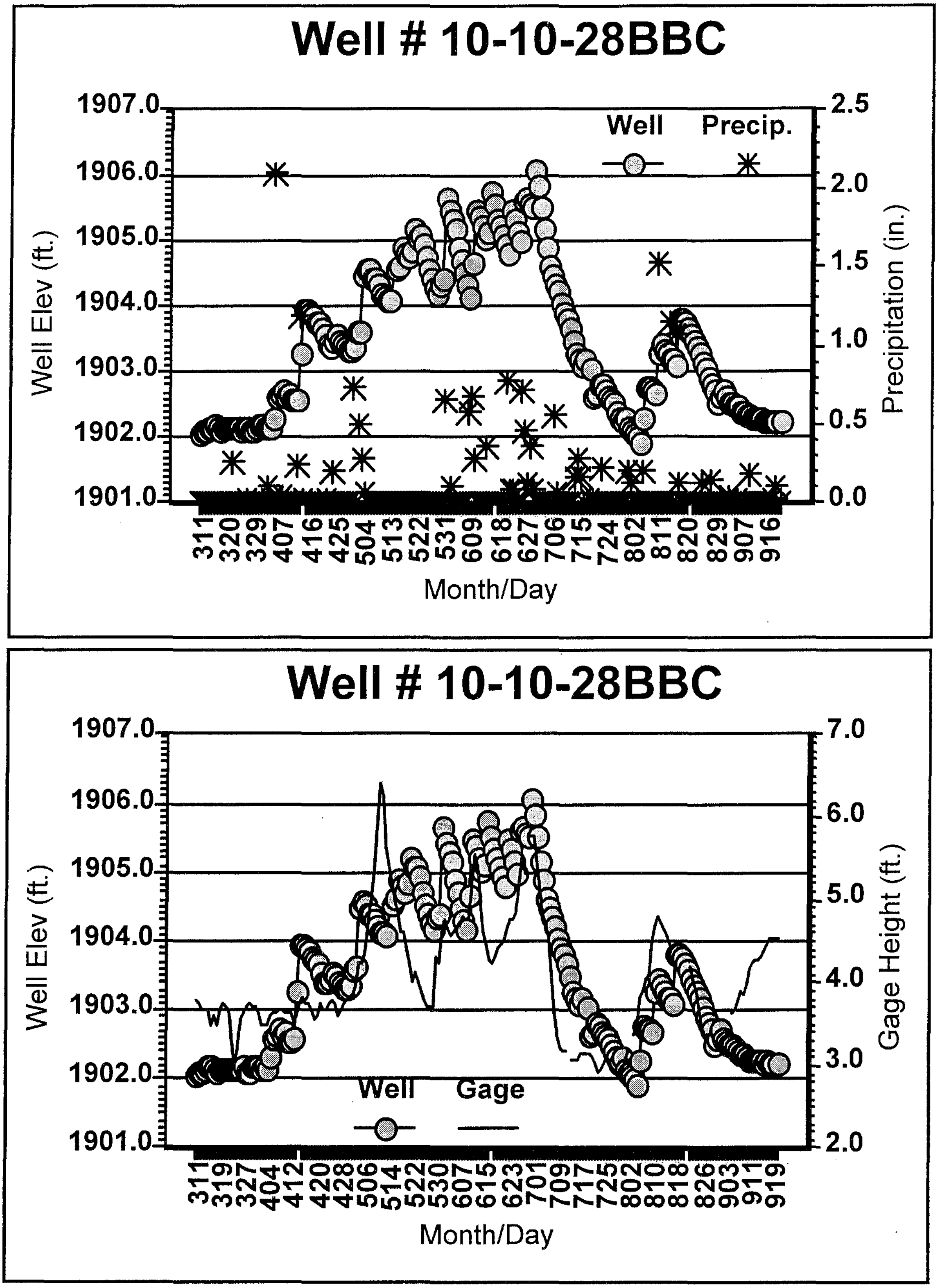


Figure 32: Alda upstream well number 2

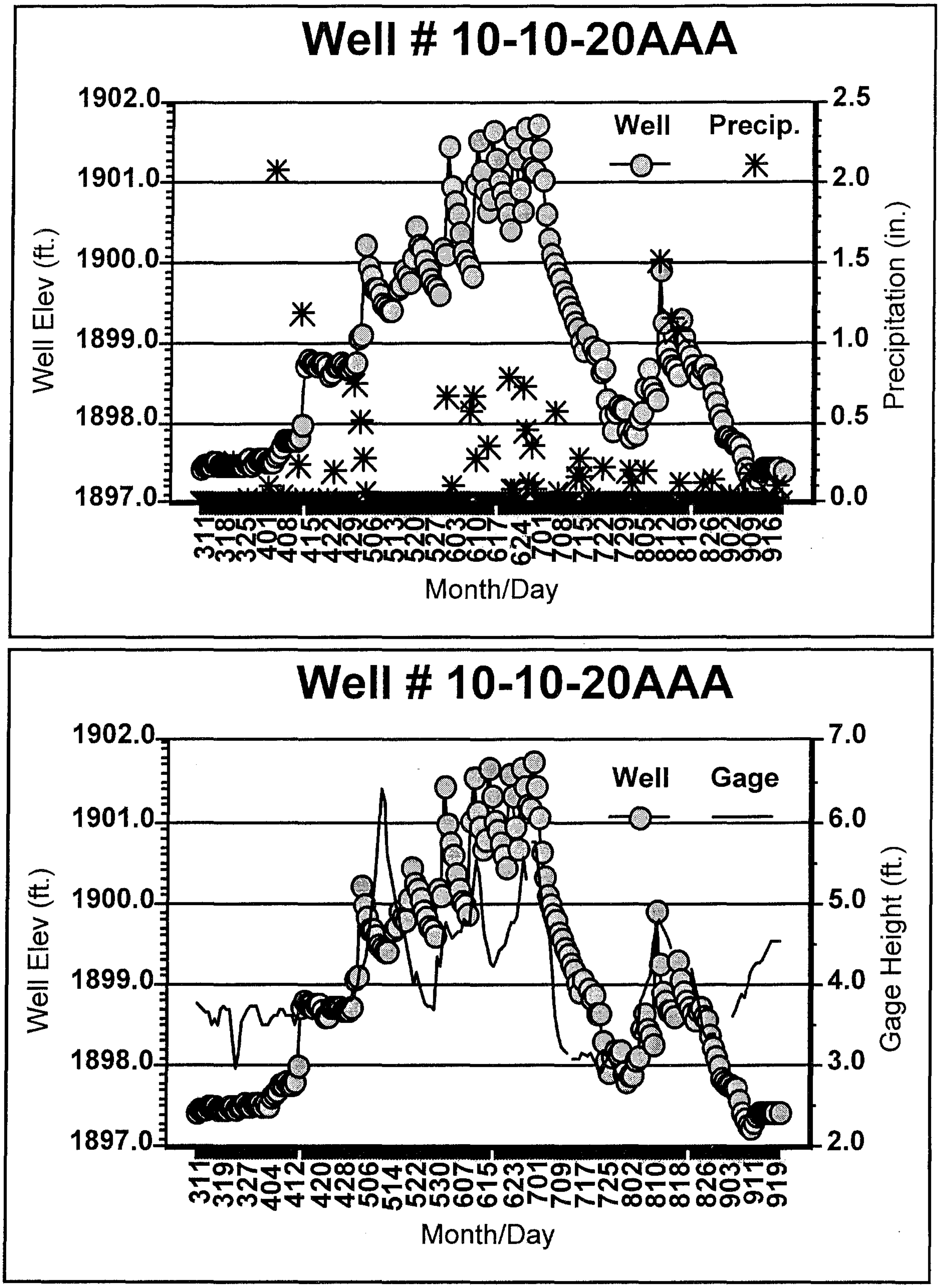


Figure 33: Alda upstream well number 3

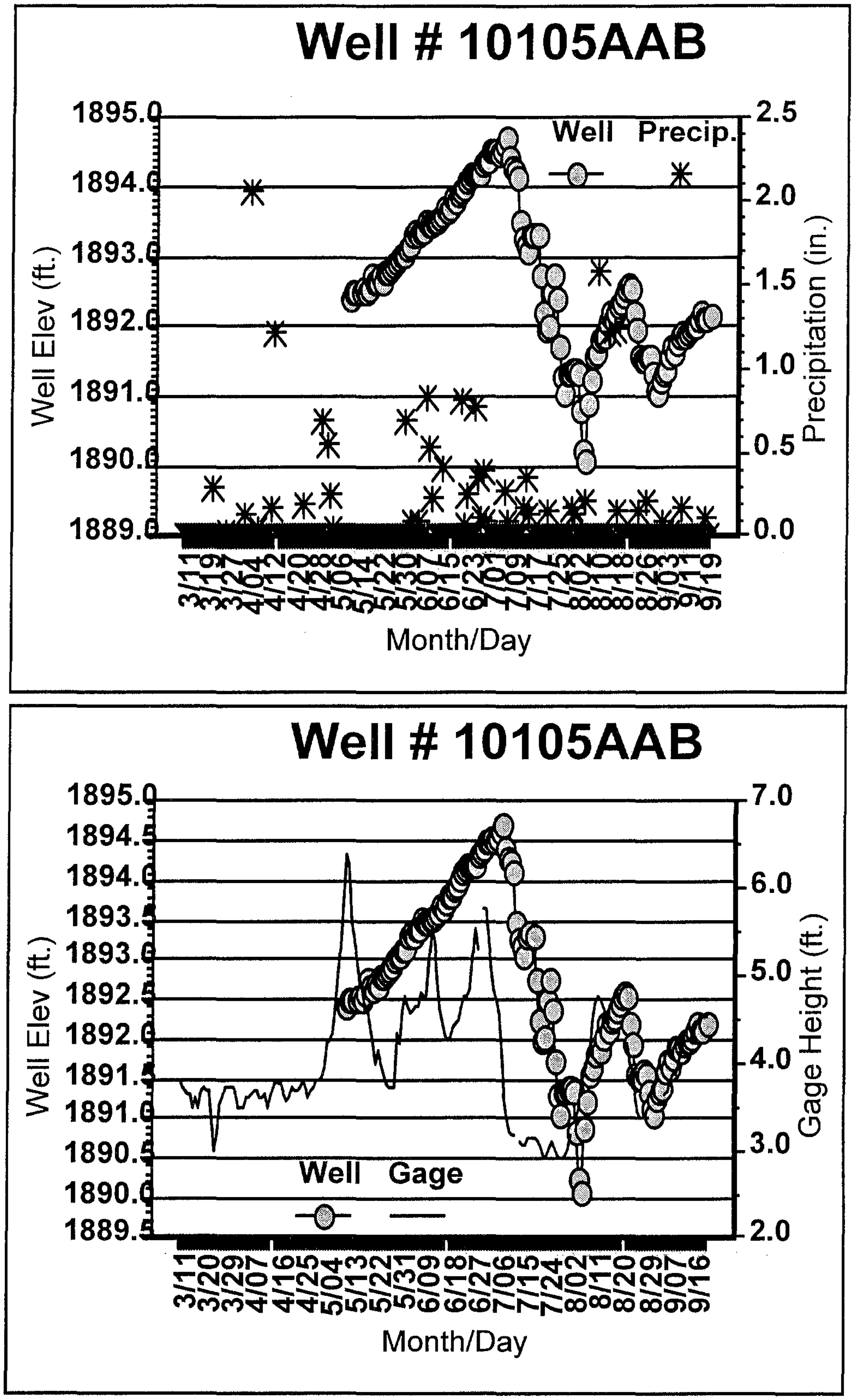


Figure 34: Alda upstream well number 4

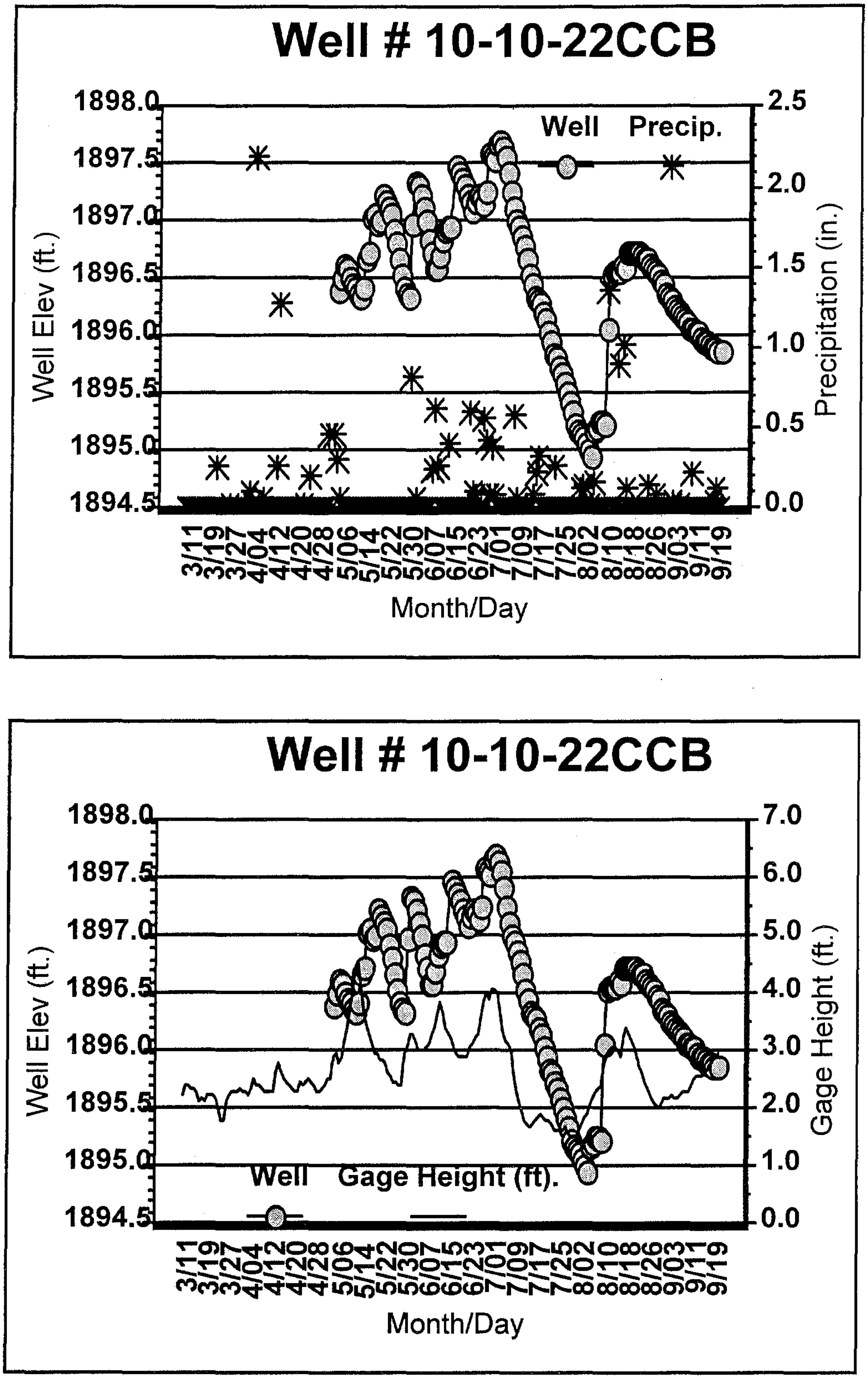


Figure 35: Alda downstream well number 1

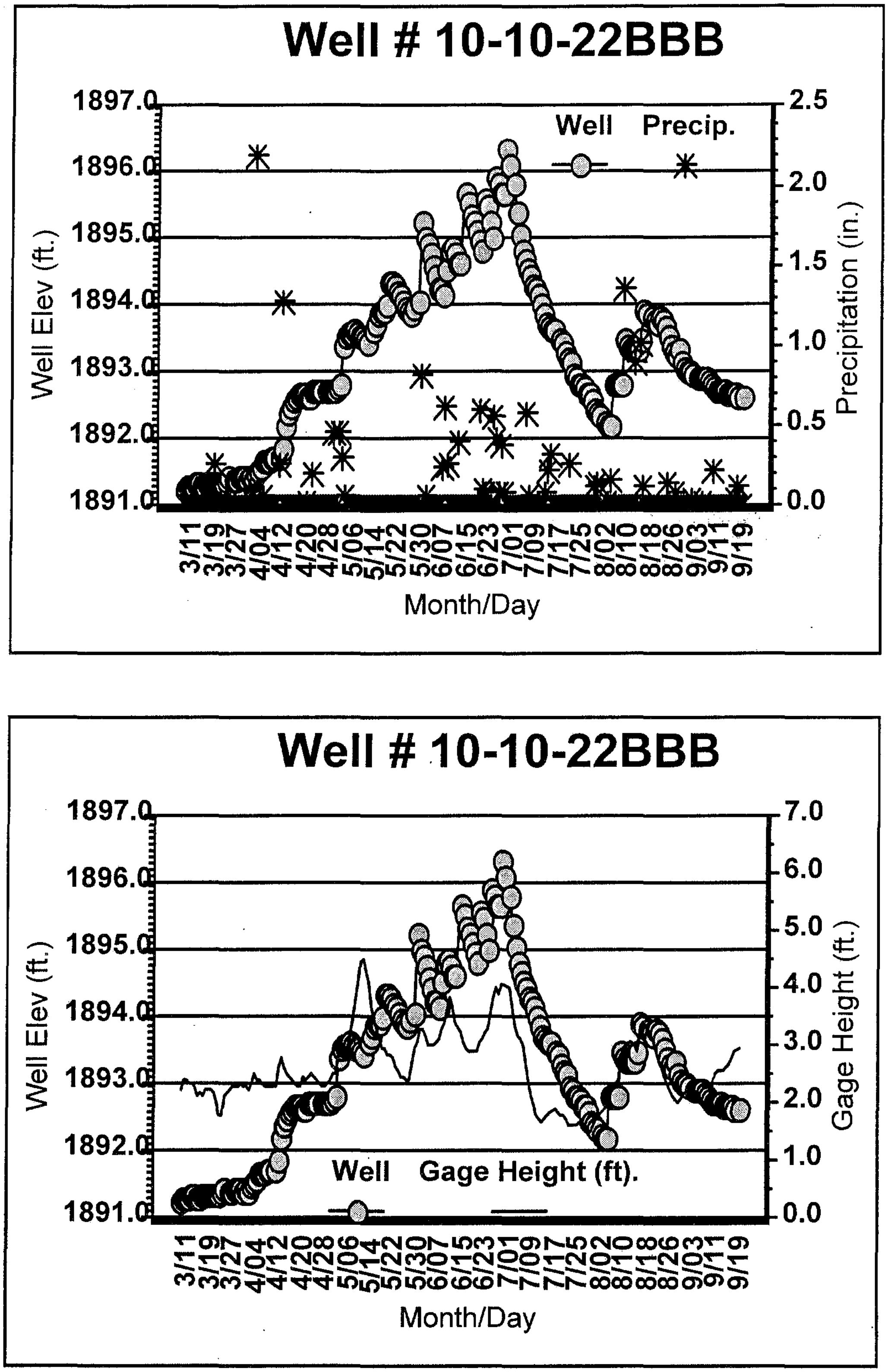


Figure 36: Alda downstream well number 2

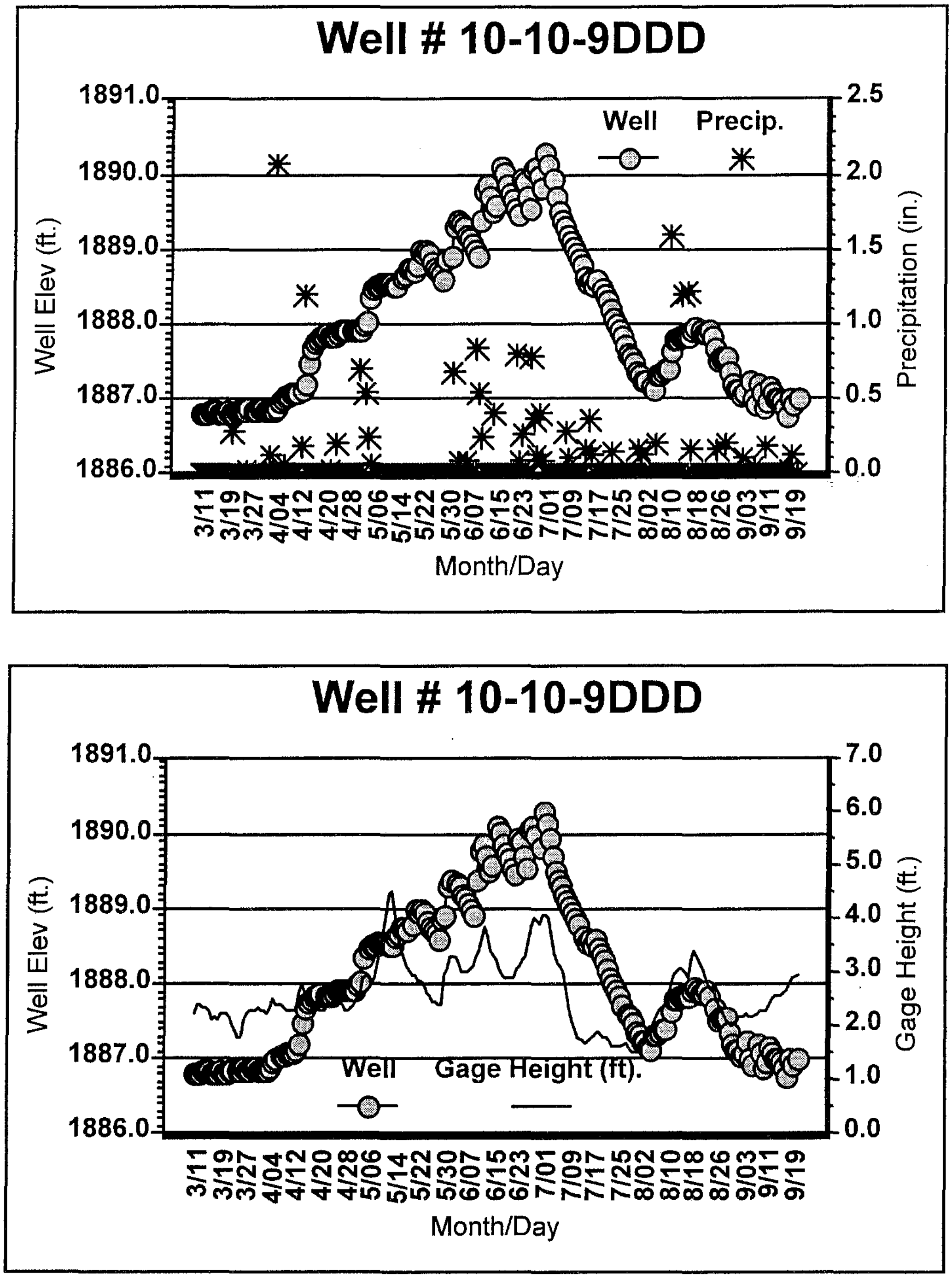


Figure 37: Alda downstream well number 3

ATTACHMENT B

Contents -

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2. Correlations of WSE on GH and ΔWSE of ΔGH by transect: pages B-13 through B-34
3. Correlations of well WSE and ΔWSE and gage height (GH) and ΔGH with precipitation for each measure of precipitation: pages B-35 through B-51

Correlations among Water Surface Elevations for all wells and gages

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
GI Gage	0.980728	< 0.000001	Alda_U_1
Mndn-D-3	0.977923	< 0.000001	Mndn_U_4
GI Gage	0.976420	< 0.000001	Mndn_D_1
Alda-D-3	0.973042	< 0.000001	Alda_U_3
Mndn-D-1	0.968657	< 0.000001	Alda_U_1
Alda-U-2	0.968194	< 0.000001	Alda_U_3
Ovtn-D-1	0.968154	< 0.000001	Ovtn_U_1
Kearney	0.962640	< 0.000001	Mndn_D_1
Ovtn-D-2	0.958566	< 0.000001	Ovtn_U_1
Mndn-U-1	0.957907	< 0.000001	Alda_U_1
Mndn-D-2	0.951688	< 0.000001	Mndn_U_3
Kearney	0.951421	< 0.000001	GI Gage
Ovtn-D-2	0.949715	< 0.000001	Ovtn_U_2
Mndn-D-1	0.946834	< 0.000001	Mndn_U_1
Alda-D-3	0.944250	< 0.000001	Alda_U_2
Ovtn-U-1	0.939752	< 0.000001	Ovtn_U_2
Overton	0.939353	< 0.000001	Kearney
Ovtn-U-1	0.937031	< 0.000001	Alda_U_3
Alda-D-3	0.936524	< 0.000001	Alda_D_2
Ovtn-D-3	0.935078	< 0.000001	Alda_U_3
Mndn-U-3	0.932159	< 0.000001	Alda_U_4
Ovtn-D-1	0.930460	< 0.000001	Ovtn_D_3
Mndn-D-2	0.930024	< 0.000001	Alda_D_2
GI Gage	0.928521	< 0.000001	Mndn_U_1
Ovtn-U-1	0.928313	< 0.000001	Alda_D_3
Ovtn-U-1	0.926669	< 0.000001	Alda_D_2
Kearney	0.923201	< 0.000001	Alda_U_1
Ovtn-D-3	0.918715	< 0.000001	Alda_U_2
Overton	0.918492	< 0.000001	Mndn_D_1
Ovtn-U-1	0.917345	< 0.000001	ElmC_U_3
Ovtn-D-3	0.917236	< 0.000001	Alda_D_3
Alda-D-2	0.917200	< 0.000001	Alda_U_3
Mndn-U-3	0.909644	< 0.000001	Alda_D_2
Ovtn-U-1	0.908816	< 0.000001	ElmC_D_3
Alda-D-1	0.900672	< 0.000001	Alda_D_2
Ovtn-U-1	0.900604	< 0.000001	Mndn_D_2
Mndn-D-2	0.900419	< 0.000001	Alda_D_1
Ovtn-U-1	0.898007	< 0.000001	Alda_U_2
ElmC-U-3	0.897562	< 0.000001	Alda_U_4
ElmC-D-1	0.892763	< 0.000001	ElmC_U_3
Alda-D-3	0.888755	< 0.000001	Alda_U_4

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
Alda-D-2	0.887453	< 0.000001	Alda_U_2
Ovtn-U-1	0.886521	< 0.000001	Mndn_D_3
ElmC-U-1	0.882092	< 0.000001	Mndn_D_1
Alda-D-2	0.880432	< 0.000001	Alda_U_4
Overton	0.879826	< 0.000001	GI Gage
Mndn-U-3	0.879232	< 0.000001	Alda_D_3
Ovtn-D-2	0.877854	< 0.000001	Ovtn_D_3
Ovtn-D-3	0.875740	< 0.000001	ElmC_D_4
Alda-D-1	0.873305	< 0.000001	Alda_U_2
Ovtn-D-3	0.871297	< 0.000001	Alda_D_2
Kearney	0.868608	< 0.000001	Mndn_U_1
Ovtn-D-2	0.865768	< 0.000001	Alda_D_2
ElmC-U-3	0.864094	< 0.000001	Alda_U_2
Ovtn-D-3	0.855794	< 0.000001	ElmC_U_4
Ovtn-D-3	0.855758	< 0.000001	ElmC_D_2
Mndn-U-1	0.852717	< 0.000001	Mndn_U_2
Ovtn-U-1	0.851750	< 0.000001	Mndn_U_3
Ovtn_D_3	0.846916	0.003966	ElmC-D-1
Mndn-U-1	0.846874	< 0.000001	Alda_U_2
Mndn-D-2	0.845790	< 0.000001	Alda_D_3
Mndn-D-2	0.845584	< 0.000001	Alda_U_4
Mndn-D-1	0.844286	< 0.000001	Mndn_U_2
Ovtn-D-1	0.843368	< 0.000001	Alda_U_3
Ovtn-U-1	0.842365	< 0.000001	ElmC_D_4
ElmC-D-2	0.841300	< 0.000001	Alda_U_3
Overton	0.840901	< 0.000001	Alda_U_1
ElmC-U-3	0.839624	< 0.000001	Alda_U_3
ElmC-U-4	0.839430	< 0.000001	Alda_U_2
ElmC-U-3	0.838869	< 0.000001	Alda_D_3
Overton	0.838203	< 0.000001	Mndn_U_1
Ovtn-D-1	0.837274	< 0.000001	ElmC_D_2
Ovtn-U-2	0.834951	< 0.000001	Mndn_U_4
ElmC-D-4	0.834595	< 0.000001	Alda_U_4
ElmC-U-4	0.830140	< 0.000001	Alda_D_3
Ovtn-D-1	0.827224	< 0.000001	Alda_U_2
Mndn-U-2	0.827041	< 0.000001	Alda_D_1
Ovtn-D-3	0.825473	< 0.000001	ElmC_U_3
Ovtn-D-3	0.824700	< 0.000001	Mndn_U_1
Ovtn-D-2	0.822315	< 0.000001	Mndn_D_3
Ovtn-U-2	0.822137	< 0.000001	Alda_D_2
ElmC-D-4	0.821761	< 0.000001	ElmC_U_3
Mndn-D-3	0.821069	< 0.000001	Mndn_D_2

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
ElmC-D-2	0.819969	< 0.000001	ElmC_U_3
ElmC-D-4	0.819080	< 0.000001	Mndn_U_1
ElmC-D-4	0.818948	< 0.000001	Alda_U_2
Ovtn-U-2	0.818859	< 0.000001	Mndn_D_3
ElmC-D-4	0.817750	< 0.000001	Alda_U_3
Mndn-U-3	0.816264	< 0.000001	Alda_D_1
ElmC-U-4	0.815996	< 0.000001	Alda_U_3
Alda-U-1	0.812450	< 0.000001	Alda_U_2
ElmC-U-3	0.812251	< 0.000001	Alda_D_1
Ovtn-D-1	0.810165	< 0.000001	Alda_D_3
Mndn-D-3	0.809118	< 0.000001	Mndn_U_3
ElmC-D-2	0.808682	< 0.000001	Alda_U_2
Mndn-U-1	0.808415	< 0.000001	Alda_D_1
Alda-U-2	0.806628	< 0.000001	Alda_U_4
Ovtn-U-1	0.806307	< 0.000001	Mndn_U_4
Ovtn-D-3	0.806084	< 0.000001	Mndn_U_2
Mndn-D-2	0.804646	< 0.000001	Alda_U_2
Ovtn-D-1	0.804555	< 0.000001	Alda_D_2
ElmC-D-4	0.803634	< 0.000001	Alda_D_3
Mndn-D-2	0.803133	< 0.000001	Alda_U_3
ElmC-U-1	0.802614	< 0.000001	Alda_U_1
Ovtn-D-3	0.801892	< 0.000001	Ovtn_U_2
Ovtn-D-1	0.801633	< 0.000001	Ovtn_D_2
Mndn-U-3	0.800778	< 0.000001	Alda_U_3
Alda-D-1	0.800453	< 0.000001	Alda_D_3
Alda-U-3	0.794949	< 0.000001	Alda_U_4
ElmC-U-1	0.794754	< 0.000001	Mndn_U_1
Alda-D-1	0.794043	< 0.000001	Alda_U_3
Ovtn-D-2	0.794003	< 0.000001	Mndn_U_4
Mndn-U-3	0.793478	< 0.000001	Mndn_U_4
Ovtn_D_1	0.788050	< 0.000001	ElmC-D-1
ElmC-D-2	0.787427	< 0.000001	Alda_D_3
Alda-D-1	0.787215	< 0.000001	Alda_U_4
GI Gage	0.786692	< 0.000001	ElmC_U_1
ElmC-D-2	0.785711	< 0.000001	Alda_D_2
ElmC-D-2	0.785699	< 0.000001	ElmC_D_4
ElmC-U-1	0.785113	< 0.000001	Mndn_U_2
Mndn-D-3	0.784862	< 0.000001	Alda_D_2
Ovtn-D-2	0.782964	< 0.000001	Mndn_D_2
ElmC-D-1	0.782264	< 0.000001	ElmC_U_1
ElmC-D-4	0.781646	< 0.000001	ElmC_U_4
Mndn-U-3	0.778464	< 0.000001	Alda_U_2

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
ElmC-D-4	0.776558	< 0.000001	Alda_D_1
Ovtn-U-3	0.771826	< 0.000001	Mndn_U_2
Mndn-U-1	0.765921	< 0.000001	Alda_U_3
Mndn-D-2	0.765424	< 0.000001	Mndn_U_4
ElmC-U-1	0.764760	< 0.000001	ElmC_U_3
Ovtn-D-2	0.761564	< 0.000001	ElmC_D_2
Ovtn-U-3	0.760979	< 0.000001	Mndn_U_1
Ovtn-D-3	0.756364	< 0.000001	Alda_U_4
Mndn-U-4	0.751284	< 0.000001	Alda_D_2
Ovtn_U_1	0.749924	< 0.000001	ElmC-D-1
Alda-D-1	0.748134	< 0.000001	Alda_U_1
Mndn-U-2	0.748125	< 0.000001	Alda_U_1
ElmC-D-1	0.748112	< 0.000001	ElmC_D_2
Ovtn-D-3	0.748026	< 0.000001	ElmC_U_1
Alda-U-1	0.746461	< 0.000001	Alda_U_3
ElmC-D-3	0.746091	< 0.000001	Mndn_D_3
GI Gage	0.741233	< 0.000001	Alda_U_2
Ovtn-D-2	0.740752	< 0.000001	Alda_D_3
ElmC-D-2	0.737802	< 0.000001	Mndn_U_2
Ovtn-D-2	0.737204	< 0.000001	Alda_U_3
Ovtn_D_2	0.733941	< 0.000001	ElmC-D-1
Ovtn-U-1	0.732443	0.000014	Ovtn_U_3
Kearney	0.730457	< 0.000001	ElmC_U_1
ElmC-D-1	0.729242	< 0.000001	Alda_U_3
ElmC-D-2	0.728850	< 0.000001	ElmC_U_1
GI Gage	0.727061	< 0.000001	Mndn_U_2
Ovtn-D-2	0.726570	< 0.000001	Mndn_U_3
Ovtn-U-2	0.726516	< 0.000001	Alda_D_3
ElmC-U-3	0.725785	< 0.000001	Alda_D_2
Ovtn-D-1	0.725156	< 0.000001	ElmC_U_4
ElmC-U-3	0.718936	< 0.000001	Mndn_U_3
ElmC-U-1	0.718386	< 0.000001	Alda_D_1
ElmC-U-3	0.718069	< 0.000001	ElmC_U_4
Ovtn-D-1	0.717475	< 0.000001	Mndn_D_2
ElmC-U-3	0.715859	< 0.000001	Mndn_U_1
ElmC-U-1	0.714508	< 0.000001	Alda_U_2
ElmC-U-4	0.713994	< 0.000001	Mndn_U_2
Ovtn-U-2	0.712705	< 0.000001	Mndn_D_2
ElmC-D-1	0.708387	< 0.000001	Alda_U_2
Ovtn-D-3	0.705507	< 0.000001	Alda_U_1
ElmC-D-2	0.705392	< 0.000001	Mndn_U_1
Ovtn-D-3	0.704799	< 0.000001	Alda_D_1

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
ElmC-D-1	0.704382	< 0.000001	ElmC_D_3
ElmC-U-3	0.702782	< 0.000001	Mndn_D_2
Ovtn-D-1	0.701991	< 0.000001	ElmC_U_3
Alda-D-2	0.699052	< 0.000001	Alda_U_1
Ovtn-U-2	0.698444	< 0.000001	Alda_U_3
Mndn-D-1	0.697555	< 0.000001	Alda_U_2
Overton	0.696147	< 0.000001	ElmC_U_1
ElmC-U-3	0.696081	< 0.000001	Alda_U_1
Ovtn-U-2	0.696021	< 0.000001	Mndn_U_3
ElmC-D-2	0.695690	< 0.000001	Alda_U_4
Ovtn-U-1	0.695455	0.000005	ElmC_D_2
ElmC-D-1	0.694042	< 0.000001	Alda_D_2
GI Gage	0.691315	< 0.000001	ElmC_D_4
ElmC-D-4	0.691109	< 0.000001	Mndn_U_2
ElmC-U-4	0.690607	< 0.000001	Mndn_U_1
Ovtn-D-1	0.690425	< 0.000001	Ovtn_U_2
ElmC-D-1	0.690257	< 0.000001	Alda_D_3
ElmC-U-4	0.689200	< 0.000001	Alda_D_2
Alda-D-3	0.686361	< 0.000001	Alda_U_1
GI Gage	0.685927	< 0.000001	Alda_D_1
Ovtn-D-3	0.685105	< 0.000001	Mndn_U_3
Mndn-D-1	0.681381	< 0.000001	Alda_D_1
Ovtn_U_2	0.678675	< 0.000001	ElmC-D-1
ElmC-D-4	0.678213	< 0.000001	Alda_U_1
Ovtn-U-3	0.677186	< 0.000001	Mndn_D_2
Ovtn-U-3	0.675216	< 0.000001	Alda_D_2
Mndn-U-1	0.674951	< 0.000001	Alda_D_3
GI Gage	0.673800	< 0.000001	Ovtn_D_3
GI Gage	0.673650	< 0.000001	Alda_U_3
Ovtn-D-3	0.672005	< 0.000001	Mndn_D_2
ElmC-D-2	0.669711	< 0.000001	Alda_U_1
ElmC-U-4	0.669223	< 0.000001	Alda_U_4
Overton	0.667991	< 0.000001	Mndn_U_2
Mndn-D-2	0.665331	< 0.000001	Alda_U_1
Ovtn-U-3	0.662862	< 0.000001	ElmC_U_3
ElmC-D-3	0.660272	< 0.000001	Mndn_U_4
Ovtn-U-3	0.658565	< 0.000001	Alda_U_4
Ovtn-U-3	0.657664	< 0.000001	Mndn_U_3
Ovtn-U-1	0.657437	< 0.000001	ElmC_U_1
ElmC-D-2	0.657148	< 0.000001	Alda_D_1
Mndn-U-1	0.656237	< 0.000001	Alda_D_2
Kearney	0.655693	< 0.000001	Alda_U_2

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
ElmC-D-1	0.654996	< 0.000001	Mndn_D_3
ElmC-D-1	0.654529	< 0.000001	ElmC_D_4
Gl Gage	0.651668	< 0.000001	ElmC_U_3
ElmC-U-3	0.648286	< 0.000001	Mndn_D_1
ElmC-U-3	0.647777	< 0.000001	Mndn_U_2
ElmC-D-4	0.647119	< 0.000001	ElmC_U_1
Ovtn-D-1	0.646793	< 0.000001	Mndn_U_3
ElmC-D-4	0.645212	< 0.000001	Alda_D_2
Ovtn-U-1	0.644872	< 0.000001	Alda_U_1
Ovtn-D-2	0.644436	< 0.000001	Alda_U_2
ElmC-D-1	0.643967	< 0.000001	Mndn_D_2
Ovtn-D-1	0.642373	< 0.000001	Alda_D_1
Ovtn_U_3	0.642275	0.000018	ElmC-D-1
Ovtn-U-3	0.640885	< 0.000001	Alda_D_1
Ovtn-U-3	0.640328	< 0.000001	Alda_U_2
ElmC-U-4	0.639448	< 0.000001	Mndn_U_3
ElmC-D-3	0.633107	< 0.000001	Mndn_D_2
ElmC-D-1	0.632100	< 0.000001	Mndn_U_4
ElmC-U-1	0.631954	< 0.000001	Alda_U_3
Mndn-D-1	0.630629	< 0.000001	Alda_D_2
Mndn-D-2	0.629590	< 0.000001	Mndn_U_1
Gl Gage	0.628858	< 0.000001	Alda_D_3
Ovtn-U-3	0.627557	< 0.000001	Alda_D_3
ElmC-D-1	0.626992	< 0.000001	Mndn_U_3
Ovtn-U-2	0.626206	< 0.000001	ElmC_D_2
Ovtn-D-3	0.623237	< 0.000001	Mndn_D_1
ElmC-D-4	0.622949	< 0.000001	Mndn_D_1
Kearney	0.622567	< 0.000001	Mndn_U_2
Mndn-U-2	0.621244	< 0.000001	Alda_U_4
Gl Gage	0.620192	< 0.000001	Alda_D_2
ElmC-D-4	0.617663	< 0.000001	Mndn_U_3
Ovtn-D-1	0.617050	< 0.000001	Alda_U_1
Gl Gage	0.614102	< 0.000001	Mndn_D_2
Mndn-D-1	0.612953	< 0.000001	Alda_U_3
Mndn-U-4	0.610758	< 0.000001	Alda_U_4
Kearney	0.610481	< 0.000001	Alda_U_3
Mndn-U-2	0.607296	< 0.000001	Alda_U_2
Ovtn-U-3	0.605448	< 0.000001	Alda_U_3
Ovtn-D-1	0.605043	< 0.000001	ElmC_U_1
Ovtn-U-3	0.602244	< 0.000001	ElmC_D_4
Ovtn-D-1	0.602145	< 0.000001	Alda_U_4
Kearney	0.599231	< 0.000001	ElmC_D_4

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
GI Gage	0.596675	< 0.000001	ElmC_D_2
ElmC-U-4	0.596417	< 0.000001	Alda_D_1
Mndn-U-4	0.595646	< 0.000001	Alda_D_3
Mndn-D-3	0.594510	< 0.000001	Alda_D_3
ElmC-D-4	0.593533	< 0.000001	Mndn_D_2
Mndn-D-3	0.592694	< 0.000001	Alda_U_4
ElmC-D-2	0.591874	< 0.000001	Mndn_D_1
Ovtn-U-3	0.591099	< 0.000001	ElmC_U_1
ElmC-D-2	0.589258	< 0.000001	Mndn_D_2
ElmC-U-1	0.586555	< 0.000001	Alda_U_4
Mndn-U-1	0.586509	< 0.000001	Alda_U_4
GI Gage	0.585925	< 0.000001	ElmC_U_4
Ovtn-U-1	0.584691	0.001360	Alda_U_4
Ovtn-D-1	0.584627	< 0.000001	ElmC_D_4
Kearney	0.584226	< 0.000001	Alda_D_2
Ovtn-U-2	0.582852	< 0.000001	Alda_U_2
Ovtn-D-3	0.582675	< 0.000001	Ovtn_U_3
Ovtn-U-3	0.580315	< 0.000001	Alda_U_1
Kearney	0.578843	< 0.000001	Ovtn_D_3
Mndn-D-2	0.578424	< 0.000001	Mndn_D_1
ElmC-U-4	0.575430	< 0.000001	Alda_U_1
ElmC-U-1	0.571445	< 0.000001	ElmC_U_4
GI Gage	0.569309	< 0.000001	Ovtn_U_1
Ovtn-D-1	0.568198	< 0.000001	Mndn_U_1
Alda-U-1	0.566457	< 0.000001	Alda_U_4
ElmC-U-2	0.563945	< 0.000001	Mndn_U_3
Kearney	0.563489	< 0.000001	Alda_D_3
Kearney	0.562884	< 0.000001	Ovtn_U_1
Ovtn-D-1	0.562799	< 0.000001	Mndn_D_1
GI Gage	0.562489	< 0.000001	Ovtn_U_3
Ovtn-U-3	0.560723	< 0.000001	Mndn_D_1
Mndn-U-3	0.560611	< 0.000001	Alda_U_1
ElmC-D-2	0.560591	< 0.000001	ElmC_U_4
ElmC-U-1	0.560113	< 0.000001	Alda_D_3
Kearney	0.559439	< 0.000001	ElmC_U_3
Kearney	0.559073	< 0.000001	Mndn_D_2
ElmC-U-4	0.556325	< 0.000001	Mndn_D_2
ElmC-D-2	0.555858	< 0.000001	Mndn_U_3
GI Gage	0.554657	< 0.000001	Ovtn_D_1
Mndn-D-1	0.552014	< 0.000001	Alda_D_3
Ovtn-D-2	0.549749	< 0.000001	ElmC_D_3
Kearney	0.542667	< 0.000001	Alda_D_1

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
ElmC-U-2	0.538599	< 0.000001	Mndn_D_2
ElmC-D-1	0.538593	< 0.000001	Alda_U_1
Overton	0.537003	< 0.000001	Alda_U_2
Ovtn-U-3	0.535542	< 0.000001	ElmC_D_2
Ovtn-D-1	0.532159	< 0.000001	Ovtn_U_3
ElmC-D-3	0.530824	< 0.000001	Mndn_U_3
Ovtn-U-2	0.530677	< 0.000001	Alda_U_4
ElmC-D-3	0.526850	< 0.000001	Mndn_U_1
Ovtn-D-2	0.526480	< 0.000001	Alda_U_4
Kearney	0.522906	< 0.000001	ElmC_D_2
GI Gage	0.522458	< 0.000001	Alda_U_4
Kearney	0.522145	< 0.000001	Ovtn_D_1
ElmC-U-2	0.519729	< 0.000001	Mndn_D_3
Ovtn-D-2	0.514741	< 0.000001	Alda_U_1
GI Gage	0.513966	< 0.000001	Mndn_U_3
Mndn-D-3	0.513805	< 0.000001	Alda_U_3
Mndn-D-1	0.513125	< 0.000001	Alda_U_4
Ovtn-D-2	0.511052	< 0.000001	Alda_D_1
ElmC-U-2	0.508321	< 0.000001	Alda_D_1
ElmC-D-3	0.507394	< 0.000001	ElmC_U_2
Mndn-U-4	0.504733	< 0.000001	Alda_U_3
Ovtn-D-3	0.503953	< 0.000001	Mndn_U_4
ElmC-D-1	0.502221	0.001538	Alda_U_4
ElmC-D-3	0.500229	< 0.000001	Alda_D_2
Kearney	0.499321	< 0.000001	Ovtn_U_3
Mndn-U-1	0.498089	< 0.000001	Mndn_U_3
Overton	0.496865	< 0.000001	Alda_D_1
Overton	0.494980	< 0.000001	ElmC_D_4
Ovtn-D-2	0.488199	< 0.000001	ElmC_U_3
Kearney	0.487397	< 0.000001	ElmC_U_4
ElmC-U-1	0.485658	< 0.000001	Alda_D_2
ElmC-U-4	0.483743	< 0.000001	Mndn_D_1
Ovtn-U-3	0.480139	< 0.000001	ElmC_U_4
Overton	0.476895	< 0.000001	Ovtn_U_3
Ovtn-D-1	0.473064	< 0.000001	Mndn_D_3
Overton	0.472104	0.000004	Ovtn_U_1
Mndn-U-2	0.466438	< 0.000001	Alda_U_3
Kearney	0.466271	< 0.000001	Ovtn_D_2
ElmC-U-2	0.465160	< 0.000001	Alda_U_4
ElmC-U-1	0.464832	< 0.000001	Mndn_D_2
ElmC-U-2	0.462898	< 0.000001	Mndn_U_4
ElmC-D-1	0.462827	0.000017	Mndn_U_2

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
Overton	0.460593	< 0.000001	Alda_U_3
Kearney	0.454076	0.000026	ElmC-D-1
GI Gage	0.452841	0.000028	ElmC-D-1
Kearney	0.452267	< 0.000001	Mndn_U_3
Overton	0.450389	< 0.000001	ElmC_U_3
Ovtn-D-2	0.444839	< 0.000001	Ovtn_U_3
Mndn-D-3	0.441259	< 0.000001	Alda_U_2
GI Gage	0.441110	< 0.000001	Ovtn_D_2
Ovtn-U-2	0.440797	< 0.000001	ElmC_U_3
Ovtn-D-2	0.431124	< 0.000001	Mndn_D_1
Ovtn-D-3	0.429342	0.000005	Mndn_D_3
Ovtn-U-2	0.429124	< 0.000001	Alda_U_1
Ovtn-U-1	0.428291	0.000035	Mndn_U_2
Ovtn-U-2	0.427461	< 0.000001	ElmC_D_3
Kearney	0.426550	0.000001	Alda_U_4
Ovtn-U-3	0.426010	0.000001	ElmC_U_2
Overton	0.424385	0.000025	Ovtn_D_3
Overton	0.424290	< 0.000001	Alda_D_2
Overton	0.422279	0.000002	ElmC_U_4
Ovtn-U-1	0.419137	0.000697	Mndn_U_1
Mndn-D-1	0.413355	< 0.000001	Mndn_U_3
Overton	0.407587	< 0.000001	Mndn_D_2
Ovtn-D-1	0.405984	< 0.000001	Mndn_U_4
Mndn-D-3	0.405826	0.000001	Alda_D_1
Overton	0.403251	< 0.000001	Alda_D_3
Mndn-U-4	0.403089	< 0.000001	Alda_U_2
Kearney	0.399433	< 0.000001	Ovtn_U_2
ElmC-U-2	0.398693	< 0.000001	ElmC_U_3
Overton	0.398213	0.000278	ElmC-D-1
Ovtn-U-2	0.398113	< 0.000001	ElmC_D_4
ElmC-U-2	0.388902	0.000001	Alda_D_2
Overton	0.385128	< 0.000001	Ovtn_D_1
Overton	0.384470	0.000008	ElmC_D_2
Ovtn-D-2	0.384145	< 0.000001	ElmC_D_4
ElmC-U-1	0.376690	< 0.000001	Mndn_U_3
Mndn-D-2	0.376066	0.000001	Mndn_U_2
Ovtn-U-3	0.370948	0.000011	Mndn_D_3
Mndn-U-2	0.365452	0.000002	Alda_D_3
GI Gage	0.360932	0.000001	Ovtn_U_2
Ovtn-D-2	0.354079	0.000031	Mndn_U_1
ElmC-D-3	0.347313	0.000001	Alda_U_1
Ovtn-D-1	0.341305	0.000012	Mndn_U_2

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
ElmC-U-3	0.338413	0.000001	Mndn_U_4
ElmC-U-3	0.337377	0.000002	Mndn_D_3
Overton	0.335592	0.000179	Alda_U_4
ElmC-U-2	0.329291	0.000307	Mndn_U_1
Ovtn-D-2	0.318430	0.000187	ElmC_U_4
Mndn-D-3	0.316124	0.000007	Alda_U_1
Ovtn-U-2	0.315192	0.000149	Alda_D_1
Mndn-U-2	0.314970	0.000053	Alda_D_2
Kearney	0.312263	0.000020	ElmC_D_3
Mndn-U-4	0.309240	0.000201	Alda_D_1
Ovtn-U-2	0.304974	0.000358	Ovtn_U_3
Ovtn-U-2	0.301153	0.000428	ElmC_U_4
Ovtn-D-2	0.298870	0.000024	ElmC_U_1
Ovtn-U-3	0.297950	0.000496	Mndn_U_4
ElmC-D-3	0.294362	0.000174	Mndn_U_2
Overton	0.292955	0.000060	Mndn_U_3
ElmC-U-2	0.292829	0.000251	Alda_D_3
ElmC-D-3	0.292671	0.000450	Alda_D_1
GI Gage	0.289434	0.000078	ElmC_D_3
ElmC-U-2	0.278430	0.002475	Mndn_U_2
Overton	0.276109	0.000176	Ovtn_D_2
ElmC-D-1	0.271426	0.047107	Mndn_U_1
Ovtn-U-3	0.270444	0.001642	ElmC_D_3
ElmC-U-2	0.270427	0.001513	Mndn_D_1
Ovtn-U-1	0.269380	0.123408	Alda_D_1
Kearney	0.268544	0.000257	Mndn_D_3
Mndn-U-2	0.264060	0.000770	Mndn_U_3
GI Gage	0.258130	0.000435	Mndn_D_3
ElmC-D-3	0.255024	0.002359	Mndn_D_1
Overton	0.254672	0.000541	ElmC_D_3
Mndn-U-4	0.247121	0.000496	Alda_U_1
ElmC-U-2	0.240617	0.002826	Alda_U_2
Ovtn-D-1	0.239935	0.000777	ElmC_D_3
ElmC-D-1	0.238830	0.154567	Alda_D_1
ElmC-U-2	0.232143	0.004004	Alda_U_1
ElmC-U-1	0.231893	0.004045	ElmC_U_2
Ovtn-D-3	0.230787	0.020881	ElmC_U_2
ElmC-D-3	0.226675	0.001481	Alda_D_3
Ovtn-U-2	0.223117	0.008054	Mndn_D_1
ElmC-D-4	0.222052	0.001860	Mndn_U_4
ElmC-D-2	0.222042	0.008372	Mndn_U_4
ElmC-D-1	0.212270	0.171763	ElmC_U_2

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
GI Gage	0.209720	0.013217	ElmC_U_2
ElmC-D-3	0.207254	0.003736	Alda_U_2
ElmC-U-2	0.202218	0.012475	Alda_U_3
ElmC-D-4	0.200158	0.005138	Mndn_D_3
ElmC-D-2	0.199900	0.017885	Mndn_D_3
ElmC-D-3	0.193171	0.006962	Alda_U_3
ElmC-D-4	0.189129	0.019617	ElmC_U_2
Kearney	0.188363	0.011105	Mndn_U_4
Overton	0.183749	0.013544	Ovtn_U_2
Ovtn-U-2	0.182443	0.036279	Mndn_U_1
ElmC-D-2	0.179542	0.037191	ElmC_U_2
GI Gage	0.178677	0.015808	Mndn_U_4
Ovtn-U-2	0.169242	0.018627	ElmC_U_1
ElmC-D-3	0.167884	0.019290	ElmC_U_3
Mndn-D-3	0.159281	0.068112	Mndn_U_1
Ovtn-D-2	0.154902	0.056714	ElmC_U_2
ElmC-D-1	0.148532	0.380295	Mndn_D_1
Overton	0.144383	0.089927	ElmC_U_2
ElmC-D-3	0.137051	0.057356	ElmC_U_1
Kearney	0.131517	0.124143	ElmC_U_2
ElmC-D-3	0.127451	0.143761	Alda_U_4
Overton	0.085721	0.249898	Mndn_D_3
Ovtn-U-2	0.065376	0.423590	ElmC_U_2
Mndn-U-1	0.051387	0.558435	Mndn_U_4
ElmC-U-2	0.040615	0.648977	ElmC_U_4
Ovtn-D-2	0.028191	0.725975	Mndn_U_2
ElmC-U-1	0.027967	0.699437	Mndn_D_3
Mndn-D-3	0.010985	0.897505	Mndn_D_1
Overton	-0.008181	0.912724	Mndn_U_4
Ovtn-D-1	-0.019882	0.807911	ElmC_U_2
ElmC-D-2	-0.031187	0.714523	ElmC_D_3
ElmC-U-1	-0.037394	0.605645	Mndn_U_4
ElmC-U-4	-0.062543	0.474500	Mndn_U_4
Ovtn-D-3	-0.081429	0.408925	ElmC_D_3
Mndn-D-3	-0.083701	0.294206	Mndn_U_2
Mndn-D-1	-0.086588	0.309034	Mndn_U_4
ElmC-D-3	-0.093887	0.192876	ElmC_D_4
Ovtn-U-2	-0.118701	0.138693	Mndn_U_2
ElmC-U-4	-0.123080	0.158128	Mndn_D_3
Ovtn-U-1	-0.152589	0.388951	Mndn_D_1
Mndn-U-2	-0.175860	0.026601	Mndn_U_4
Ovtn-U-1	-0.380418	0.005892	ElmC_U_2

Gage or Well 1	Corr. Coeff.	Probability	Gage or Well 2
ElmC-D-3	-0.381506	0.000006	ElmC_U_4
ElmC-D-1	-0.483076	0.002458	ElmC_U_4
Ovtn-U-1	-0.572217	0.001816	ElmC_U_4
Ovtn-D-3	No Data		Ovtn_U_1

Pearson correlation matrix - WSE with GH in the Overton transect
NOTE - underline indicates significant correlations; highlight indicates most significant correlation for the well WSE and its lagged data.

Well	Variable	Overton gage	Kearney gage	G.I. gage
Ovtn_U_3	WSE	0.459731	0.515290	0.561808
		< 0.000001	< 0.000001	< 0.000001
		133	133	133
	lag WSE	0.473049	0.580480	0.650910
		< 0.000001	< 0.000001	< 0.000001
		132	132	132
	2 lag WSE	0.426435	0.540511	0.618991
		< 0.000001	< 0.000001	< 0.000001
		131	131	131
	3 lag WSE	0.377841	0.491936	0.581507
		0.000009	< 0.000001	< 0.000001
		130	130	130
	4 lag WSE	0.329772	0.445597	0.539976
		0.000135	< 0.000001	< 0.000001
		129	129	129
	5 lag WSE	0.280346	0.401508	0.498587
		0.001350	0.000003	< 0.000001
		128	128	128
Ovtn_U_2	WSE	0.199799	0.396302	0.366949
		0.005339	< 0.000001	< 0.000001
		193	193	193
	lag WSE	0.184881	0.383440	0.358831
		0.010252	< 0.000001	< 0.000001
		192	192	192
	2 lag WSE	0.166388	0.359362	0.339019
		0.021420	< 0.000001	0.000002
		191	191	191
	3 lag WSE	0.144917	0.334013	0.312171
		0.046054	0.000002	0.000012
		190	190	190
	4 lag WSE	0.125003	0.310036	0.285939
		0.086558	0.000014	0.000066
		189	189	189
	5 lag WSE	0.101770	0.289633	0.263044
		0.164620	0.000055	0.000265
		188	188	188

Pearson correlation matrix - WSE with GH in the Overton transect (continued)

Well	Variable	Overton gage	Kearney gage	G.I. gage
Ovtn_U_1	WSE	0.472594	0.552877	0.565428
		0.000004	< 0.000001	< 0.000001
		87	87	87
	lag WSE	0.514491	0.579266	0.590577
		< 0.000001	< 0.000001	< 0.000001
		87	87	87
	2 lag WSE	0.563527	0.605201	0.599724
		< 0.000001	< 0.000001	< 0.000001
		87	87	87
	3 lag WSE	0.601265	0.633172	0.612130
		< 0.000001	< 0.000001	< 0.000001
		87	87	87
	4 lag WSE	0.639022	0.660190	0.629148
		< 0.000001	< 0.000001	< 0.000001
		87	87	87
	5 lag WSE	0.670726	0.690879	0.653222
		< 0.000001	< 0.000001	< 0.000001
		87	87	87
Ovtn_D_3	WSE	0.413958	0.581046	0.663907
		0.000011	< 0.000001	< 0.000001
		105	105	105
	lag WSE	0.375395	0.559627	0.659072
		0.000086	< 0.000001	< 0.000001
		104	104	104
	2 lag WSE	0.336866	0.516725	0.637999
		0.000503	< 0.000001	< 0.000001
		103	103	103
	3 lag WSE	0.293243	0.462381	0.589319
		0.002779	0.000001	< 0.000001
		102	102	102
	4 lag WSE	0.245608	0.409573	0.536052
		0.013300	0.000021	< 0.000001
		101	101	101
	5 lag WSE	0.197266	0.356506	0.487318
		0.049156	0.000272	< 0.000001
		100	100	100

Pearson correlation matrix - WSE with GH in the Overton transect (continued)

Well	Variable	Overton gage	Kearney gage	G.I. gage
Ovtn_D_2	WSE	0.297693	0.473229	0.446551
		0.000026	< 0.000001	< 0.000001
		193	193	193
	lag WSE	0.287976	0.467417	0.443973
		0.000051	< 0.000001	< 0.000001
		192	192	192
	2 lag WSE	0.272139	0.445257	0.429144
		0.000140	< 0.000001	< 0.000001
		191	191	191
	3 lag WSE	0.254959	0.420218	0.401699
		0.000385	< 0.000001	< 0.000001
		190	190	190
	4 lag WSE	0.237246	0.396306	0.373500
		0.001013	< 0.000001	< 0.000001
		189	189	189
	5 lag WSE	0.215590	0.374780	0.347688
		0.002965	< 0.000001	0.000001
		188	188	188
Ovtn_D_1	WSE	0.397409	0.528457	0.556859
		< 0.000001	< 0.000001	< 0.000001
		193	193	193
	lag WSE	0.398649	0.536015	0.563383
		< 0.000001	< 0.000001	< 0.000001
		192	192	192
	2 lag WSE	0.396511	0.524653	0.557867
		< 0.000001	< 0.000001	< 0.000001
		191	191	191
	3 lag WSE	0.394521	0.512981	0.537691
		< 0.000001	< 0.000001	< 0.000001
		190	190	190
	4 lag WSE	0.392206	0.504329	0.520735
		< 0.000001	< 0.000001	< 0.000001
		189	189	189
	5 lag WSE	0.386563	0.499434	0.507888
		< 0.000001	< 0.000001	< 0.000001
		188	188	188

Pearson correlation matrix - change in WSE with GH change in the Overton transect

Well	No. of lags	ΔStage Overton	ΔStage Kearney	ΔStage G.I.	Kearney gage	G.I. gage
Ovtn_U_3	ΔWSE	0.125282	0.115348	0.102719	0.107630	0.077902
		0.152334	0.187824	0.241187	0.219301	0.374616
		132	132	132	132	132
	lag ΔWSE	0.006335	0.222020	0.289274	0.356902	0.300149
		0.942751	0.010814	0.000805	0.000029	0.000496
		131	131	131	131	131
	2 lags ΔWSE	-0.124836	-0.084947	0.124398	0.34395	0.336356
		0.157027	0.336586	0.158497	0.000062	0.000091
		130	130	130	130	130
	3 lags ΔWSE	-0.088125	-0.204921	-0.127640	0.300505	0.315634
		0.320661	0.019829	0.149441	0.000540	0.000269
		129	129	129	129	129
	4 lags ΔWSE	-0.000374	-0.116192	-0.196657	0.275659	0.277652
		0.996659	0.191518	0.026090	0.001636	0.001508
		128	128	128	128	128
	5 lags ΔWSE	-0.058637	-0.059207	-0.095168	0.263546	0.259764
		0.512577	0.508477	0.287190	0.002756	0.003185
		127	127	127	127	127
Ovtn_U_2	ΔWSE	0.271959	0.359839	0.286851	0.055733	0.032007
		0.000136	< 0.000001	0.000055	0.442598	0.659413
		192	192	192	192	192
	lag ΔWSE	0.087088	0.262105	0.294780	0.119918	0.09953
		0.230935	0.000249	0.000035	0.098455	0.170715
		191	191	191	191	191
	2 lags ΔWSE	0.016581	0.024404	0.173656	0.126678	0.139822
		0.820381	0.738222	0.016569	0.081573	0.054347
		190	190	190	190	190
	3 lags ΔWSE	-0.022083	-0.087610	-0.038543	0.107352	0.132442
		0.762949	0.230621	0.598501	0.141480	0.069262
		189	189	189	189	189
	4 lags ΔWSE	0.052458	-0.065018	-0.138923	0.091597	0.100906
		0.474628	0.375360	0.057258	0.211239	0.168252
		188	188	188	188	188
	5 lags ΔWSE	0.014298	-0.012847	-0.066540	0.088872	0.085995
		0.846004	0.861469	0.365562	0.226448	0.241903
		187	187	187	187	187
Ovtn_U_1	ΔWSE	0.035797	0.259220	0.149037	-0.104359	-0.103223
		0.743508	0.015949	0.170827	0.338951	0.344266
		86	86	86	86	86

Pearson correlation matrix - ΔWSE with ΔGH for Overton transect (continued)

Well	No. of lags	ΔStage Overton	ΔStage Kearney	ΔStage G.I.	Kearney gage	G.I. gage
Ovtn_U_1	lag ΔWSE	-0.090521	-0.007281	0.206255	-0.105856	-0.042993
		0.407175	0.946949	0.056743	0.332029	0.694283
		86	86	86	86	86
	2 lags ΔWSE	0.092949	-0.033144	-0.041785	-0.114797	-0.055062
		0.394653	0.761925	0.702464	0.292573	0.614590
		86	86	86	86	86
	3 lags ΔWSE	0.003991	-0.040685	-0.074746	-0.125914	-0.076568
		0.970908	0.709947	0.493988	0.248010	0.483489
		86	86	86	86	86
	4 lags ΔWSE	0.049746	-0.087375	-0.145334	-0.149125	-0.118197
		0.649210	0.423734	0.181826	0.170572	0.278419
		86	86	86	86	86
	5 lags ΔWSE	0.101962	-0.055553	-0.136855	-0.161600	-0.156257
		0.350221	0.611430	0.208938	0.137153	0.150801
		86	86	86	86	86
Ovtn_D_3	ΔWSE	0.285073	0.286190	0.125120	0.073153	0.025168
		0.003355	0.003228	0.205677	0.460521	0.799807
		104	104	104	104	104
	lag ΔWSE	-0.014693	0.301865	0.262364	0.138604	0.075194
		0.882893	0.001943	0.007422	0.162637	0.450313
		103	103	103	103	103
	2 lags ΔWSE	0.039137	0.142322	0.434235	0.170676	0.158911
		0.696134	0.153595	0.000005	0.086326	0.110645
		102	102	102	102	102
	3 lags ΔWSE	0.032932	-0.051435	0.050595	0.163512	0.170711
		0.743721	0.609478	0.615342	0.102292	0.087855
		101	101	101	101	101
	4 lags ΔWSE	0.024534	-0.022338	-0.076711	0.159466	0.157669
		0.808557	0.825406	0.448102	0.113018	0.117189
		100	100	100	100	100
	5 lags ΔWSE	0.034944	-0.027531	-0.039488	0.155195	0.152562
		0.731318	0.786777	0.697970	0.125063	0.131674
		99	99	99	99	99
Ovtn_D_2	ΔWSE	0.208968	0.284649	0.299825	0.008856	-0.001985
		0.003628	0.000063	0.000024	0.902965	0.978205
		192	192	192	192	192
	lag ΔWSE	0.111553	0.292547	0.234034	0.080563	0.051711
		0.124448	0.000040	0.001120	0.267909	0.477431
		191	191	191	191	191

Pearson correlation matrix - ΔWSE with ΔGH for Overton transect (continued)

Well	No. of lags	ΔStage Overton	ΔStage Kearney	ΔStage G.I.	Kearney gage	G.I. gage
Ovtn_D_2	2 lags ΔWSE	-0.016998	0.05056	0.243283	0.093091	0.107491
		0.815938	0.488456	0.000719	0.201435	0.139901
		190	190	190	190	190
	3 lags ΔWSE	0.026843	-0.061303	-0.000638	0.078965	0.107914
		0.713882	0.402046	0.993048	0.280106	0.139395
		189	189	189	189	189
	4 lags ΔWSE	0.040502	-0.033499	-0.096152	0.072325	0.087156
		0.581047	0.648117	0.189309	0.323959	0.234313
		188	188	188	188	188
	5 lags ΔWSE	0.028820	-0.042153	-0.060465	0.062383	0.073603
		0.695393	0.566769	0.411049	0.396338	0.316768
		187	187	187	187	187
Ovtn_D_1	ΔWSE	0.153901	0.219695	0.243429	-0.034819	-0.02805
		0.033064	0.002200	0.000668	0.631614	0.699336
		192	192	192	192	192
	lag ΔWSE	0.051910	0.269177	0.182902	0.030699	0.013621
		0.475730	0.000166	0.011323	0.673327	0.851649
		191	191	191	191	191
	2 lags ΔWSE	-0.030731	0.002719	0.220844	0.031426	0.0642
		0.673826	0.970298	0.002199	0.666885	0.378860
		190	190	190	190	190
	3 lags ΔWSE	0.020582	-0.068945	-0.058656	0.014632	0.050809
		0.778630	0.345848	0.422711	0.841613	0.487479
		189	189	189	189	189
	4 lags ΔWSE	0.025909	-0.045938	-0.097688	0.004143	0.029074
		0.724136	0.531316	0.182308	0.955003	0.692054
		188	188	188	188	188
	5 lags ΔWSE	0.066075	-0.035627	-0.068129	-0.005019	0.013205
		0.368924	0.628329	0.354197	0.945647	0.857645
		187	187	187	187	187

Pearson correlation matrix - WSE on GH in the Elm Creek transect

Well		Overton Stage	Kearney Stage	G.I. Stage	Precip	Precip 1 Lag
ELMC_U_4	WSE	0.368476	0.444745	0.542419	-0.040436	-0.067655
		0.000013	< 0.000001	< 0.000001	0.643995	0.439073
		133	133	133	133	133
	lag WSE	0.340036	0.423556	0.527423	-0.017348	-0.042654
		0.000066	< 0.000001	< 0.000001	0.843486	0.627235
		132	132	132	132	132
	2 lags WSE	0.314127	0.402475	0.512620	-0.023480	-0.019550
		0.000258	0.000002	< 0.000001	0.790079	0.824594
		131	131	131	131	131
	3 lags WSE	0.291527	0.382831	0.496803	-0.025458	-0.025810
		0.000765	0.000007	< 0.000001	0.773719	0.770676
		130	130	130	130	130
	4 lags WSE	0.272351	0.365737	0.480379	-0.026678	-0.027997
		0.001794	0.000020	< 0.000001	0.764098	0.752802
		129	129	129	129	129
ELMC_U_3	WSE	0.441937	0.571207	0.656980	0.084317	0.129855
		< 0.000001	< 0.000001	< 0.000001	0.242447	0.071133
		194	194	194	194	194
	lag WSE	0.408549	0.546071	0.634892	-0.019255	0.083606
		< 0.000001	< 0.000001	< 0.000001	0.790405	0.247691
		193	193	193	193	193
	2 lags WSE	0.371955	0.505880	0.594605	-0.036603	-0.020225
		< 0.000001	< 0.000001	< 0.000001	0.614235	0.780667
		192	192	192	192	192
	3 lags WSE	0.333410	0.462013	0.546820	-0.051064	-0.037765
		0.000002	< 0.000001	< 0.000001	0.482963	0.603986
		191	191	191	191	191
	4 lags WSE	0.290267	0.419810	0.499052	-0.038260	-0.052232
		0.000049	< 0.000001	< 0.000001	0.600214	0.474175
		190	190	190	190	190
ELMC_U_2	WSE	0.132997	0.191161	0.225314	0.033827	0.069007
		0.102379	0.018317	0.005256	0.679080	0.398246
		152	152	152	152	152
	lag WSE	0.066603	0.134957	0.175785	-0.038195	0.036936
		0.416489	0.098502	0.030852	0.641493	0.652522
		151	151	151	151	151
	2 lags WSE	0.004007	0.067842	0.119458	-0.073296	-0.037730
		0.961184	0.409434	0.145384	0.372725	0.646673
		150	150	150	150	150

Pearson correlation matrix - WSE on GH in the Elm Creek transect (continued)

Well		Overton Stage	Kearney Stage	G.I. Stage	Precip	Precip 1 Lag
	3 lags WSE	-0.056813	0.000947	0.054559	-0.118701	-0.072782
		0.491325	0.990850	0.508704	0.149351	0.377719
		149	149	149	149	149
	4 lags WSE	-0.126283	-0.067585	-0.009778	-0.111328	-0.118162
		0.126164	0.414403	0.906105	0.177957	0.152623
		148	148	148	148	148
ELMC_U_1	WSE	0.704805	0.756265	0.800218	0.089113	0.239254
		< 0.000001	< 0.000001	< 0.000001	0.217797	0.000805
		193	193	193	193	193
	lag WSE	0.660054	0.736675	0.811888	-0.036361	0.088713
		< 0.000001	< 0.000001	< 0.000001	0.616574	0.221092
		192	192	192	192	192
	2 lags WSE	0.602074	0.678408	0.776819	-0.088247	-0.036919
		< 0.000001	< 0.000001	< 0.000001	0.224764	0.612121
		191	191	191	191	191
	3 lags WSE	0.537274	0.605938	0.712407	-0.096156	-0.088985
		< 0.000001	< 0.000001	< 0.000001	0.186923	0.222120
		190	190	190	190	190
	4 lags WSE	0.476686	0.535516	0.639889	-0.075585	-0.097004
		< 0.000001	< 0.000001	< 0.000001	0.301269	0.184220
		189	189	189	189	189
ELMC_D_4	WSE	0.463270	0.572072	0.657835	0.089161	0.071032
		< 0.000001	< 0.000001	< 0.000001	0.216343	0.325012
		194	194	194	194	194
	lag WSE	0.433449	0.553198	0.643616	0.058700	0.087370
		< 0.000001	< 0.000001	< 0.000001	0.417428	0.226965
		193	193	193	193	193
	2 lags WSE	0.398555	0.527152	0.622872	0.064779	0.056657
		< 0.000001	< 0.000001	< 0.000001	0.372027	0.435056
		192	192	192	192	192
	3 lags WSE	0.360993	0.498393	0.596536	0.055239	0.062754
		< 0.000001	< 0.000001	< 0.000001	0.447860	0.388447
		191	191	191	191	191
	4 lags WSE	0.320676	0.466817	0.566419	0.046258	0.053209
		0.000006	< 0.000001	< 0.000001	0.526245	0.465933
		190	190	190	190	190
ELMC_D_3	WSE	0.274015	0.354633	0.314241	0.016965	0.121650
		0.000111	< 0.000001	0.000008	0.814371	0.091083
		194	194	194	194	194

Pearson correlation matrix - WSE on GH in the Elm Creek transect (continued)

Well		Overton Stage	Kearney Stage	G.I. Stage	Precip	Precip 1 Lag
	lag WSE	0.232856	0.315062	0.279906	-0.024557	0.020081
		0.001119	0.000008	0.000081	0.734612	0.781629
		193	193	193	193	193
	2 lags WSE	0.188123	0.270003	0.234964	-0.030144	-0.021876
		0.008974	0.000152	0.001036	0.678097	0.763276
		192	192	192	192	192
	3 lags WSE	0.142311	0.222820	0.188202	-0.036365	-0.027488
		0.049545	0.001947	0.009127	0.617471	0.705821
		191	191	191	191	191
	4 lags WSE	0.093305	0.175033	0.141241	-0.031188	-0.033593
		0.200393	0.015717	0.051921	0.669262	0.645426
		190	190	190	190	190
ELMC_D_2	WSE	0.402651	0.534295	0.606910	0.175690	0.240111
		0.000001	< 0.000001	< 0.000001	0.037863	0.004270
		140	140	140	140	140
	lag WSE	0.403135	0.536234	0.607795	0.001996	0.173861
		0.000001	< 0.000001	< 0.000001	0.981392	0.040669
		139	139	139	139	139
	2 lags WSE	0.383416	0.509408	0.580763	-0.077970	-0.001163
		0.000003	< 0.000001	< 0.000001	0.363356	0.989196
		138	138	138	138	138
	3 lags WSE	0.360489	0.475768	0.542745	-0.046060	-0.082040
		0.000015	< 0.000001	< 0.000001	0.593022	0.340557
		137	137	137	137	137
	4 lags WSE	0.330170	0.442586	0.506373	-0.008003	-0.049742
		0.000087	< 0.000001	< 0.000001	0.926328	0.565233
		136	136	136	136	136
ELMC_D_1	WSE	0.397525	0.446926	0.442865	0.487534	0.305902
		0.000286	0.000036	0.000044	0.000005	0.006113
		79	79	79	79	79
	lag WSE	0.456815	0.528888	0.503979	-0.044881	0.493152
		0.000026	0.000001	0.000003	0.696405	0.000004
		78	78	78	78	78
	2 lags WSE	0.532560	0.603248	0.616856	-0.022146	-0.042176
		0.000001	< 0.000001	< 0.000001	0.849398	0.717539
		76	76	76	76	76
	3 lags WSE	0.575599	0.613335	0.622762	-0.075709	-0.012436
		< 0.000001	< 0.000001	< 0.000001	0.515683	0.915090
		76	76	76	76	76

Pearson correlation matrix - WSE on GH in the Elm Creek transect (continued)

Well	Overton Stage	Kearney Stage	G.I. Stage	Precip	Precip 1 Lag
4 lags WSE	0.594439	0.590522	0.591011	-0.041889	-0.076977
	< 0.000001	< 0.000001	< 0.000001	0.721214	0.511555
	75	75	75	75	75

Pearson correlation matrix - ΔWSE on ΔGH and river stage

Well		ΔStage Overton	ΔStage Kearney	ΔStage G.I.	Kearney Stage	G.I. Stage
ELMC_U_4	WSE	-0.138614	-0.189332	-0.126849	0.072712	0.046616
		0.112950	0.029685	0.147230	0.407357	0.595576
		132	132	132	132	132
	lag WSE	-0.035811	-0.041704	-0.086858	0.063566	0.028641
		0.684683	0.636245	0.323903	0.470725	0.745380
		131	131	131	131	131
	2 lags WSE	0.034018	0.036873	0.045617	0.070795	0.037770
		0.700811	0.677049	0.606300	0.423479	0.669644
		130	130	130	130	130
	3 lags WSE	-0.041588	0.038757	0.081011	0.075883	0.052845
		0.639819	0.662781	0.361424	0.392712	0.551989
		129	129	129	129	129
	4 lags WSE	0.090486	0.045956	0.077256	0.084927	0.068101
		0.309734	0.606480	0.386064	0.340521	0.444987
		128	128	128	128	128
ELMC_U_3	WSE	0.256465	0.355596	0.334081	0.085799	0.075774
		0.000318	< 0.000001	0.000002	0.235463	0.294935
		193	193	193	193	193
	lag WSE	0.050823	0.225142	0.292001	0.139572	0.141693
		0.483876	0.001691	0.000040	0.053508	0.049945
		192	192	192	192	192
	2 lags WSE	0.036798	0.057174	0.121054	0.152451	0.168618
		0.613282	0.432096	0.095285	0.035256	0.019713
		191	191	191	191	191
	3 lags WSE	0.047639	-0.028795	-0.005290	0.145780	0.167672
		0.513957	0.693308	0.942249	0.044758	0.020759
		190	190	190	190	190
	4 lags WSE	0.066364	0.007038	-0.079692	0.146819	0.148902
		0.364245	0.923429	0.275692	0.043803	0.040865
		189	189	189	189	189
ELMC_U_2	WSE	0.075483	0.030156	0.102207	0.108101	0.096765
		0.358592	0.714118	0.213290	0.187922	0.238807
		150	150	150	150	150
	lag WSE	0.014143	0.098776	0.056759	0.125353	0.105408
		0.864072	0.230725	0.491734	0.127694	0.200758
		149	149	149	149	149
	2 lags WSE	-0.017898	0.003231	0.067587	0.126616	0.120831
		0.829055	0.968915	0.414387	0.125160	0.143502
		148	148	148	148	148

Pearson correlation matrix - ΔWSE on ΔGH and river stage (continued)

Well		ΔStage Overton	ΔStage Kearney	ΔStage G.I.	Kearney Stage	G.I. Stage
	3 lags WSE	0.073139	0.013351	-0.000814	0.130233	0.121077
		0.378654	0.872486	0.992197	0.115900	0.144062
		147	147	147	147	147
	4 lags WSE	-0.097728	-0.060636	-0.087982	0.115550	0.101744
		0.240588	0.467206	0.290968	0.164879	0.221715
		146	146	146	146	146
ELMC_U_1	WSE	0.360972	0.520963	0.359602	0.042321	-0.029288
		< 0.000001	< 0.000001	< 0.000001	0.559996	0.686756
		192	192	192	192	192
	lag WSE	0.125790	0.366955	0.473393	0.131517	0.078641
		0.082931	< 0.000001	< 0.000001	0.069746	0.279525
		191	191	191	191	191
	2 lags WSE	0.061303	0.136633	0.298290	0.164340	0.146465
		0.400787	0.060141	0.000029	0.023467	0.043754
		190	190	190	190	190
	3 lags WSE	-0.033967	-0.023319	0.080971	0.158484	0.164804
		0.642646	0.750105	0.268033	0.029397	0.023441
		189	189	189	189	189
	4 lags WSE	-0.017656	-0.061295	-0.032620	0.143008	0.157132
		0.809954	0.403374	0.656758	0.050251	0.031279
		188	188	188	188	188
ELMC_D_4	WSE	0.183201	0.152215	0.191582	0.130341	0.106078
		0.010766	0.034581	0.007607	0.070807	0.142034
		193	193	193	193	193
	lag WSE	0.116843	0.173409	0.169990	0.172020	0.144466
		0.106531	0.016155	0.018411	0.017041	0.045586
		192	192	192	192	192
	2 lags WSE	0.051316	0.055566	0.135149	0.185781	0.175488
		0.480803	0.445171	0.062307	0.010079	0.015172
		191	191	191	191	191
	3 lags WSE	0.034904	0.043621	0.073127	0.198279	0.193531
		0.632588	0.550110	0.316015	0.006100	0.007465
		190	190	190	190	190
	4 lags WSE	0.043175	0.082928	0.070115	0.218071	0.209169
		0.555257	0.256599	0.337705	0.002574	0.003870
		189	189	189	189	189
ELMC_D_3	WSE	0.155937	0.277505	0.275816	0.164621	0.142852
		0.030347	0.000093	0.000103	0.022151	0.047496
		193	193	193	193	193

Pearson correlation matrix - change in WSE on change in river stage and river stage
Correlations - ΔWSE on ΔGH and river stage (continued)

Well		ΔStage Overton	ΔStage Kearney	ΔStage G.I.	Kearney Stage	G.I. Stage
	lag WSE	0.042409	0.072376	0.172922	0.181697	0.181957
		0.559176	0.318455	0.016461	0.011660	0.011540
		192	192	192	192	192
	2 lags WSE	0.005941	0.016947	0.013936	0.185938	0.185203
		0.934986	0.816002	0.848254	0.010014	0.010318
		191	191	191	191	191
	3 lags WSE	0.006978	-0.008935	-0.015910	0.185707	0.182966
		0.923878	0.902620	0.827527	0.010310	0.011513
		190	190	190	190	190
	4 lags WSE	-0.025776	-0.022069	-0.035128	0.179928	0.174565
		0.724789	0.763094	0.631313	0.013233	0.016287
		189	189	189	189	189
ELMC_D_2	WSE	0.114860	0.209672	0.297625	0.001209	-0.001037
		0.178169	0.013239	0.000373	0.988730	0.990332
		139	139	139	139	139
	lag WSE	0.141392	0.212967	0.221535	0.052605	0.047219
		0.098088	0.012146	0.009020	0.540030	0.582346
		138	138	138	138	138
	2 lags WSE	-0.045745	0.033825	0.113148	0.060335	0.071647
		0.595555	0.694764	0.188021	0.483698	0.405415
		137	137	137	137	137
	3 lags WSE	-0.007439	-0.056137	-0.037122	0.047106	0.063712
		0.931506	0.516255	0.667874	0.586041	0.461190
		136	136	136	136	136
	4 lags WSE	-0.004927	-0.040691	-0.058671	0.037218	0.050885
		0.954777	0.639364	0.499080	0.668244	0.557802
		135	135	135	135	135
ELMC_D_1	WSE	0.334626	0.194106	0.018867	0.697345	-0.251144
		0.002934	0.090733	0.870623	< 0.000001	0.027582
		77	77	77	77	77
	lag WSE	0.040848	0.304825	0.197849	-0.039170	0.698117
		0.726077	0.007420	0.086675	0.736911	< 0.000001
		76	76	76	76	76
	2 lags WSE	0.004496	0.054997	0.225879	0.058157	-0.047911
		0.969463	0.639323	0.051345	0.620169	0.683137
		75	75	75	75	75
	3 lags WSE	-0.142240	-0.129605	0.040136	-0.060502	0.088813
		0.226693	0.271083	0.734217	0.608606	0.451761
		74	74	74	74	74

Pearson correlation matrix - change in WSE on change in river stage and river stage
Correlations - ΔWSE on ΔGH and river stage (continued)

Well		ΔStage Overton	ΔStage Kearney	ΔStage G.I.	Kearney Stage	G.I. Stage
	4 lags WSE	-0.018928	-0.170858	-0.211432	-0.010109	-0.060764
		0.873710	0.148383	0.072549	0.932354	0.609574
		73	73	73	73	73

Pearson correlation matrix - Minden WSE with GH

		Overton gage	Kearney gage	G.I. GAGE	PRECIP1	PRECIP2
MIN_U_4	WSE	-0.006545	0.196171	0.180965	0.058451	0.061641
		0.927639	0.005986	0.011350	0.416979	0.391968
		195	195	195	195	195
	Lag WSE	-0.040970	0.160746	0.141605	0.035977	0.037433
		0.570580	0.025153	0.048893	0.618471	0.604324
		194	194	194	194	194
	2 Lag WSE	-0.076202	0.123971	0.102463	0.041400	0.043652
		0.292207	0.085850	0.156205	0.567558	0.546655
		193	193	193	193	193
MIN_U_3	WSE	0.274106	0.455610	0.503980	0.007574	0.000212
		0.000105	< 0.000001	< 0.000001	0.916310	0.997657
		195	195	195	195	195
	Lag WSE	0.223565	0.408077	0.454305	-0.004123	-0.013272
		0.001727	< 0.000001	< 0.000001	0.954496	0.854276
		194	194	194	194	194
	2 Lag WSE	0.173542	0.359435	0.404490	-0.002833	-0.011845
		0.015796	< 0.000001	< 0.000001	0.968814	0.870126
		193	193	193	193	193
MIN_U_2	WSE	0.669717	0.648060	0.736987	0.095199	0.093425
		< 0.000001	< 0.000001	< 0.000001	0.232614	0.241471
		159	159	159	159	159
	Lag WSE	0.649082	0.628824	0.709531	-0.030187	-0.030399
		< 0.000001	< 0.000001	< 0.000001	0.705638	0.703666
		159	159	159	159	159
	2 Lag WSE	0.622727	0.597615	0.668039	-0.058730	-0.062311
		< 0.000001	< 0.000001	< 0.000001	0.462128	0.435231
		159	159	159	159	159
MIN_U_1	WSE	0.836332	0.881629	0.931792	0.175538	0.176785
		< 0.000001	< 0.000001	< 0.000001	0.044088	0.042581
		132	132	132	132	132
	Lag WSE	0.789073	0.840966	0.912527	0.012064	0.010873
		< 0.000001	< 0.000001	< 0.000001	0.890803	0.901525
		132	132	132	132	132
	2 Lag WSE	0.734753	0.781374	0.858087	-0.022195	-0.028221
		< 0.000001	< 0.000001	< 0.000001	0.800572	0.748052
		132	132	132	132	132
MIN_D_3	WSE	0.084113	0.270252	0.250645	0.039908	0.042163
		0.242366	0.000133	0.000409	0.579630	0.558382
		195	195	195	195	195

Pearson correlation matrix - Minden WSE with GH (continued)

		Overton gage	Kearney gage	G.I. GAGE	PRECIP1	PRECIP2
MIN_D_3	Lag WSE	0.048362	0.234725	0.211041	0.026076	0.027492
		0.503085	0.000986	0.003139	0.718162	0.703558
		194	194	194	194	194
	2 Lag WSE	0.012216	0.197956	0.171609	0.027477	0.029219
		0.866102	0.005787	0.017018	0.704450	0.686675
		193	193	193	193	193
MIN_D_2	WSE	0.399496	0.569126	0.605698	0.019679	0.017175
		< 0.000001	< 0.000001	< 0.000001	0.784803	0.811638
		195	195	195	195	195
	Lag WSE	0.350603	0.521805	0.557220	0.001358	-0.003764
		0.000001	< 0.000001	< 0.000001	0.985010	0.958458
		194	194	194	194	194
	2 Lag WSE	0.302107	0.473961	0.507727	0.008410	0.003394
		0.000020	< 0.000001	< 0.000001	0.907594	0.962632
		193	193	193	193	193
MIN_D_1	WSE	0.914788	0.974060	0.977902	0.131802	0.136985
		< 0.000001	< 0.000001	< 0.000001	0.120591	0.106546
		140	140	140	140	140
	Lag WSE	0.856716	0.933306	0.978988	0.058066	0.058258
		< 0.000001	< 0.000001	< 0.000001	0.497148	0.495728
		139	139	139	139	139
	2 Lag WSE	0.784157	0.866290	0.937507	0.033137	0.033246
		< 0.000001	< 0.000001	< 0.000001	0.699618	0.698674
		138	138	138	138	138

Pearson correlation matrix - Minden ΔWSE with ΔGH

		ΔStage Overton	ΔStage Kearney	ΔStage G. I.	PRECIP1	PRECIP2
MIN_U_4	WSE	0.040487	0.087019	0.154321	0.200989	0.218389
		0.575135	0.227627	0.031679	0.004953	0.002220
		194	194	194	194	194
	Lag WSE	-0.004565	0.026644	0.084178	-0.080905	-0.089056
		0.949757	0.713010	0.244459	0.263350	0.218092
		193	193	193	193	193
	2 Lag WSE	-0.096325	-0.047937	-0.049317	0.05812	0.044653
		0.183818	0.509077	0.496941	0.423277	0.538553
		192	192	192	192	192
MIN_U_3	WSE	0.067379	0.092115	0.142660	0.094804	0.112102
		0.350570	0.201447	0.047217	0.188543	0.119654
		194	194	194	194	194
	Lag WSE	-0.047692	0.023043	0.063460	-0.031987	-0.033427
		0.510132	0.750417	0.380608	0.658777	0.644441
		193	193	193	193	193
	2 Lag WSE	-0.095559	-0.066729	-0.009785	0.103909	0.099304
		0.187342	0.357774	0.892850	0.151490	0.170561
		192	192	192	192	192
MIN_U_2	WSE	0.132879	0.195270	0.341588	0.392885	0.387142
		0.096036	0.013943	0.000011	< 0.000001	0.000001
		158	158	158	158	158
	Lag WSE	0.061602	0.132400	0.157069	0.089219	0.099421
		0.441947	0.097250	0.048735	0.264941	0.213919
		158	158	158	158	158
	2 Lag WSE	0.111294	0.068026	0.003857	0.057898	0.054649
		0.163873	0.395730	0.961635	0.469931	0.495250
		158	158	158	158	158
MIN_U_1	WSE	0.231460	0.462558	0.506963	0.494899	0.500851
		0.007814	< 0.000001	< 0.000001	< 0.000001	< 0.000001
		131	131	131	131	131
	Lag WSE	0.082257	0.211756	0.436771	0.094527	0.108965
		0.350286	0.015181	< 0.000001	0.282845	0.215380
		131	131	131	131	131
	2 Lag WSE	0.085895	0.068271	0.103750	0.036746	0.041105
		0.329316	0.438451	0.238289	0.676910	0.641105
		131	131	131	131	131
MIN_D_3	WSE	0.080274	0.135026	0.202180	0.144641	0.155245
		0.265857	0.060498	0.004697	0.044200	0.030660
		194	194	194	194	194

Pearson correlation matrix - Minden ΔWSE with ΔGH (continued)

		ΔStage Overton	ΔStage Kearney	ΔStage G. I.	PRECIP1	PRECIP2
MIN_D_3	Lag WSE	-0.031964	0.025047	0.101412	-0.050579	-0.054882
		0.659010	0.729521	0.160518	0.484836	0.448409
		193	193	193	193	193
	2 Lag WSE	-0.103642	-0.055115	-0.061614	0.064165	0.057730
		0.152548	0.447680	0.395895	0.376588	0.426399
		192	192	192	192	192
MIN_D_2	WSE	0.081992	0.187578	0.201456	0.108554	0.126311
		0.255729	0.008817	0.004851	0.131896	0.079264
		194	194	194	194	194
	Lag WSE	-0.032924	-0.002351	0.079947	-0.064461	-0.065273
		0.649435	0.974117	0.269067	0.373129	0.367128
		193	193	193	193	193
	2 Lag WSE	-0.044904	-0.059848	-0.055145	0.028989	0.029790
		0.536271	0.409600	0.447436	0.689789	0.681671
		192	192	192	192	192
MIN_D_1	WSE	0.520244	0.813890	0.748478	0.291526	0.311461
		< 0.000001	< 0.000001	< 0.000001	0.000498	0.000190
		139	139	139	139	139
	Lag WSE	0.243332	0.428854	0.774966	0.100955	0.101316
		0.004029	< 0.000001	< 0.000001	0.238725	0.237044
		138	138	138	138	138
	2 Lag WSE	0.143552	0.197365	0.383226	0.080952	0.090690
		0.094225	0.020793	0.000004	0.347020	0.291906
		137	137	137	137	137

Pearson correlation matrix - Alda WSE with GH

Well	Lags	Overton gage	Kearney gage	G. I. Stage	PRECIP1	PRECIP2
Alda U 4	WSE	0.315312	0.448472	0.533534	0.116783	0.088139
		0.000218	< 0.000001	< 0.000001	0.180675	0.313052
		133	133	133	133	133
	Lag WSE	0.269287	0.418220	0.497765	0.102778	0.066197
		0.001794	0.000001	< 0.000001	0.240915	0.450766
		132	132	132	132	132
	2 lags WSE	0.213227	0.380306	0.464256	0.079325	0.057165
		0.014473	0.000007	< 0.000001	0.367780	0.516631
		131	131	131	131	131
Alda U 3	WSE	0.457285	0.605453	0.668632	0.151604	0.107413
		< 0.000001	< 0.000001	< 0.000001	0.034844	0.135014
		195	195	195	194	195
	Lag WSE	0.444969	0.597767	0.658608	0.105474	0.023413
		< 0.000001	< 0.000001	< 0.000001	0.143284	0.745911
		194	194	194	194	194
	2 lags WSE	0.425849	0.577163	0.638075	0.017649	0.023193
		< 0.000001	< 0.000001	< 0.000001	0.807525	0.748847
		193	193	193	193	193
Alda U 2	WSE	0.535361	0.659674	0.741198	0.137692	0.057898
		< 0.000001	< 0.000001	< 0.000001	0.055548	0.421406
		195	195	195	194	195
	Lag WSE	0.511159	0.639684	0.716927	0.056124	-0.005867
		< 0.000001	< 0.000001	< 0.000001	0.436991	0.935290
		194	194	194	194	194
	2 lags WSE	0.481451	0.609000	0.684253	-0.011179	-0.001980
		< 0.000001	< 0.000001	< 0.000001	0.877370	0.978198
		193	193	193	193	193
Alda U 1	WSE	0.843833	0.933093	0.980883	0.203406	0.119419
		< 0.000001	< 0.000001	< 0.000001	0.004447	0.096345
		195	195	195	194	195
	Lag WSE	0.785595	0.886829	0.954918	0.117630	0.023555
		< 0.000001	< 0.000001	< 0.000001	0.102369	0.744418
		194	194	194	194	194
	2 lags WSE	0.716278	0.820947	0.899636	0.019412	0.004378
		< 0.000001	< 0.000001	< 0.000001	0.788734	0.951815
		193	193	193	193	193
Alda D 3	WSE	0.390738	0.557514	0.621010	0.096767	0.054027
		< 0.000001	< 0.000001	< 0.000001	0.179515	0.453166
		195	195	195	194	195

Pearson correlation matrix - Alda WSE with GH (continued)

Well	Lags	Overton gage	Kearney gage	G. I. Stage	PRECIP1	PRECIP2
Alda D 3	Lag WSE	0.364300	0.535246	0.597563	0.052955	0.021552
		< 0.000001	< 0.000001	< 0.000001	0.463361	0.765485
		194	194	194	194	194
	2 lags WSE	0.334601	0.505679	0.568369	0.018560	0.020821
		0.000002	< 0.000001	< 0.000001	0.797801	0.773803
		193	193	193	193	193
Alda D 2	WSE	0.425531	0.590284	0.621290	0.093614	0.060140
		< 0.000001	< 0.000001	< 0.000001	0.194180	0.403625
		195	195	195	194	195
	Lag WSE	0.400124	0.568282	0.596193	0.054222	0.009805
		< 0.000001	< 0.000001	< 0.000001	0.452714	0.892073
		194	194	194	194	194
	2 lags WSE	0.369617	0.537099	0.564743	0.003218	0.009168
		< 0.000001	< 0.000001	< 0.000001	0.964573	0.899301
		193	193	193	193	193
Alda D 1	WSE	0.494896	0.584336	0.693872	0.153590	0.077496
		< 0.000001	< 0.000001	< 0.000001	0.070022	0.362773
		140	140	140	140	140
	Lag WSE	0.442526	0.525124	0.634947	0.074082	-0.004884
		< 0.000001	< 0.000001	< 0.000001	0.386098	0.954497
		139	139	139	139	139
	2 lags WSE	0.384920	0.462326	0.570780	-0.010823	0.008865
		0.000003	< 0.000001	< 0.000001	0.899742	0.917809
		138	138	138	138	138

Pearson correlation matrix - Alda ΔWSE with ΔGH

Well	Lags	ΔStage Overton	ΔStage Kearney	ΔStage G.I.	PRECIP1	PRECIP2
Alda U 4	ΔWSE	0.120218	0.095433	0.137109	0.072748	0.115577
		0.169737	0.276374	0.116952	0.407129	0.186942
		132	132	132	132	132
	Lag ΔWSE	0.078983	0.102645	0.077982	0.123852	0.045415
		0.369855	0.243352	0.375976	0.158718	0.606497
		131	131	131	131	131
	2 lags ΔWSE	0.044773	0.090135	0.065905	0.038781	0.102922
		0.612985	0.307797	0.456279	0.661340	0.243913
		130	130	130	130	130
Alda U 3	ΔWSE	0.190601	0.270457	0.257591	0.194838	0.347387
		0.007766	0.000137	0.000288	0.006481	0.000001
		194	194	194	194	194
	Lag ΔWSE	0.103775	0.215043	0.213091	0.361933	-0.007891
		0.150943	0.002671	0.002926	< 0.000001	0.913271
		193	193	193	193	193
	2 lags ΔWSE	0.064249	0.047628	0.096972	-0.009377	-0.068489
		0.375964	0.511814	0.180875	0.897293	0.345207
		192	192	192	192	192
Alda U 2	ΔWSE	0.266769	0.339394	0.364484	0.415291	0.314704
		0.000170	0.000001	< 0.000001	< 0.000001	0.000008
		194	194	194	194	194
	Lag ΔWSE	0.097874	0.212213	0.209619	0.331517	-0.03148
		0.175696	0.003048	0.003436	0.000002	0.663852
		193	193	193	193	193
	2 lags ΔWSE	0.074493	0.037141	0.063428	-0.026272	-0.070379
		0.304468	0.609027	0.382107	0.717560	0.332027
		192	192	192	192	192
Alda U 1	ΔWSE	0.320253	0.548697	0.800044	0.324399	0.358348
		0.000005	< 0.000001	< 0.000001	0.000004	< 0.000001
		194	194	194	194	194
	Lag ΔWSE	0.169462	0.305522	0.497991	0.367308	0.066843
		0.018472	0.000016	< 0.000001	< 0.000001	0.355689
		193	193	193	193	193
	2 lags ΔWSE	0.104259	0.136848	0.225271	0.070111	0.008064
		0.150108	0.058391	0.001681	0.333877	0.911605
		192	192	192	192	192
Alda D 3	ΔWSE	0.237087	0.329996	0.301026	0.336896	0.234424
		0.000873	0.000003	0.000020	0.000002	0.001002
		194	194	194	194	194

Pearson correlation matrix - Alda ΔWSE with ΔGH

Well	Lags	ΔStage Overton	ΔStage Kearney	ΔStage G.I.	PRECIP1	PRECIP2
Alda D 3	Lag ΔWSE	0.096461	0.230231	0.246551	0.248593	-0.011231
		0.182044	0.001277	0.000547	0.000490	0.876804
		193	193	193	193	193
	2 lags ΔWSE	0.094851	0.028845	0.116437	-0.010130	-0.041055
		0.190648	0.691251	0.107762	0.889092	0.571801
		192	192	192	192	192
Alda D 2	ΔWSE	0.242164	0.310570	0.273483	0.238586	0.291919
		0.000669	0.000010	0.000114	0.000808	0.000036
		194	194	194	194	194
	Lag ΔWSE	0.103761	0.214647	0.214105	0.295655	-0.014015
		0.151000	0.002721	0.002791	0.000030	0.846605
		193	193	193	193	193
	2 lags ΔWSE	0.081798	0.012937	0.086824	-0.015917	-0.069044
		0.259354	0.858648	0.231123	0.826553	0.341305
		192	192	192	192	192
Alda D 1	ΔWSE	0.193407	0.235522	0.265623	0.385784	0.383028
		0.022535	0.005254	0.001576	0.000003	0.000003
		139	139	139	139	139
	Lag ΔWSE	0.099870	0.060699	0.104994	0.395107	-0.063626
		0.243834	0.479428	0.220361	0.000002	0.458461
		138	138	138	138	138
	2 lags ΔWSE	0.025878	-0.053928	-0.050804	-0.069654	-0.04156
		0.764048	0.531391	0.555476	0.418635	0.629666
		137	137	137	137	137

Pearson correlation matrix - Precipitation at OVTN_U_3 & OVTN_D_3

Well or Gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days	lagged 5 days
Overton	r	0.085757	0.132979	0.133366	0.129549	0.124650	0.104809
	Prob > r	0.233247	0.064539	0.064457	0.073308	0.085779	0.150114
	n	195	194	193	192	191	190
Kearney	r	0.091823	**0.174598**	0.180220	**0.164926**	**0.142633**	0.124871
	Prob > r	0.201711	0.014897	0.012141	0.022252	0.049027	0.086053
	n	195	194	193	192	191	190
G. I.	r	0.079098	**0.147450**	0.183945	**0.174697**	**0.148390**	0.126386
	Prob > r	0.271693	0.040199	0.010445	0.015371	0.040493	0.082284
	n	195	194	193	192	191	190
ΔOverton	r	**0.146276**	0.182403	-0.000183	-0.022189	-0.026515	-0.086828
	Prob > r	0.041832	0.010910	0.997980	0.759993	0.715784	0.233576
	n	194	194	193	192	191	190
ΔKearney	r	**0.155252**	0.334341	0.021547	-0.067976	-0.096622	-0.077938
	Prob > r	0.030652	0.000002	0.766142	0.348844	0.183622	0.285142
	n	194	194	193	192	191	190
ΔG. I.	r	**0.175089**	0.294230	**0.158549**	-0.044501	-0.119093	-0.100186
	Prob > r	0.014613	0.000031	0.027646	0.539939	0.100811	0.169034
	n	194	194	193	192	191	190
Ovtn_U_3	r	0.003496	0.078856	0.074898	0.085936	0.095756	0.091143
	Prob > r	0.968140	0.366935	0.391546	0.325347	0.272901	0.296779
	n	133	133	133	133	133	133
Ovtn_U_2	r	0.120782	**0.154385**	0.177329	**0.167263**	**0.158578**	0.140797
	Prob > r	0.094290	0.032055	0.013621	0.020401	0.028446	0.052670
	n	193	193	193	192	191	190
Ovtn_U_1	r	0.152578	0.191656	0.147904	0.111927	0.079951	0.043645
	Prob > r	0.158291	0.075352	0.171582	0.304888	0.467005	0.693430
	n	87	87	87	86	85	84
ΔOvtn_U_3	r	0.016110	0.086171	-0.014972	-0.009019	-0.010825	-0.032214
	Prob > r	0.854532	0.325883	0.864703	0.918247	0.901952	0.713851
	n	132	132	132	132	132	132
ΔOvtn_U_2	r	0.270278	**0.190191**	0.122686	-0.060499	-0.051509	-0.103400
	Prob > r	0.000150	0.008234	0.090019	0.404514	0.479150	0.155705
	n	192	192	192	192	191	190
ΔOvtn_U_1	r	0.254502	0.124754	-0.192892	-0.151363	-0.133857	-0.060624
	Prob > r	0.018045	0.252428	0.075177	0.164174	0.221961	0.583823
	n	86	86	86	86	85	84

Note -
Bold indicates statistically significant correlation
Highlight indicates the best correlation for the site

Pearson correlation matrix - Precipitation at OVTN_U_2 & OVTN_D_2

Well or Gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days	lagged 5 days
Overton	r	0.053867	0.096874	0.102883	0.111596	0.112053	0.095588
	Prob > r	0.454511	0.179033	0.154507	0.123307	0.122756	0.189554
	n	195	194	193	192	191	190
Kearney	r	0.047568	0.124817	0.130976	0.125500	0.114838	0.103960
	Prob > r	0.509022	0.082908	0.069434	0.082832	0.113669	0.153462
	n	195	194	193	192	191	190
G. I.	r	0.037364	0.098701	0.136791	0.129898	0.115148	0.101790
	Prob > r	0.604052	0.170933	0.057835	0.072529	0.112693	0.162276
	n	195	194	193	192	191	190
ΔOverton	r	**0.142937**	0.165905	0.025210	0.028417	-0.004672	-0.072868
	Prob > r	0.046786	0.020783	0.727838	0.695598	0.948857	0.317737
	n	194	194	193	192	191	190
ΔKearney	r	**0.149539**	0.312038	0.025857	-0.027326	-0.048588	-0.049406
	Prob > r	0.037425	0.000009	0.721130	0.706742	0.504465	0.498446
	n	194	194	193	192	191	190
ΔG. I.	r	**0.192157**	0.264042	**0.167134**	-0.033867	-0.068232	-0.062094
	Prob > r	0.007270	0.000199	0.020169	0.640965	0.348300	0.394727
	n	194	194	193	192	191	190
Ovtn_U_3	r	-0.016606	0.067661	0.055037	0.066844	0.082207	0.078556
	Prob > r	0.849531	0.439032	0.529214	0.444594	0.346860	0.368762
	n	133	133	133	133	133	133
Ovtn_U_2	r	0.044182	0.077408	0.092941	0.088848	0.089983	0.076833
	Prob > r	0.541794	0.284617	0.198593	0.220385	0.215737	0.292045
	n	193	193	193	192	191	190
Ovtn_U_1	r	0.085045	0.155241	0.118091	0.089376	0.068308	0.046663
	Prob > r	0.433514	0.151069	0.275995	0.413156	0.534486	0.673394
	n	87	87	87	86	85	84
ΔOvtn_U_3	r	0.010780	0.099725	-0.015020	-0.007432	-0.002161	-0.030339
	Prob > r	0.902363	0.255250	0.864278	0.932601	0.980378	0.729847
	n	132	132	132	132	132	132
ΔOvtn_U_2	r	0.240391	**0.188414**	0.076817	-0.022168	0.008847	-0.074076
	Prob > r	0.000783	0.008866	0.289589	0.760215	0.903317	0.309762
	n	192	192	192	192	191	190
ΔOvtn_U_1	r	0.178430	0.246034	-0.165600	-0.121952	-0.091204	-0.021485
	Prob > r	0.100238	0.022403	0.127564	0.263324	0.406460	0.846190
	n	86	86	86	86	85	84

Pearson correlation matrix - Precipitation at OVTN_U_1							
Well or Gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days	lagged 5 days
Overton	r	0.071569	0.114966	0.117947	0.122560	0.121312	0.101147
	Prob > r	0.368473	0.147724	0.137433	0.122602	0.126487	0.203139
	n	160	160	160	160	160	160
Kearney	r	0.066232	0.142112	0.147645	0.137283	0.123450	0.108657
	Prob > r	0.405344	0.073035	0.062439	0.083434	0.119888	0.171410
	n	160	160	160	160	160	160
G. I.	r	0.050551	0.112494	0.149211	0.139672	0.121144	0.105439
	Prob > r	0.525548	0.156690	0.059681	0.078150	0.127016	0.184523
	n	160	160	160	160	160	160
ΔOverton	r	0.136634	0.175710	0.013161	0.019288	-0.004550	-0.081721
	Prob > r	0.085913	0.026252	0.868806	0.808715	0.954467	0.304276
	n	159	160	160	160	160	160
ΔKearney	r	**0.158129**	0.312877	0.024558	-0.041471	-0.056540	-0.060882
	Prob > r	0.046509	0.000056	0.757891	0.602585	0.477618	0.444407
	n	159	160	160	160	160	160
ΔG. I.	r	**0.209649**	0.270761	**0.162660**	-0.040259	-0.080475	-0.068564
	Prob > r	0.007995	0.000534	0.039871	0.613243	0.311729	0.388967
	n	159	160	160	160	160	160
Ovtn_U_3	r	-0.016467	0.074793	0.085026	0.100348	0.121878	0.119318
	Prob > r	0.872148	0.461874	0.400292	0.318061	0.222354	0.229961
	n	98	99	100	101	102	103
Ovtn_U_2	r	0.052701	0.083821	0.095507	0.088338	0.088350	0.074286
	Prob > r	0.510767	0.293511	0.229612	0.266648	0.266585	0.350523
	n	158	159	160	160	160	160
Ovtn_U_1	r	0.085045	0.155241	0.118091	0.089376	0.068308	0.046663
	Prob > r	0.433514	0.151069	0.275995	0.413156	0.534486	0.673394
	n	87	87	87	86	85	84
ΔOvtn_U_3	r	**0.221467**	0.499093	0.052254	0.079907	0.113758	-0.018296
	Prob > r	0.029252	< 0.000001	0.607487	0.429358	0.257336	0.855174
	n	97	98	99	100	101	102
ΔOvtn_U_2	r	0.275966	**0.186412**	0.058878	-0.046768	-0.002726	-0.089012
	Prob > r	0.000468	0.019019	0.460998	0.557033	0.972706	0.263004
	n	157	158	159	160	160	160
ΔOvtn_U_1	r	0.178430	0.246034	-0.165600	-0.121952	-0.091204	-0.021485
	Prob > r	0.100238	0.022403	0.127564	0.263324	0.406460	0.846190
	n	86	86	86	86	85	84

Pearson correlation matrix - Precipitation at OVTN_D_3

Well or Gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days	lagged 5 days
Ovtn_D_3	r	0.170578	0.212650	0.172173	0.123900	0.110038	0.146955
	Prob > r	0.081902	0.029413	0.079042	0.207937	0.263800	0.134667
	n	105	105	105	105	105	105
Ovtn_D_2	r	0.138803	0.207424	**0.188560**	**0.174220**	**0.155440**	0.133955
	Prob > r	0.054215	0.003798	0.008636	0.015657	0.031778	0.065392
	n	193	193	193	192	191	190
Ovtn_D_1	r	0.134788	0.198752	**0.153200**	0.127429	0.114475	0.106880
	Prob > r	0.061636	0.005590	0.033414	0.078176	0.114824	0.142179
	n	193	193	193	192	191	190
ΔOvtn_D_3	r	0.186697	0.154019	-0.115942	-0.132504	-0.023422	0.137547
	Prob > r	0.057742	0.118514	0.241180	0.179961	0.813430	0.163808
	n	104	104	104	104	104	104
ΔOvtn_D_2	r	**0.273555**	0.300470	-0.096405	-0.066906	-0.085320	-0.095587
	Prob > r	0.000123	0.000023	0.183453	0.356501	0.240576	0.189556
	n	192	192	192	192	191	190
ΔOvtn_D_1	r	0.291042	**0.222167**	**-0.168281**	-0.088077	-0.042105	-0.022783
	Prob > r	0.000042	0.001954	0.019637	0.224435	0.563038	0.755033
	n	192	192	192	192	191	190

Pearson correlation matrix - Precipitation at OVTN_D_2

Well or Gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days	lagged 5 days
Ovtn_D_3	r	0.111024	0.153629	0.123037	0.080472	0.076891	0.121799
	Prob > r	0.259520	0.117656	0.211146	0.414472	0.435613	0.215810
	n	105	105	105	105	105	105
Ovtn_D_2	r	0.080974	0.132796	0.114321	0.104850	0.094392	0.078478
	Prob > r	0.262945	0.065616	0.113403	0.147797	0.193990	0.281805
	n	193	193	193	192	191	190
Ovtn_D_1	r	0.106795	0.161370	0.120905	0.100891	0.096855	0.099172
	Prob > r	0.139343	0.024963	0.093954	0.163796	0.182561	0.173411
	n	193	193	193	192	191	190
ΔOvtn_D_3	r	0.174800	0.154894	-0.091926	-0.115304	0.008268	0.161973
	Prob > r	0.075937	0.116412	0.353355	0.243796	0.933609	0.100444
	n	104	104	104	104	104	104
ΔOvtn_D_2	r	0.329766	**0.225253**	-0.095900	-0.042561	-0.046090	-0.069115
	Prob > r	0.000003	0.001682	0.185770	0.557768	0.526650	0.343369
	n	192	192	192	192	191	190
ΔOvtn_D_1	r	0.350802	**0.189233**	**-0.152528**	-0.067392	-0.010758	0.011519
	Prob > r	0.000001	0.008570	0.034681	0.353010	0.882579	0.874664
	n	192	192	192	192	191	190

Pearson correlation matrix - Precipitation at OVTN_D_1							
Well or Gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days	lagged 5 days
Overton	r	0.053867	0.096874	0.102883	0.111596	0.112053	0.095588
	Prob > r	0.454511	0.179033	0.154507	0.123307	0.122756	0.189554
	n	195	194	193	192	191	190
Kearney	r	0.047568	0.124817	0.130976	0.125500	0.114838	0.103960
	Prob > r	0.509022	0.082908	0.069434	0.082832	0.113669	0.153462
	n	195	194	193	192	191	190
G. I.	r	0.037364	0.098701	0.136791	0.129898	0.115148	0.101790
	Prob > r	0.604052	0.170933	0.057835	0.072529	0.112693	0.162276
	n	195	194	193	192	191	190
ΔOverton	r	**0.142937**	0.165905	0.025210	0.028417	-0.004672	-0.072868
	Prob > r	0.046786	0.020783	0.727838	0.695598	0.948857	0.317737
	n	194	194	193	192	191	190
ΔKearney	r	**0.149539**	0.312038	0.025857	-0.027326	-0.048588	-0.049406
	Prob > r	0.037425	0.000009	0.721130	0.706742	0.504465	0.498446
	n	194	194	193	192	191	190
ΔG. I.	r	**0.192157**	0.264042	**0.167134**	-0.033867	-0.068232	-0.062094
	Prob > r	0.007270	0.000199	0.020169	0.640965	0.348300	0.394727
	n	194	194	193	192	191	190
Ovtn_D_3	r	0.111024	0.153629	0.123037	0.080472	0.076891	0.121799
	Prob > r	0.259520	0.117656	0.211146	0.414472	0.435613	0.215810
	n	105	105	105	105	105	105
Ovtn_D_2	r	0.080974	0.132796	0.114321	0.104850	0.094392	0.078478
	Prob > r	0.262945	0.065616	0.113403	0.147797	0.193990	0.281805
	n	193	193	193	192	191	190
Ovtn_D_1	r	0.106795	0.161370	0.120905	0.100891	0.096855	0.099172
	Prob > r	0.139343	0.024963	0.093954	0.163796	0.182561	0.173411
	n	193	193	193	192	191	190
ΔOvtn_D_3	r	0.174800	0.154894	-0.091926	-0.115304	0.008268	0.161973
	Prob > r	0.075937	0.116412	0.353355	0.243796	0.933609	0.100444
	n	104	104	104	104	104	104
ΔOvtn_D_2	r	0.329766	**0.225253**	-0.095900	-0.042561	-0.046090	-0.069115
	Prob > r	0.000003	0.001682	0.185770	0.557768	0.526650	0.343369
	n	192	192	192	192	191	190
ΔOvtn_D_1	r	0.350802	**0.189233**	**-0.152528**	-0.067392	-0.010758	0.011519
	Prob > r	0.000001	0.008570	0.034681	0.353010	0.882579	0.874664
	n	192	192	192	192	191	190

Pearson correlation matrix - precipitation at well: ElmC_U_4						
Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.104427	**0.150778**	**0.182792**	0.201850	**0.186277**
	Prob > r	0.146266	0.035858	0.010947	0.004991	0.009876
	n	195	194	193	192	191
Kearney	r	0.113058	**0.170447**	**0.192990**	0.223201	**0.218784**
	Prob > r	0.115565	0.017496	0.007166	0.001859	0.002360
	n	195	194	193	192	191
G. I.	r	0.089705	**0.169319**	**0.183848**	**0.194989**	0.202195
	Prob > r	0.212352	0.018267	0.010486	0.006723	0.005030
	n	195	194	193	192	191
ΔOverton	r	0.120989	0.179124	0.133155	0.069593	-0.069120
	Prob > r	0.092866	0.012453	0.064884	0.337472	0.342049
	n	194	194	193	192	191
ΔKearney	r	**0.204802**	0.230426	0.095581	0.118556	-0.023492
	Prob > r	0.004176	0.001228	0.186082	0.101461	0.747012
	n	194	194	193	192	191
ΔG. I.	r	**0.231969**	0.343438	0.065944	0.044821	0.027499
	Prob > r	0.001136	0.000001	0.362209	0.537031	0.705717
	n	194	194	193	192	191
ElmC_U_4	r	-0.040436	-0.067655	-0.058665	-0.061350	-0.059319
	Prob > r	0.643995	0.439073	0.502382	0.482988	0.497617
	n	133	133	133	133	133
ElmC_U_3	r	0.084317	0.129855	0.142048	0.135630	0.110105
	Prob > r	0.242447	0.071133	0.048772	0.060690	0.129441
	n	194	194	193	192	191
ElmC_U_2	r	0.033827	0.069007	0.026857	0.081475	0.107079
	Prob > r	0.679080	0.398246	0.742579	0.318349	0.189169
	n	152	152	152	152	152
ElmC_U_1	r	0.089113	0.239254	**0.227818**	**0.195714**	0.115264
	Prob > r	0.217797	0.000805	0.001441	0.006517	0.112327
	n	193	193	193	192	191
ΔElmC_U_4	r	**-0.261308**	-0.287587	0.144287	0.034361	0.096409
	Prob > r	0.002475	0.000827	0.098816	0.695699	0.271468
	n	132	132	132	132	132
ΔElmC_U_3	r	0.368958	**0.162240**	0.040564	-0.021420	-0.089703
	Prob > r	< 0.000001	0.024182	0.575413	0.768074	0.217175
	n	193	193	193	192	191
ΔElmC_U_2	r	0.095450	0.027976	-0.083189	0.106661	0.039515
	Prob > r	0.245279	0.733979	0.311500	0.193909	0.631158
	n	150	150	150	150	150
ΔElmC_U_1	r	**0.287167**	0.345199	-0.029794	-0.073894	-0.185125
	Prob > r	0.000054	0.000001	0.681636	0.308385	0.010351
	n	192	192	192	192	191

Pearson correlation matrix - precipitation at wells: ELMC_U_3, ELMC_U_2, & ELMC_U_1

Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.051638	0.096882	0.108520	0.128747	0.130316
	Prob > r	0.473423	0.178995	0.133030	0.075118	0.072358
	n	195	194	193	192	191
Kearney	r	0.057930	0.127340	0.135337	0.137066	0.133201
	Prob > r	0.421156	0.076829	0.060575	0.057987	0.066212
	n	195	194	193	192	191
G. I.	r	0.042319	0.108850	0.136088	0.133283	0.124191
	Prob > r	0.556922	0.130840	0.059147	0.065330	0.086949
	n	195	194	193	192	191
ΔOverton	r	**0.152335**	0.174949	0.052685	0.074624	-0.000146
	Prob > r	0.033968	0.014693	0.466813	0.303616	0.998400
	n	194	194	193	192	191
ΔKearney	r	**0.203556**	0.279949	0.036827	0.002247	-0.020735
	Prob > r	0.004417	0.000077	0.611128	0.975322	0.775865
	n	194	194	193	192	191
ΔG. I.	r	**0.223431**	0.286716	0.122229	-0.015925	-0.043447
	Prob > r	0.001738	0.000051	0.090382	0.826466	0.550652
	n	194	194	193	192	191
ElmC_U_4	r	-0.013766	-0.042408	-0.032838	-0.032062	-0.028965
	Prob > r	0.875031	0.627906	0.707486	0.714095	0.740677
	n	133	133	133	133	133
ElmC_U_3	r	0.123898	0.163143	0.126771	0.112668	0.099395
	Prob > r	0.085216	0.023033	0.078951	0.119722	0.171301
	n	194	194	193	192	191
ElmC_U_2	r	-0.001383	0.003385	0.000365	0.021618	0.069367
	Prob > r	0.986513	0.966990	0.996444	0.791510	0.395779
	n	152	152	152	152	152
ElmC_U_1	r	**0.168731**	0.321281	**0.216297**	0.124175	0.096180
	Prob > r	0.018991	0.000005	0.002518	0.086157	0.185643
	n	193	193	193	192	191
ΔElmC_U_4	r	**-0.300511**	-0.307643	0.138779	0.078349	0.108890
	Prob > r	0.000463	0.000333	0.112519	0.371870	0.213924
	n	132	132	132	132	132
ΔElmC_U_3	r	0.483477	0.139574	-0.135245	-0.049000	-0.045635
	Prob > r	< 0.000001	0.052879	0.060750	0.499715	0.530742
	n	193	193	193	192	191
ΔElmC_U_2	r	0.048810	-0.018493	0.005598	0.041414	0.085464
	Prob > r	0.553084	0.822277	0.945790	0.614835	0.298406
	n	150	150	150	150	150
ΔElmC_U_1	r	0.396906	**0.350807**	**-0.246022**	**-0.212288**	-0.063842
	Prob > r	< 0.000001	0.000001	0.000582	0.003115	0.380257
	n	192	192	192	192	191

Pearson correlation matrix - precipitation at wells: ELMC_D_4 & ELMC_D_3

Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.042732	0.087149	0.098177	0.117101	0.116297
	Prob > r	0.553079	0.226934	0.174356	0.105754	0.109123
	n	195	194	193	192	191
Kearney	r	0.046898	0.113014	0.120770	0.123112	0.118174
	Prob > r	0.515018	0.116658	0.094323	0.088901	0.103487
	n	195	194	193	192	191
G. I.	r	0.031202	0.093950	0.120031	0.118617	0.110553
	Prob > r	0.665002	0.192575	0.096372	0.101283	0.127880
	n	195	194	193	192	191
ΔOverton	r	**0.145170**	0.171830	0.050989	0.069621	-0.009432
	Prob > r	0.043422	0.016589	0.481296	0.337277	0.896967
	n	194	194	193	192	191
ΔKearney	r	**0.192048**	0.266602	0.036389	0.004946	-0.024934
	Prob > r	0.007304	0.000172	0.615375	0.945721	0.732059
	n	194	194	193	192	191
ΔG. I.	r	**0.217552**	0.270372	0.117585	-0.009692	-0.038801
	Prob > r	0.002310	0.000137	0.103402	0.893864	0.594084
	n	194	194	193	192	191
ElmC_D_4	r	0.059621	0.059428	0.070917	0.079524	0.074196
	Prob > r	0.408924	0.410442	0.327064	0.272880	0.307689
	n	194	194	193	192	191
ElmC_D_3	r	-0.031952	0.052953	0.036622	0.039564	0.036213
	Prob > r	0.658290	0.463376	0.613114	0.585854	0.618938
	n	194	194	193	192	191
ElmC_D_2	r	**0.196134**	0.284533	**0.182905**	0.134520	0.087294
	Prob > r	0.020206	0.000656	0.030538	0.113057	0.305094
	n	140	140	140	140	140
ElmC_D_1	r	0.487534	**0.305902**	0.182363	0.080299	0.013450
	Prob > r	0.000005	0.006113	0.107712	0.484641	0.907573
	n	79	79	79	78	77
ΔElmC_D_4	r	0.163098	0.009923	0.052950	0.063992	-0.018721
	Prob > r	0.023433	0.891056	0.464571	0.377880	0.797142
	n	193	193	193	192	191
ΔElmC_D_3	r	**0.174556**	0.329008	-0.054101	0.000324	-0.025227
	Prob > r	0.015185	0.000003	0.454903	0.996443	0.729038
	n	193	193	193	192	191
ΔElmC_D_2	r	0.247875	0.081810	**-0.179918**	-0.073415	-0.070331
	Prob > r	0.003260	0.338353	0.034059	0.390402	0.410669
	n	139	139	139	139	139
ΔElmC_D_1	r	**0.403349**	-0.173744	-0.113749	0.545307	-0.083118
	Prob > r	0.000251	0.128189	0.321390	< 0.000001	0.472340
	n	78	78	78	78	77

Pearson correlation matrix - precipitation at wells: ElmC_D_2 & ElmC_D_1

Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.051638	0.096882	0.108520	0.128747	0.130316
	Prob > r	0.473423	0.178995	0.133030	0.075118	0.072358
	n	195	194	193	192	191
Kearney	r	0.057930	0.127340	0.135337	0.137066	0.133201
	Prob > r	0.421156	0.076829	0.060575	0.057987	0.066212
	n	195	194	193	192	191
G. I.	r	0.042319	0.108850	0.136088	0.133283	0.124191
	Prob > r	0.556922	0.130840	0.059147	0.065330	0.086949
	n	195	194	193	192	191
ΔOverton	r	**0.152335**	0.174949	0.052685	0.074624	-0.000146
	Prob > r	0.033968	0.014693	0.466813	0.303616	0.998400
	n	194	194	193	192	191
ΔKearney	r	**0.203556**	0.279949	0.036827	0.002247	-0.020735
	Prob > r	0.004417	0.000077	0.611128	0.975322	0.775865
	n	194	194	193	192	191
ΔG. I.	r	**0.223431**	0.286716	0.122229	-0.015925	-0.043447
	Prob > r	0.001738	0.000051	0.090382	0.826466	0.550652
	n	194	194	193	192	191
ElmC_D_4	r	0.072589	0.073622	0.086179	0.094920	0.090844
	Prob > r	0.314490	0.307637	0.233386	0.190325	0.211358
	n	194	194	193	192	191
ElmC_D_3	r	-0.029316	0.055268	0.039332	0.041439	0.038521
	Prob > r	0.684913	0.444032	0.587074	0.568207	0.596754
	n	194	194	193	192	191
ElmC_D_2	r	**0.218307**	0.313876	**0.204620**	0.150996	0.105018
	Prob > r	0.009564	0.000159	0.015304	0.074942	0.216879
	n	140	140	140	140	140
ElmC_D_1	r	0.510559	**0.328121**	0.197865	0.093534	0.026393
	Prob > r	0.000002	0.003156	0.080472	0.415347	0.819762
	n	79	79	79	78	77
ΔElmC_D_4	r	0.169105	0.017543	0.060918	0.065158	-0.010906
	Prob > r	0.018724	0.808662	0.400024	0.369229	0.880971
	n	193	193	193	192	191
ΔElmC_D_3	r	**0.176027**	0.327163	-0.053912	-0.003451	-0.023851
	Prob > r	0.014337	0.000003	0.456485	0.962106	0.743282
	n	193	193	193	192	191
ΔElmC_D_2	r	0.266938	0.087168	**-0.192315**	-0.081374	-0.067609
	Prob > r	0.001490	0.307559	0.023323	0.340943	0.429055
	n	139	139	139	139	139
ΔElmC_D_1	r	**0.419666**	-0.175486	-0.135520	0.517861	-0.083974
	Prob > r	0.000131	0.124347	0.236800	0.000001	0.467779
	n	78	78	78	78	77

Pearson correlation matrix - precipitation at well Mndn_U_4						
Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.105651	**0.152204**	**0.186871**	0.200552	**0.184588**
	Prob > r	0.141571	0.034123	0.009263	0.005284	0.010579
	n	195	194	193	192	191
Kearney	r	0.119503	**0.175527**	**0.199972**	0.227761	**0.223004**
	Prob > r	0.096112	0.014364	0.005299	0.001487	0.001929
	n	195	194	193	192	191
G. I.	r	0.101277	**0.180493**	**0.194591**	**0.204036**	0.211801
	Prob > r	0.158897	0.011787	0.006693	0.004530	0.003268
	n	195	194	193	192	191
ΔOverton	r	0.104887	0.180163	0.136998	0.065597	-0.070389
	Prob > r	0.145534	0.011945	0.057453	0.366005	0.333236
	n	194	194	193	192	191
ΔKearney	r	**0.196904**	0.224982	0.098594	0.120875	-0.024682
	Prob > r	0.005926	0.001611	0.172522	0.094904	0.734669
	n	194	194	193	192	191
ΔG. I.	r	**0.234225**	0.341763	0.060459	0.046526	0.030082
	Prob > r	0.001012	0.000001	0.403588	0.521639	0.679531
	n	194	194	193	192	191
Mndn_U_4	r	0.058451	0.065775	0.072505	0.085666	0.084808
	Prob > r	0.416979	0.362186	0.316318	0.237427	0.243419
	n	195	194	193	192	191
Mndn_U_3	r	0.007574	0.016084	0.040997	0.065937	0.070080
	Prob > r	0.916310	0.823854	0.571335	0.363521	0.335368
	n	195	194	193	192	191
Mndn_U_2	r	0.095199	0.198968	**0.163865**	0.144881	0.109091
	Prob > r	0.232614	0.012202	0.040296	0.071147	0.176626
	n	159	158	157	156	155
Mndn_U_1	r	**0.175538**	0.188733	0.141972	0.146012	0.137418
	Prob > r	0.044088	0.030214	0.104406	0.094810	0.116122
	n	132	132	132	132	132
ΔMndn_U_4	r	0.200989	0.064689	0.063642	0.135452	-0.017266
	Prob > r	0.004953	0.370186	0.379246	0.061031	0.812603
	n	194	194	193	192	191
ΔMndn_U_3	r	0.094804	0.085672	0.241103	**0.231123**	0.040588
	Prob > r	0.188543	0.234933	0.000731	0.001258	0.577192
	n	194	194	193	192	191
ΔMndn_U_2	r	0.392885	**0.317342**	-0.110737	-0.058688	-0.110050
	Prob > r	< 0.000001	0.000048	0.167375	0.466766	0.172830
	n	158	158	157	156	155
ΔMndn_U_1	r	0.494899	0.034524	-0.062316	0.009270	-0.026660
	Prob > r	< 0.000001	0.695450	0.479508	0.916306	0.762453
	n	131	131	131	131	131

Pearson correlation matrix - Precipitation at wells: Mndn_U_3, Mndn_U_2, & Mndn_U_1

Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.088318	0.136811	**0.161704**	0.175787	**0.163069**
	Prob > r	0.219534	0.057146	0.024660	0.014733	0.024198
	n	195	194	193	192	191
Kearney	r	0.102018	**0.155450**	**0.174439**	0.194833	**0.187442**
	Prob > r	0.155855	0.030437	0.015255	0.006768	0.009417
	n	195	194	193	192	191
G. I.	r	0.090443	**0.165932**	**0.174053**	0.180485	**0.178316**
	Prob > r	0.208601	0.020762	0.015486	0.012240	0.013586
	n	195	194	193	192	191
ΔOverton	r	0.114032	0.188229	0.099060	0.057445	-0.057103
	Prob > r	0.113378	0.008581	0.170494	0.428687	0.432667
	n	194	194	193	192	191
ΔKearney	r	**0.190148**	0.214600	0.077126	0.083944	-0.035161
	Prob > r	0.007916	0.002657	0.286381	0.247022	0.629175
	n	194	194	193	192	191
ΔG. I.	r	**0.222377**	0.325715	0.034978	0.028488	-0.013137
	Prob > r	0.001830	0.000004	0.629149	0.694878	0.856860
	n	194	194	193	192	191
Mndn_U_4	r	0.037441	0.043640	0.047828	0.063015	0.060582
	Prob > r	0.603301	0.545714	0.508928	0.385218	0.405108
	n	195	194	193	192	191
Mndn_U_3	r	-0.017175	-0.008394	0.015095	0.041338	0.044671
	Prob > r	0.811641	0.907526	0.834946	0.569154	0.539464
	n	195	194	193	192	191
Mndn_U_2	r	0.105423	0.203945	**0.164369**	**0.144651**	0.104343
	Prob > r	0.185990	0.010162	0.039678	0.071601	0.196329
	n	159	158	157	156	155
Mndn_U_1	r	0.184956	**0.184761**	0.121967	0.120664	0.099795
	Prob > r	0.033743	0.033935	0.163567	0.168146	0.254914
	n	132	132	132	132	132
ΔMndn_U_4	r	0.231175	0.055338	0.039779	0.151758	-0.031636
	Prob > r	0.001182	0.443456	0.582833	0.035617	0.663957
	n	194	194	193	192	191
ΔMndn_U_3	r	**0.141431**	0.089317	**0.227717**	0.251187	0.033754
	Prob > r	0.049175	0.215538	0.001448	0.000441	0.642966
	n	194	194	193	192	191
ΔMndn_U_2	r	0.427118	**0.301278**	-0.128540	-0.060931	-0.123858
	Prob > r	< 0.000001	0.000120	0.108627	0.449881	0.124671
	n	158	158	157	156	155
ΔMndn_U_1	r	0.518812	-0.003432	-0.082618	-0.005846	-0.061164
	Prob > r	< 0.000001	0.968962	0.348169	0.947160	0.487685
	n	131	131	131	131	131

Pearson correlation matrix - precipitation at well: Mndn_D_3						
Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.106617	**0.153282**	**0.183242**	0.196985	**0.182564**
	Prob > r	0.137947	0.032859	0.010748	0.006171	0.011478
	n	195	194	193	192	191
Kearney	r	0.121610	**0.179280**	**0.200266**	0.225790	**0.218517**
	Prob > r	0.090349	0.012376	0.005231	0.001638	0.002390
	n	195	194	193	192	191
G. I.	r	0.103039	**0.182177**	**0.196439**	0.205549	**0.209541**
	Prob > r	0.151737	0.011011	0.006181	0.004234	0.003623
	n	195	194	193	192	191
ΔOverton	r	0.113455	0.180583	0.117587	0.063200	-0.064250
	Prob > r	0.115228	0.011745	0.103396	0.383820	0.377218
	n	194	194	193	192	191
ΔKearney	r	**0.201890**	0.231703	0.084014	0.109817	-0.035010
	Prob > r	0.004758	0.001151	0.245386	0.129438	0.630650
	n	194	194	193	192	191
ΔG. I.	r	**0.234208**	0.341399	0.060867	0.043784	0.013558
	Prob > r	0.001013	0.000001	0.400413	0.546498	0.852323
	n	194	194	193	192	191
Mndn_D_3	r	0.042163	0.053733	0.068097	0.088049	0.092298
	Prob > r	0.558382	0.456803	0.346714	0.224580	0.204112
	n	195	194	193	192	191
Mndn_D_2	r	0.017175	0.045251	0.070354	0.101781	0.109898
	Prob > r	0.811638	0.530971	0.330928	0.160092	0.130167
	n	195	194	193	192	191
Mndn_D_1	r	0.136985	**0.196654**	**0.202025**	0.225246	**0.222875**
	Prob > r	0.106546	0.019871	0.016679	0.007457	0.008125
	n	140	140	140	140	140
ΔMndn_D_3	r	**0.155245**	0.134753	**0.172834**	0.253109	0.036313
	Prob > r	0.030660	0.061025	0.016234	0.000397	0.617969
	n	194	194	193	192	191
ΔMndn_D_2	r	0.126311	**0.190825**	**0.167326**	0.203960	0.051193
	Prob > r	0.079264	0.007693	0.020025	0.004546	0.481857
	n	194	194	193	192	191
ΔMndn_D_1	r	0.311461	**0.236829**	0.021889	0.096438	-0.010728
	Prob > r	0.000190	0.005000	0.798131	0.258746	0.900254
	n	139	139	139	139	139

Pearson correlation matrix - precipitation at wells: Mndn_D_2 and Mndn_D_1						
Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.076122	0.122831	0.139957	0.158040	**0.156631**
	Prob > r	0.290195	0.087962	0.052225	0.028572	0.030476
	n	195	194	193	192	191
Kearney	r	0.082802	**0.144050**	**0.153106**	0.171757	**0.167345**
	Prob > r	0.249811	0.045082	0.033524	0.017213	0.020673
	n	195	194	193	192	191
G. I.	r	0.068025	**0.143492**	**0.156308**	0.160196	**0.158833**
	Prob > r	0.344705	0.045931	0.029950	0.026446	0.028188
	n	195	194	193	192	191
ΔOverton	r	0.115079	0.181162	0.067004	0.071628	-0.011743
	Prob > r	0.110085	0.011473	0.354529	0.323501	0.871906
	n	194	194	193	192	191
ΔKearney	r	**0.174889**	0.246718	0.035770	0.075544	-0.022842
	Prob > r	0.014727	0.000524	0.621407	0.297681	0.753782
	n	194	194	193	192	191
ΔG. I.	r	**0.202419**	0.325770	0.055039	0.016394	-0.009526
	Prob > r	0.004647	0.000004	0.447114	0.821436	0.895942
	n	194	194	193	192	191
Mndn_D_3	r	0.005237	0.013689	0.026935	0.047604	0.049557
	Prob > r	0.942070	0.849744	0.710024	0.512027	0.495990
	n	195	194	193	192	191
Mndn_D_2	r	-0.028723	-0.002488	0.022140	0.053554	0.061413
	Prob > r	0.690188	0.972532	0.759893	0.460666	0.398687
	n	195	194	193	192	191
Mndn_D_1	r	0.105097	**0.168261**	0.163056	0.183871	**0.177680**
	Prob > r	0.216532	0.046897	0.054241	0.029656	0.035709
	n	140	140	140	140	140
ΔMndn_D_3	r	**0.156095**	0.099380	**0.163733**	0.255040	0.012351
	Prob > r	0.029747	0.167994	0.022891	0.000357	0.865344
	n	194	194	193	192	191
ΔMndn_D_2	r	0.134322	**0.180466**	**0.166098**	0.208975	0.051548
	Prob > r	0.061865	0.011800	0.020967	0.003627	0.478818
	n	194	194	193	192	191
ΔMndn_D_1	r	0.283473	**0.256245**	-0.020071	0.083256	-0.025890
	Prob > r	0.000721	0.002328	0.814584	0.329855	0.762246
	n	139	139	139	139	139

Pearson correlation matrix - precipitation at well: Alda_U_4

Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.083873	0.120247	0.133345	0.153875	**0.147003**
	Prob > r	0.243717	0.094902	0.064499	0.033094	0.042425
	n	195	194	193	192	191
Kearney	r	0.089372	0.139914	**0.155261**	0.179955	**0.173476**
	Prob > r	0.214058	0.051683	0.031081	0.012501	0.016396
	n	195	194	193	192	191
G. I.	r	0.093410	**0.161589**	**0.164350**	0.180865	**0.176903**
	Prob > r	0.193995	0.024389	0.022375	0.012056	0.014360
	n	195	194	193	192	191
ΔOverton	r	0.103558	0.138107	0.054350	0.076095	-0.035322
	Prob > r	0.150733	0.054808	0.452833	0.294157	0.627605
	n	194	194	193	192	191
ΔKearney	r	**0.145507**	0.201630	0.064015	0.096460	-0.032579
	Prob > r	0.042933	0.004814	0.376453	0.183200	0.654581
	n	194	194	193	192	191
ΔG. I.	r	**0.210479**	0.292925	0.012877	0.068661	-0.021919
	Prob > r	0.003222	0.000034	0.858933	0.343999	0.763430
	n	194	194	193	192	191
Alda_U_4	r	0.088139	0.102401	0.122032	0.135406	0.133811
	Prob > r	0.313052	0.240842	0.161724	0.120184	0.124654
	n	133	133	133	133	133
Alda_U_3	r	0.107413	0.156444	0.132918	0.135084	0.110424
	Prob > r	0.135014	0.029379	0.065367	0.061744	0.128329
	n	195	194	193	192	191
Alda_U_2	r	0.057898	0.138698	0.137360	0.147422	0.129152
	Prob > r	0.421406	0.053770	0.056792	0.041294	0.074968
	n	195	194	193	192	191
Alda_U_1	r	0.119419	0.208937	**0.175552**	**0.193224**	**0.165599**
	Prob > r	0.096345	0.003459	0.014606	0.007247	0.022054
	n	195	194	193	192	191
D_Alda_U_4	r	0.115577	0.080655	0.100912	0.074406	-0.005458
	Prob > r	0.186942	0.357920	0.249608	0.396491	0.950470
	n	132	132	132	132	132
D_Alda_U_3	r	0.347387	**0.214489**	-0.103992	0.014333	-0.095738
	Prob > r	0.000001	0.002671	0.150086	0.843582	0.187681
	n	194	194	193	192	191
D_Alda_U_2	r	**0.314704**	0.420412	-0.012299	0.056091	-0.084789
	Prob > r	0.000008	< 0.000001	0.865195	0.439666	0.243527
	n	194	194	193	192	191
D_Alda_U_1	r	0.358348	**0.336474**	-0.127107	0.064623	-0.107409
	Prob > r	< 0.000001	0.000002	0.078153	0.373183	0.139149
	n	194	194	193	192	191

Pearson correlation matrix - precipitation at wells: Alda_U_3, Alda_U_2, & Alda_U_1

Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.071515	0.103799	0.112944	0.132000	0.125508
	Prob > r	0.320464	0.149781	0.117846	0.067987	0.083626
	n	195	194	193	192	191
Kearney	r	0.081417	0.128553	**0.141491**	0.162219	**0.153458**
	Prob > r	0.257843	0.074038	0.049672	0.024576	0.034050
	n	195	194	193	192	191
G. I.	r	0.091327	**0.155715**	**0.155069**	0.168431	**0.159325**
	Prob > r	0.204166	0.030152	0.031292	0.019527	0.027698
	n	195	194	193	192	191
ΔOverton	r	0.088297	0.121749	0.037990	0.070276	-0.033750
	Prob > r	0.220848	0.090816	0.599910	0.332738	0.643001
	n	194	194	193	192	191
ΔKearney	r	0.135711	0.187692	0.053790	0.080292	-0.041844
	Prob > r	0.059194	0.008776	0.457503	0.268256	0.565455
	n	194	194	193	192	191
ΔG. I.	r	**0.217948**	0.276394	-0.002301	0.054918	-0.044364
	Prob > r	0.002267	0.000096	0.974666	0.449307	0.542257
	n	194	194	193	192	191
Alda_U_4	r	0.103981	0.116783	0.134854	0.145798	0.142120
	Prob > r	0.233622	0.180675	0.121717	0.094030	0.102716
	n	133	133	133	133	133
Alda_U_3	r	0.107228	0.151604	0.126706	0.129353	0.104419
	Prob > r	0.135690	0.034844	0.079104	0.073745	0.150560
	n	195	194	193	192	191
Alda_U_2	r	0.057898	0.137692	0.133741	0.143144	0.123768
	Prob > r	0.421409	0.055548	0.063702	0.047622	0.088036
	n	195	194	193	192	191
Alda_U_1	r	0.117078	0.203406	**0.165832**	**0.180407**	**0.148830**
	Prob > r	0.103101	0.004447	0.021176	0.012278	0.039896
	n	195	194	193	192	191
D_Alda_U_4	r	0.122600	0.072748	0.092805	0.061174	-0.016747
	Prob > r	0.161374	0.407129	0.289875	0.485924	0.848846
	n	132	132	132	132	132
D_Alda_U_3	r	0.361836	0.194838	-0.108988	0.016399	-0.096780
	Prob > r	< 0.000001	0.006481	0.131356	0.821386	0.182900
	n	194	194	193	192	191
D_Alda_U_2	r	**0.331412**	0.415291	-0.024792	0.052778	-0.090262
	Prob > r	0.000002	< 0.000001	0.732171	0.467197	0.214310
	n	194	194	193	192	191
D_Alda_U_1	r	0.366401	**0.324399**	**-0.143097**	0.052945	-0.122303
	Prob > r	< 0.000001	0.000004	0.047114	0.465789	0.091893
	n	194	194	193	192	191

Pearson correlation matrix - precipitation at well: Alda_D_3						
Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.083873	0.120247	0.133345	0.153875	**0.147003**
	Prob > r	0.243717	0.094902	0.064499	0.033094	0.042425
	n	195	194	193	192	191
Kearney	r	0.089372	0.139914	**0.155261**	0.179955	**0.173476**
	Prob > r	0.214058	0.051683	0.031081	0.012501	0.016396
	n	195	194	193	192	191
G. I.	r	0.093410	**0.161589**	**0.164350**	0.180865	**0.176903**
	Prob > r	0.193995	0.024389	0.022375	0.012056	0.014360
	n	195	194	193	192	191
ΔOverton	r	0.103558	0.138107	0.054350	0.076095	-0.035322
	Prob > r	0.150733	0.054808	0.452833	0.294157	0.627605
	n	194	194	193	192	191
ΔKearney	r	**0.145507**	0.201630	0.064015	0.096460	-0.032579
	Prob > r	0.042933	0.004814	0.376453	0.183200	0.654581
	n	194	194	193	192	191
ΔG. I.	r	**0.210479**	0.292925	0.012877	0.068661	-0.021919
	Prob > r	0.003222	0.000034	0.858933	0.343999	0.763430
	n	194	194	193	192	191
Alda_D_3	r	0.054027	0.097717	0.106495	0.108384	0.103297
	Prob > r	0.453166	0.175260	0.140465	0.134545	0.155017
	n	195	194	193	192	191
Alda_D_2	r	0.060140	0.100916	0.102284	0.114686	0.108324
	Prob > r	0.403625	0.161484	0.156934	0.113196	0.135795
	n	195	194	193	192	191
Alda_D_1	r	0.077496	0.154774	0.163422	0.165981	0.165374
	Prob > r	0.362773	0.067863	0.053695	0.050005	0.050860
	n	140	140	140	140	140
D_Alda_D_3	r	**0.234424**	0.349123	0.060305	0.022481	-0.027500
	Prob > r	0.001002	0.000001	0.404787	0.756934	0.705707
	n	194	194	193	192	191
D_Alda_D_2	r	0.291919	**0.252163**	0.002460	0.074871	-0.037120
	Prob > r	0.000036	0.000390	0.972912	0.302017	0.610178
	n	194	194	193	192	191
D_Alda_D_1	r	**0.383028**	0.387379	0.034657	0.052084	0.007811
	Prob > r	0.000003	0.000002	0.685451	0.542574	0.927288
	n	139	139	139	139	139

Pearson correlation matrix - precipitation at wells: Alda_D_2 and Alda_D_1

Well or gage	Stat.	Precip.	lagged 1 day	lagged 2 days	lagged 3 days	lagged 4 days
Overton	r	0.056544	0.086068	0.090623	0.107510	0.102823
	Prob > r	0.432372	0.232769	0.210067	0.137736	0.156929
	n	195	194	193	192	191
Kearney	r	0.065882	0.110772	0.117491	0.129447	0.122099
	Prob > r	0.360151	0.124136	0.103678	0.073535	0.092440
	n	195	194	193	192	191
G. I.	r	0.081709	0.144240	0.138966	0.141471	0.126045
	Prob > r	0.256138	0.044797	0.053931	0.050307	0.082303
	n	195	194	193	192	191
ΔOverton	r	0.095331	0.110910	0.020981	0.063603	-0.026256
	Prob > r	0.186088	0.123666	0.772106	0.380793	0.718438
	n	194	194	193	192	191
ΔKearney	r	0.137123	0.178664	0.029297	0.045869	-0.035765
	Prob > r	0.056575	0.012684	0.685879	0.527544	0.623291
	n	194	194	193	192	191
ΔG. I.	r	**0.213922**	0.268453	-0.021817	0.008586	-0.071783
	Prob > r	0.002744	0.000154	0.763290	0.905917	0.323729
	n	194	194	193	192	191
Alda_D_3	r	0.041117	0.080653	0.086180	0.085496	0.078534
	Prob > r	0.568188	0.263596	0.233380	0.238361	0.280183
	n	195	194	193	192	191
Alda_D_2	r	0.041173	0.076967	0.076367	0.084319	0.075802
	Prob > r	0.567661	0.286112	0.291160	0.244910	0.297305
	n	195	194	193	192	191
Alda_D_1	r	0.079559	0.160167	0.167011	0.165635	0.155055
	Prob > r	0.350100	0.058711	0.048580	0.050492	0.067359
	n	140	140	140	140	140
D_Alda_D_3	r	**0.252732**	0.317211	0.034280	-0.000337	-0.041370
	Prob > r	0.000378	0.000007	0.636019	0.996294	0.569871
	n	194	194	193	192	191
D_Alda_D_2	r	0.309658	**0.222422**	-0.009118	0.047680	-0.048812
	Prob > r	0.000011	0.001826	0.899845	0.511350	0.502501
	n	194	194	193	192	191
D_Alda_D_1	r	0.435777	**0.403029**	0.023961	0.020063	-0.037859
	Prob > r	< 0.000001	0.000001	0.779492	0.814655	0.658144
	n	139	139	139	139	139

APPENDIX D

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

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

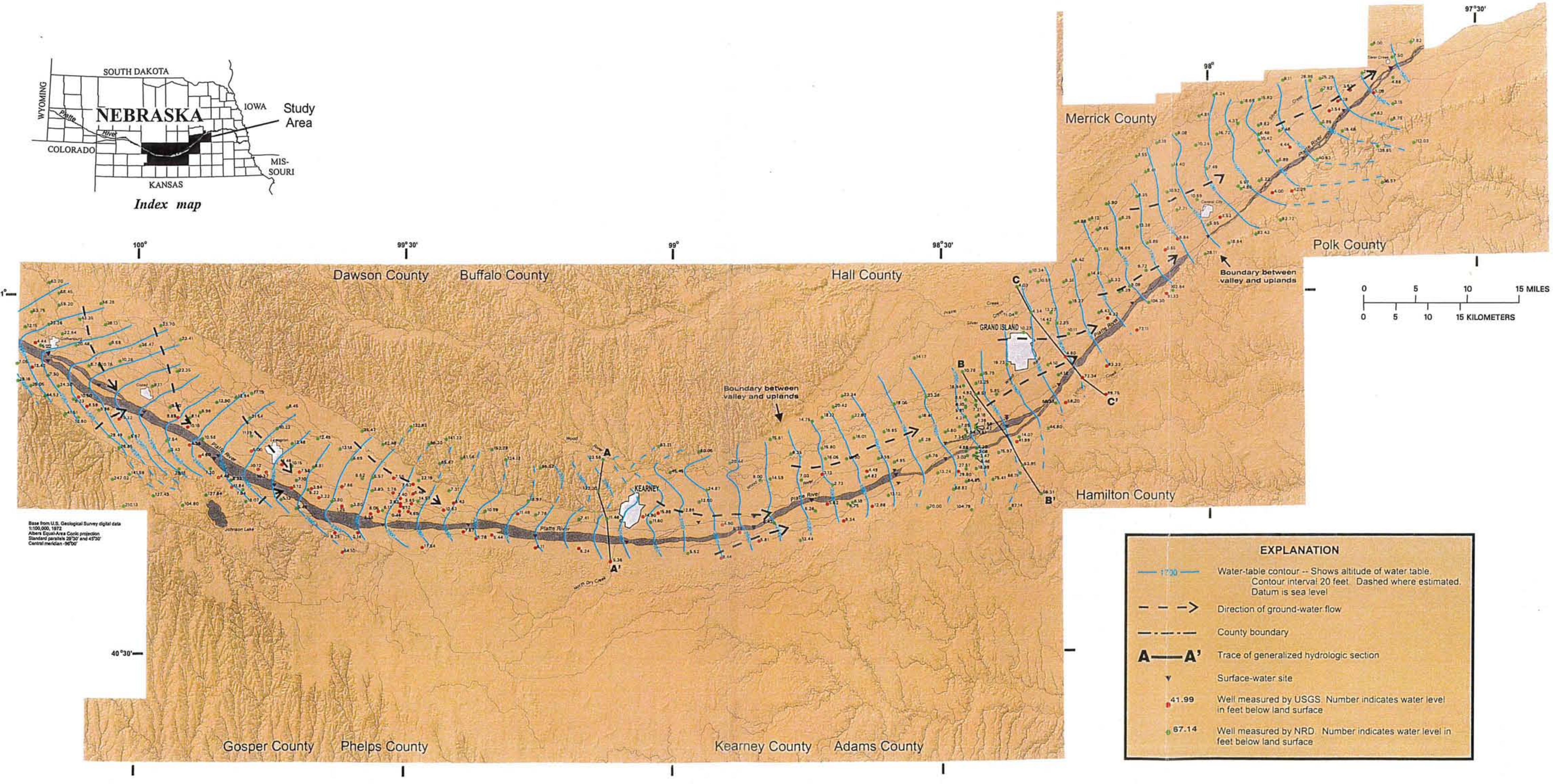
USGS developed a snapshot of ground water elevation for the entire Central Platte Valley for the end of May 1999. Between May 25 and 27, 1999, USGS personnel measured ground water levels in 77 irrigation wells next to the Platte River and surface water levels at 35 locations along the Platte River. These 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.

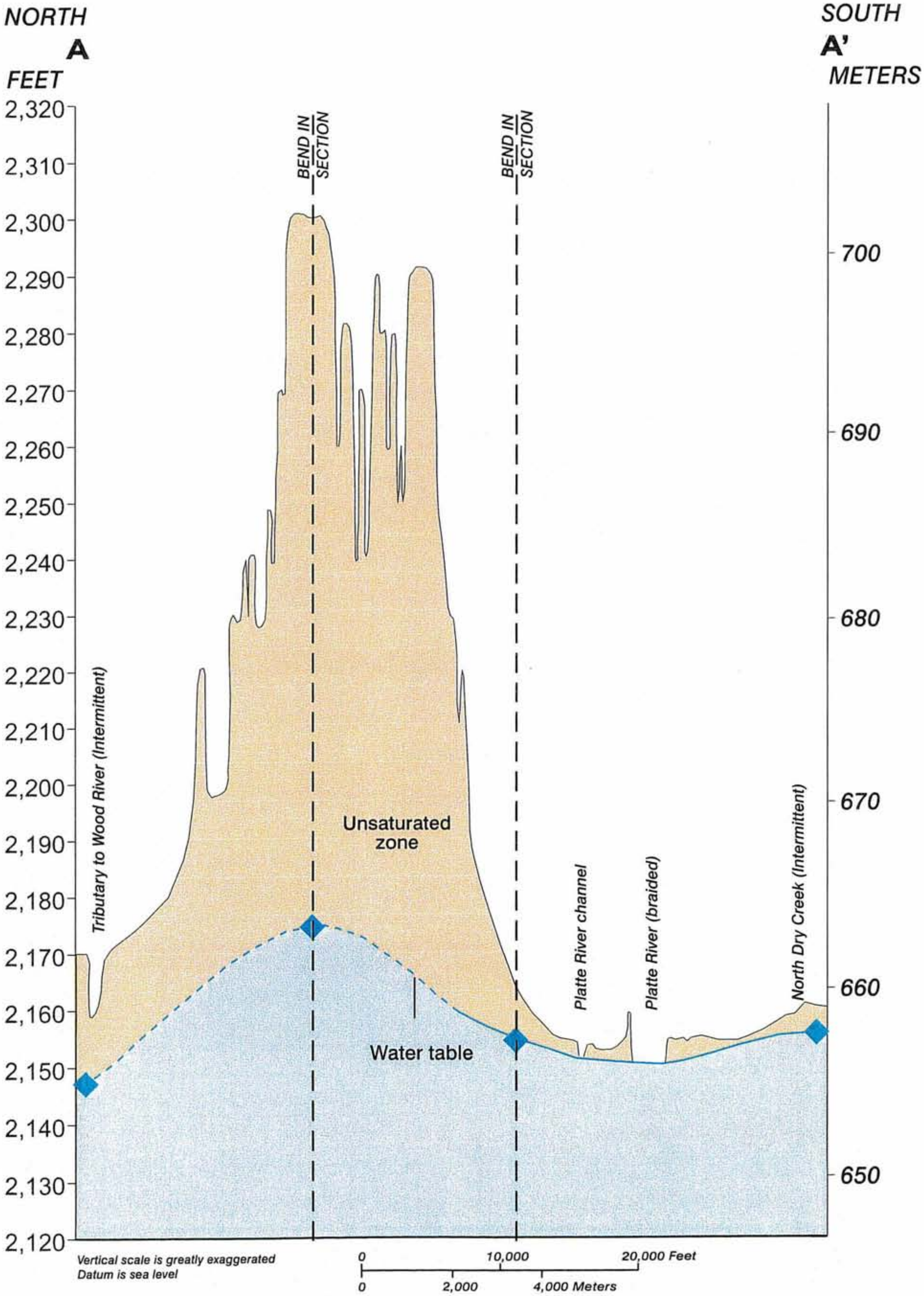
Geologic section A-A' shows the elevations of the ground surface, and the measured water table across the section shown on the ground water contour map. It also identifies the Platte River on the left side of the figure and ends just short of the Wood River on the right side of the figure.

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.



Base from U.S. Geological Survey digital data
1:100,000, 1972
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30'
Central meridian -96°00'



Vertical scale is greatly exaggerated
Datum is sea level

Figure 3. *Generalized hydrologic section A-A', near Kearney, spring 1999. Trace of section shown in figure 1.*

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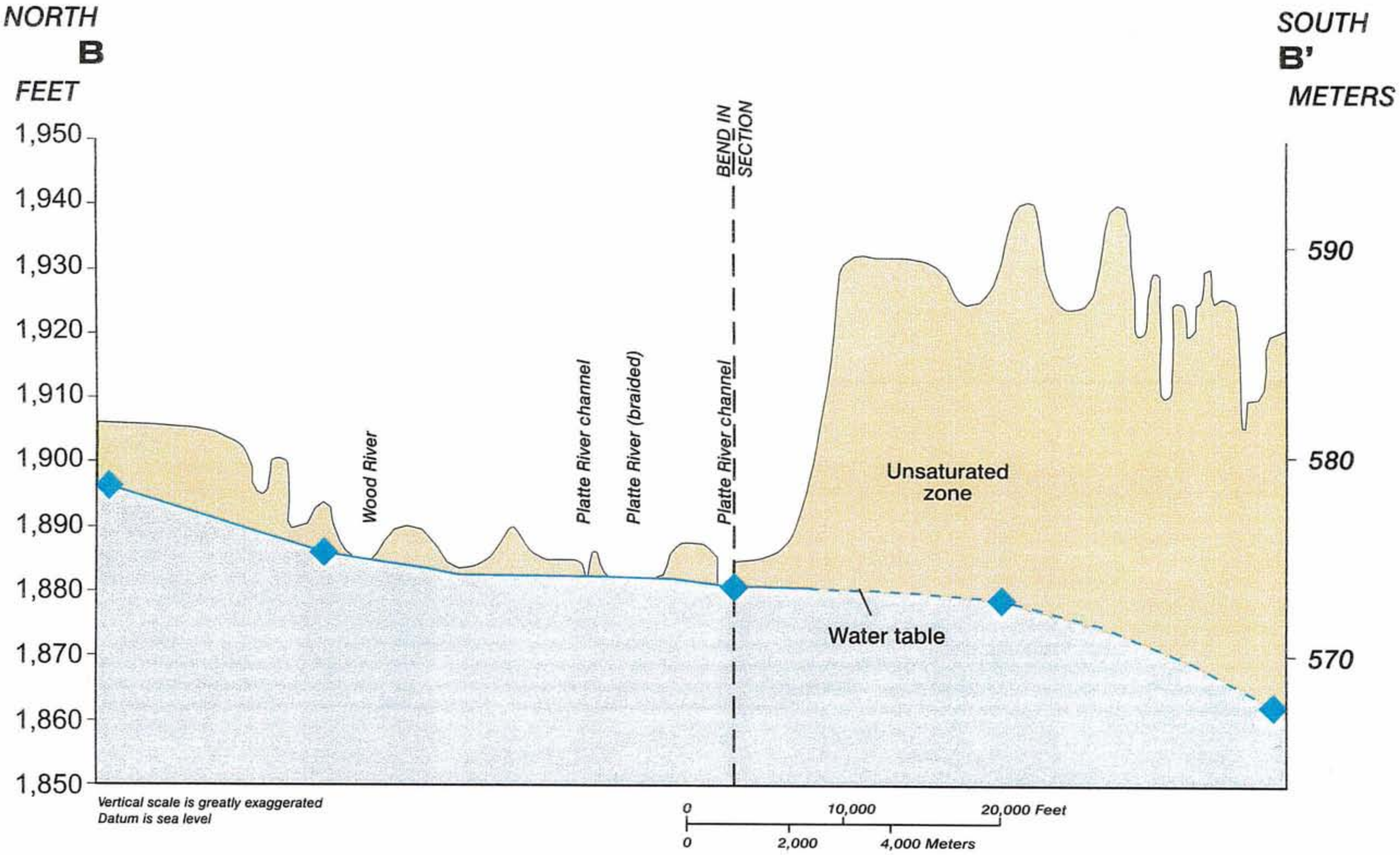

Vertical scale is greatly exaggerated
Datum is sea level

Figure 4. *Generalized hydrologic section B-B', west of Grand Island, spring 1999. Trace of section shown in figure 1.*

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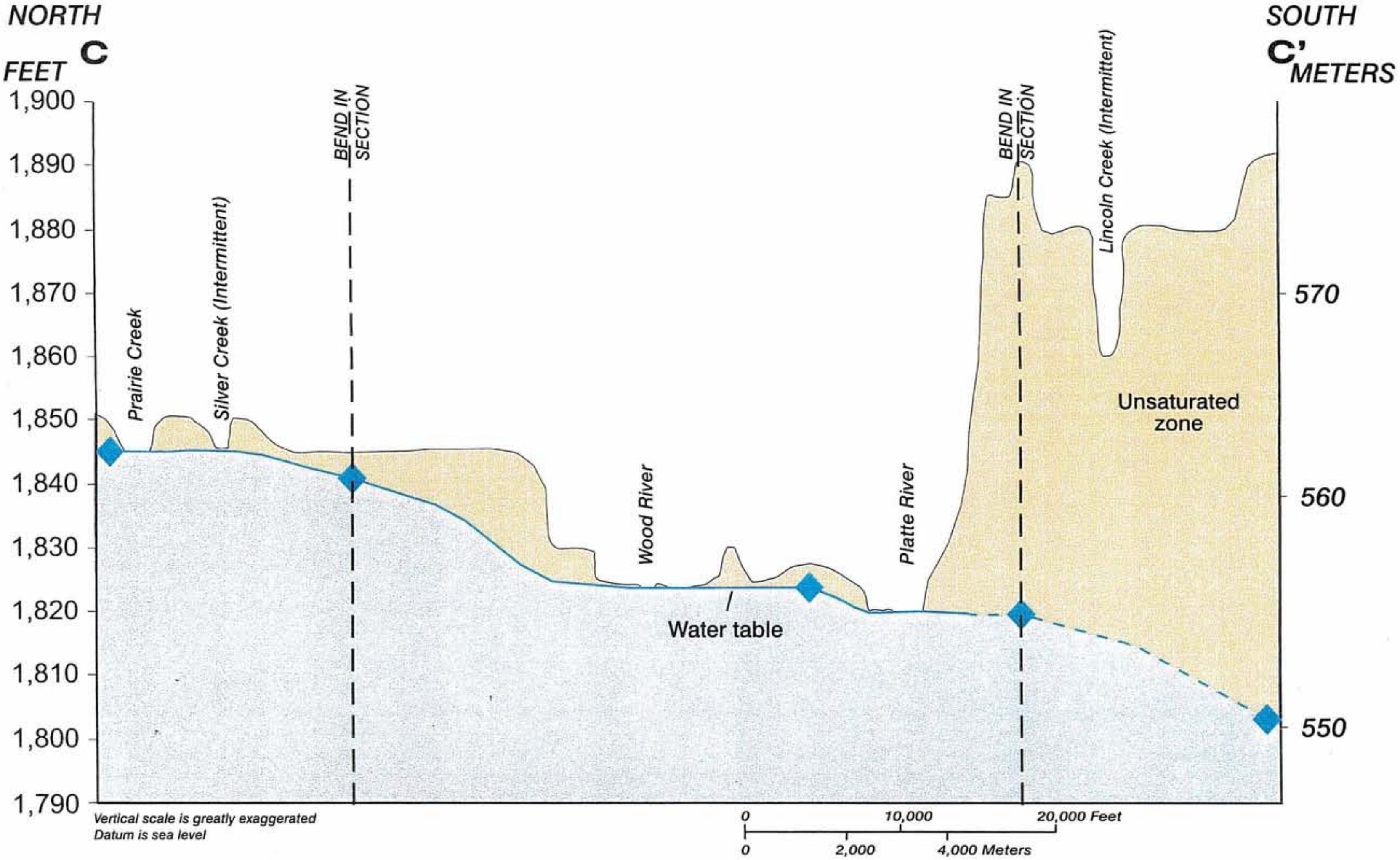


Figure 5. *Generalized hydrologic section C-C', east of Grand Island, spring 1999. Trace of section shown in figure 1.*

APPENDIX E

HISTORIC PRECIPITATION

APPENDIX E

HISTORIC PRECIPITATION

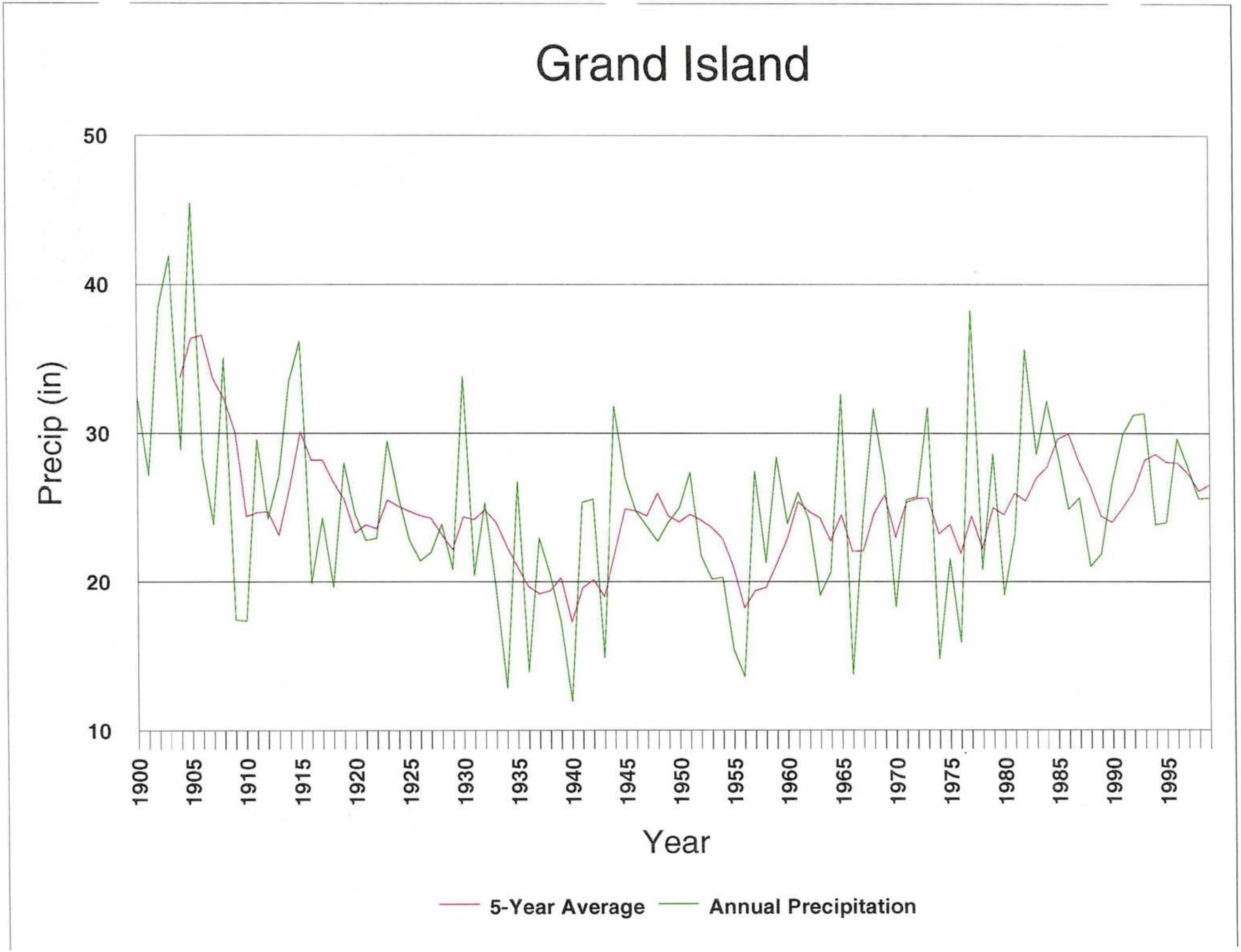
Appendix E contains precipitation records for 11 weather stations in the Central Platte Valley, all of which have 100 years of record. The stations generally from west to east are Paxton, Gothenburg, Elwood, Holdrege, Kearney, Minden, Ravenna, Loup City, Grand Island, Central City, and Fullerton.

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

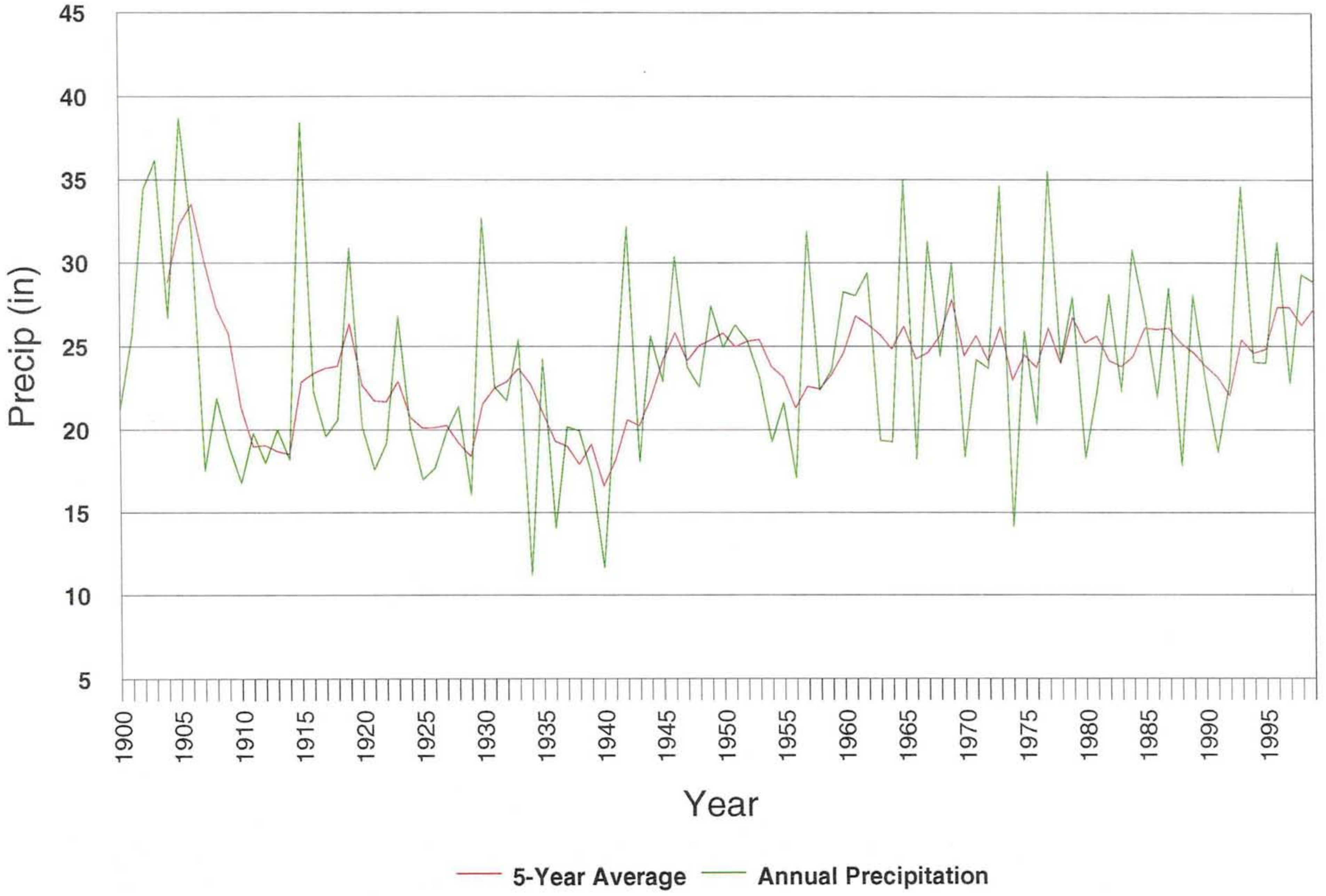
Figure 12 is a composite graph showing the average and 5-year running average of the 11 stations.

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.

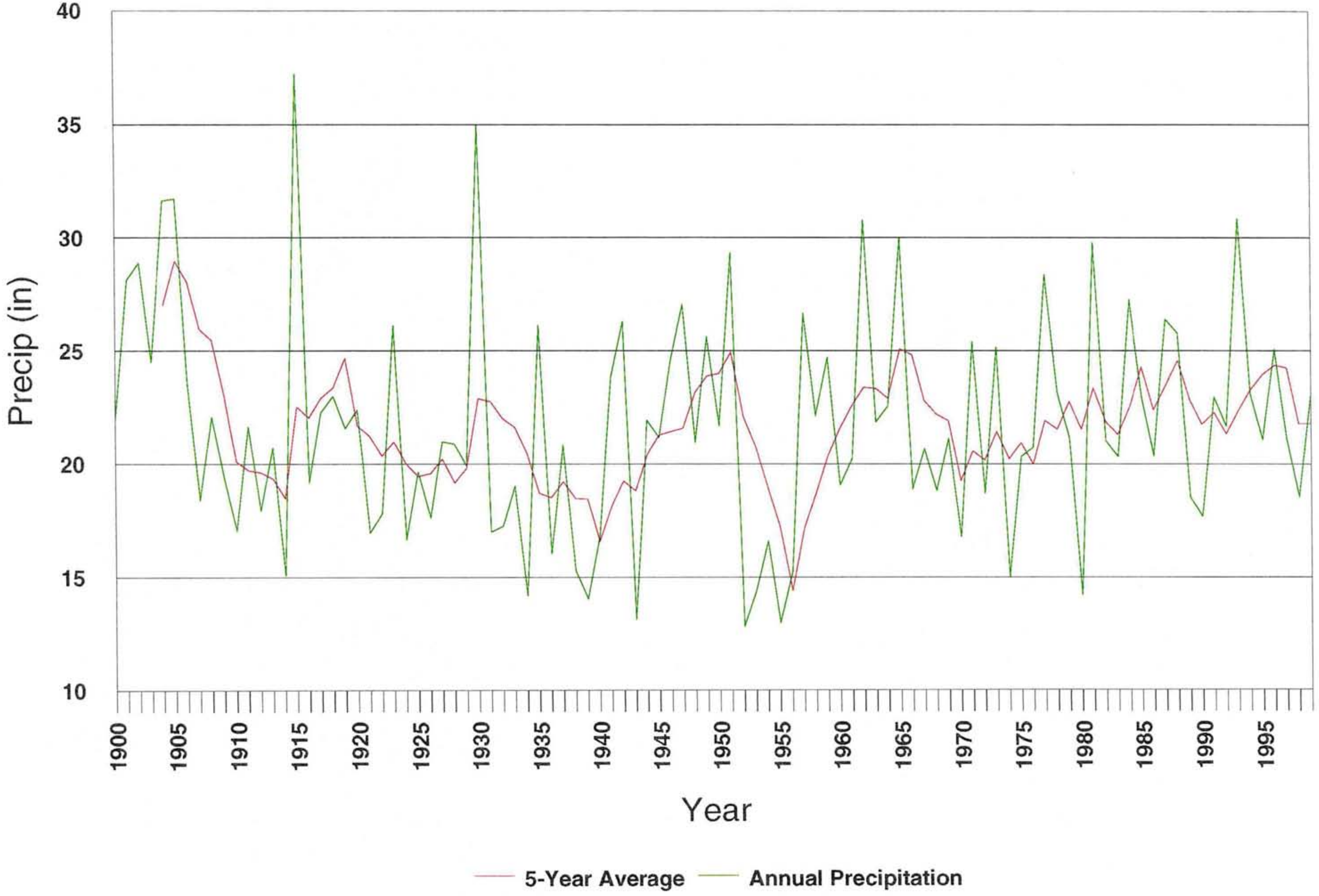
Table E-1 lists the quantity of above average precipitation during the 19 and 9 year periods since 1980 and 1990, respectively, and the quantity above average per year for each of the eleven stations.

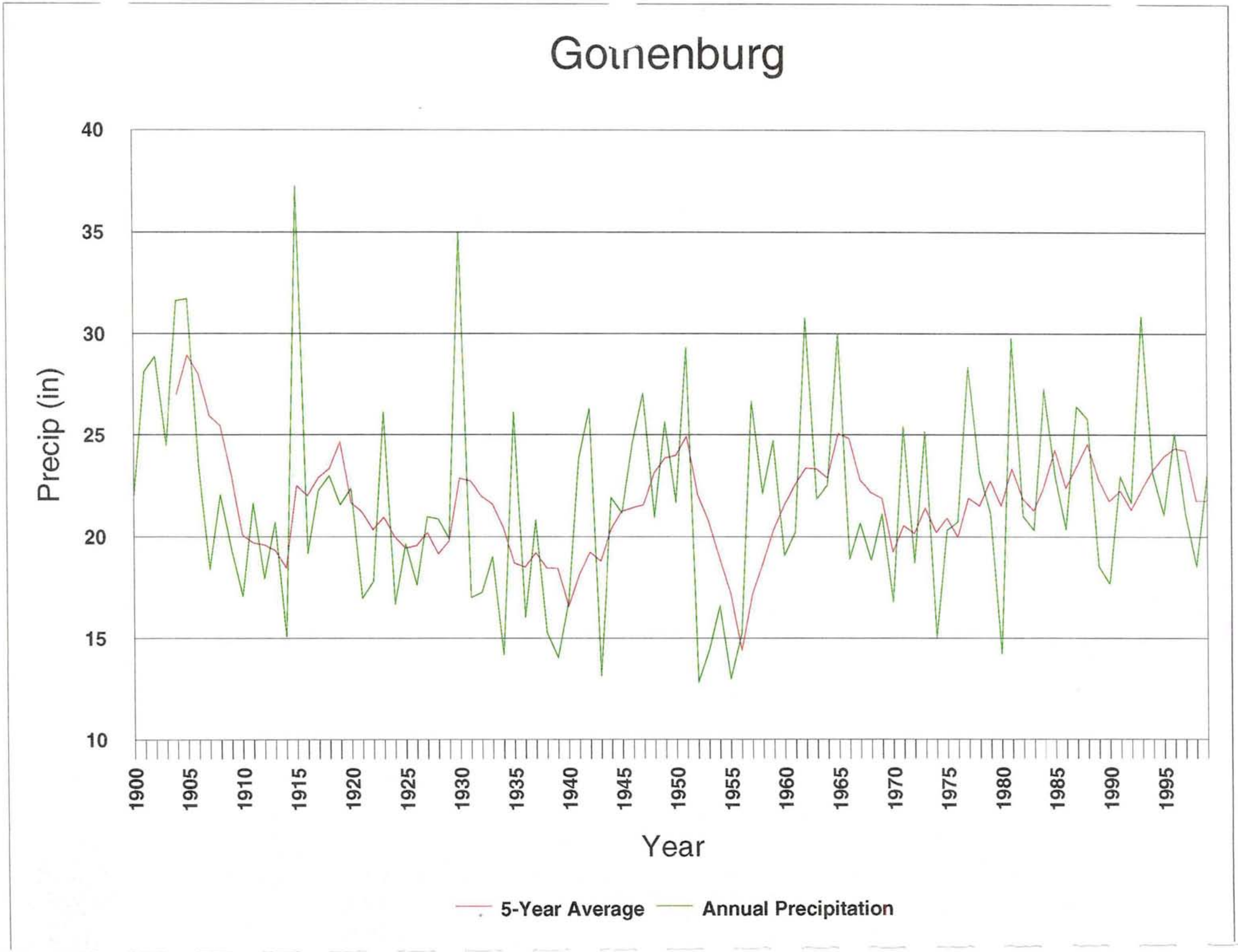

Grand Island
Precip (in)
50
40
30
20
10
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation

Kearney


45
40
35
30
25
20
15
10
5
Precip (in)
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation

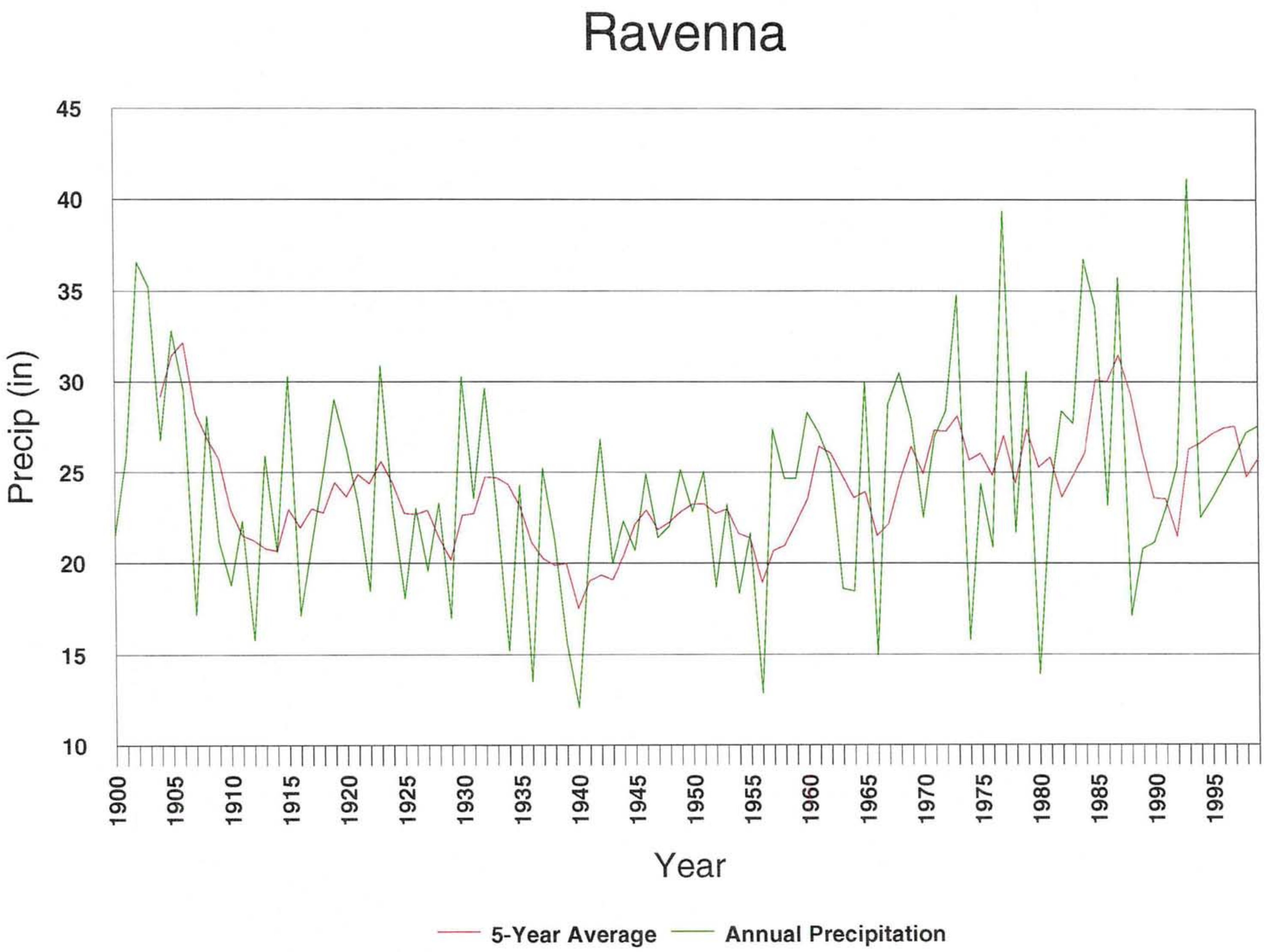
Gothenburg


Precip (in)
40
35
30
25
20
15
10
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation

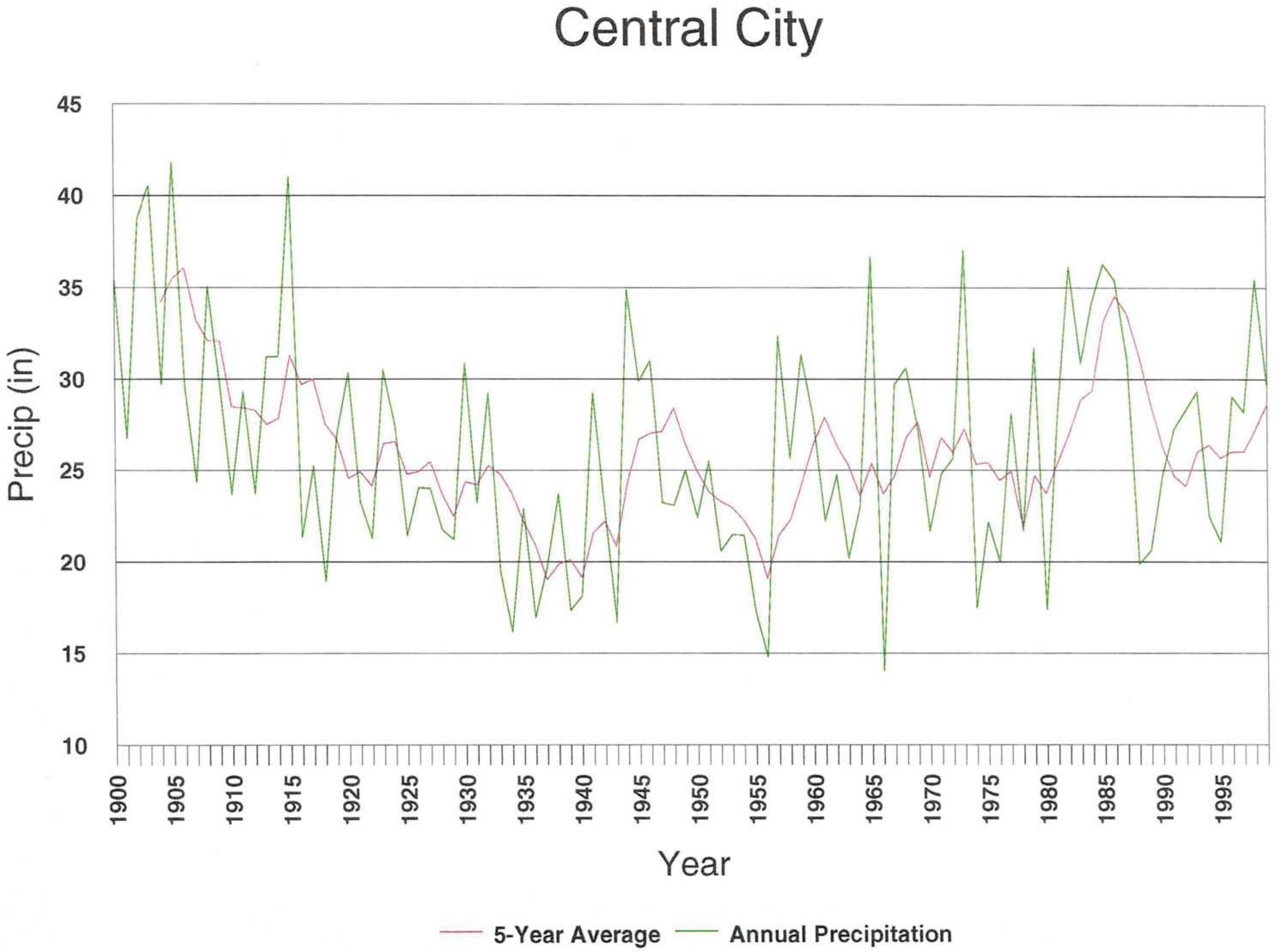


Gothenburg

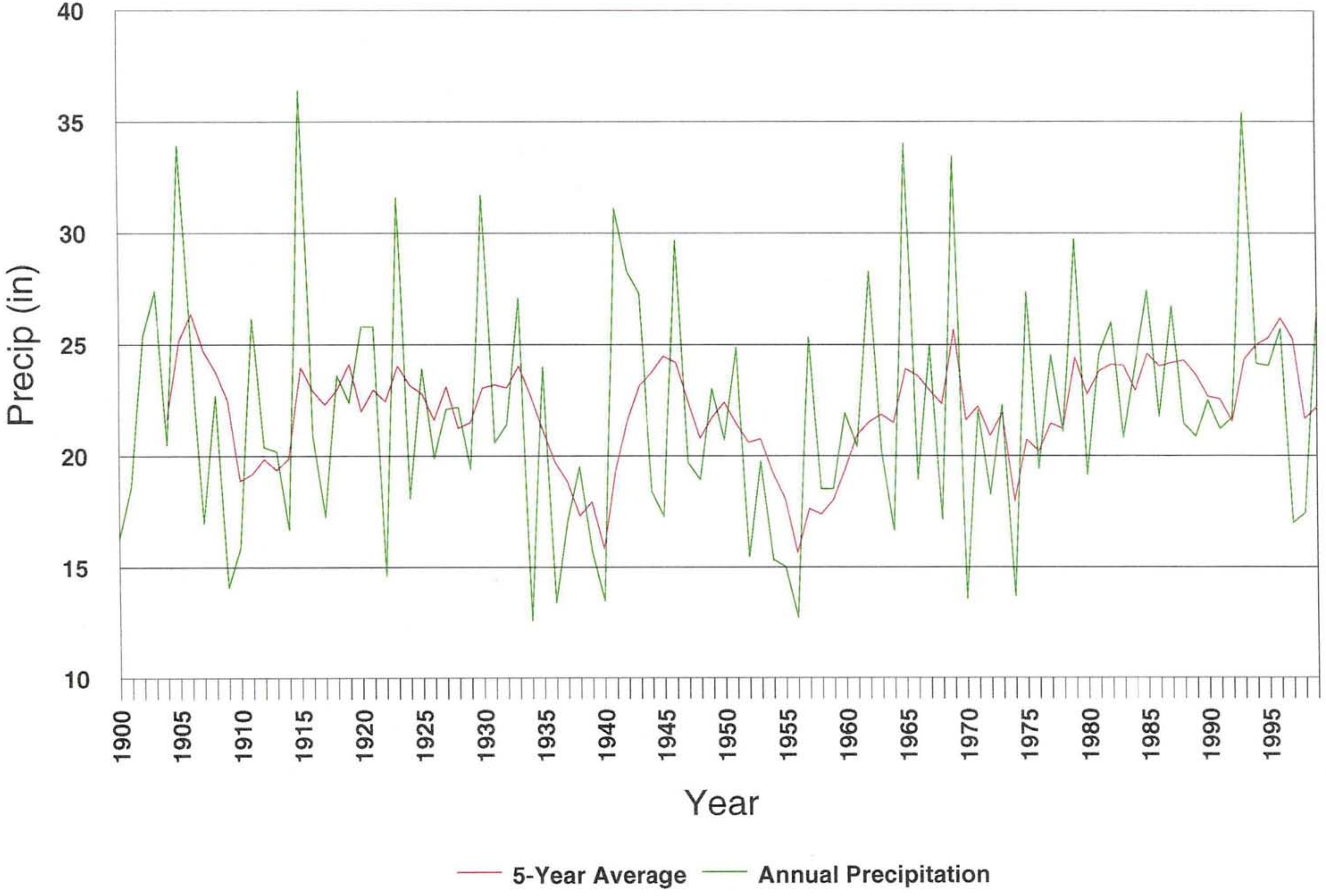
40
35
30
25
20
15
10
Precip (in)
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation

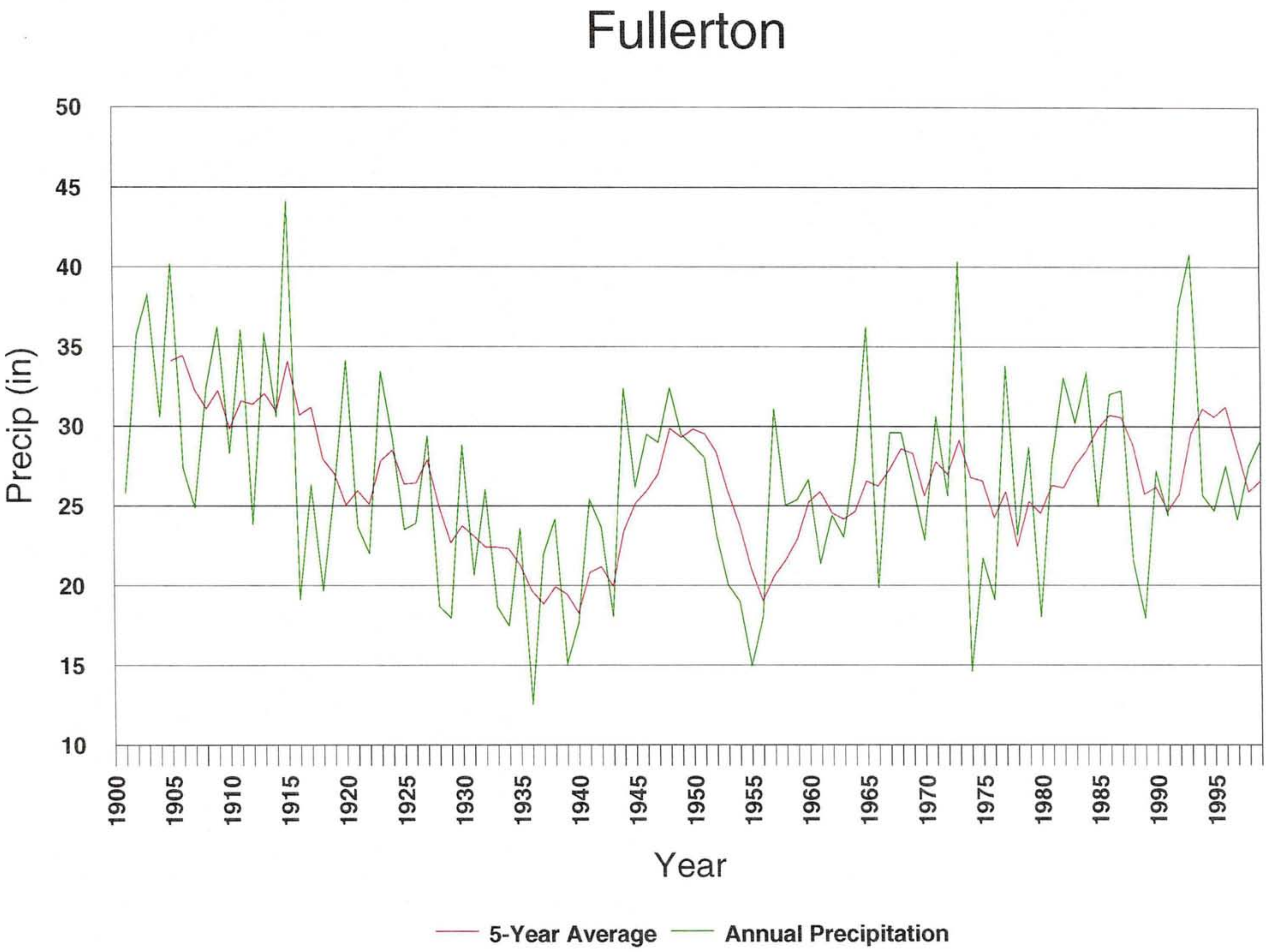


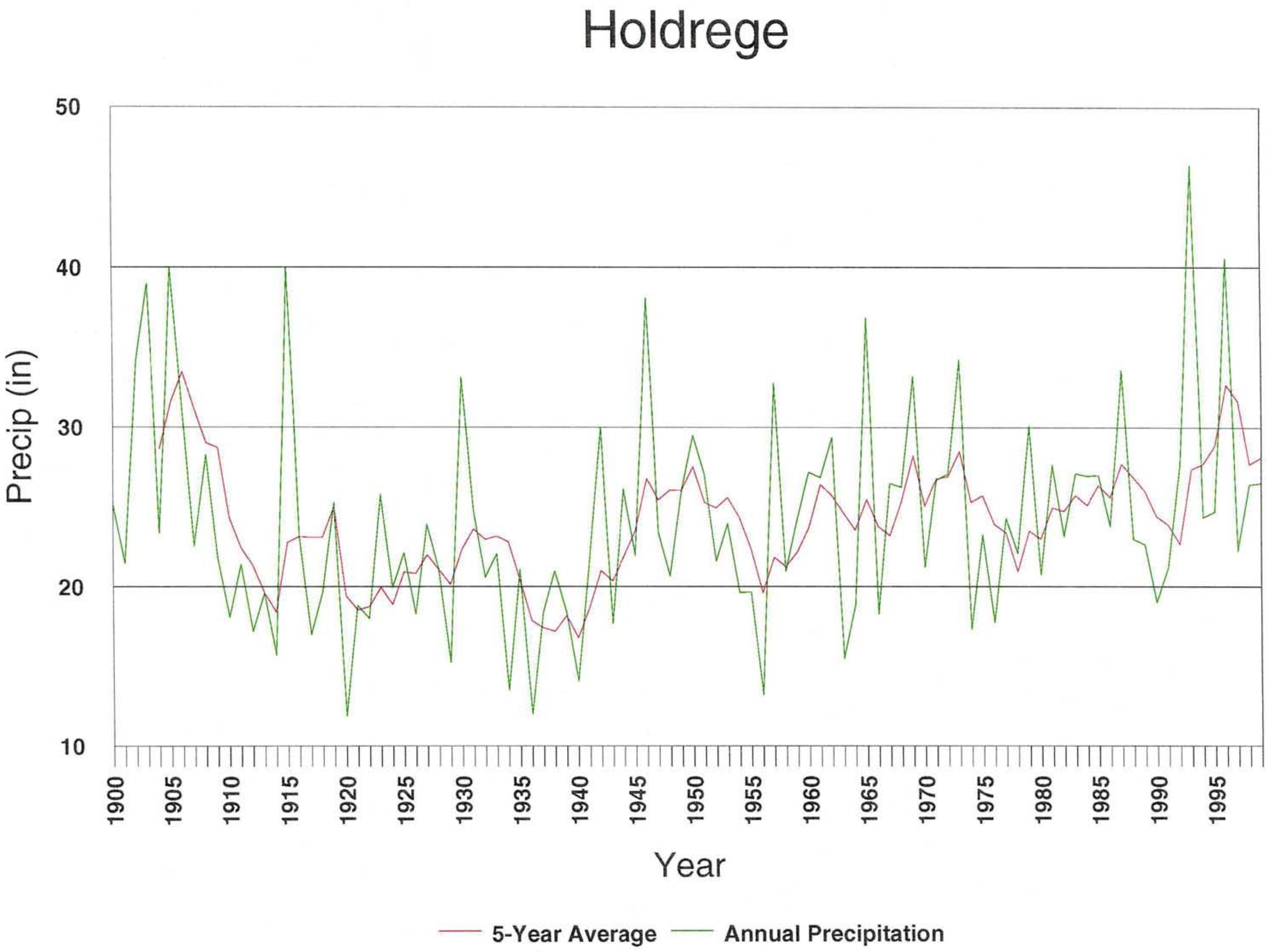
Ravenna
Precip (in)
45
40
35
30
25
20
15
10
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation


Central City
Precip (in)
45
40
35
30
25
20
15
10
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation

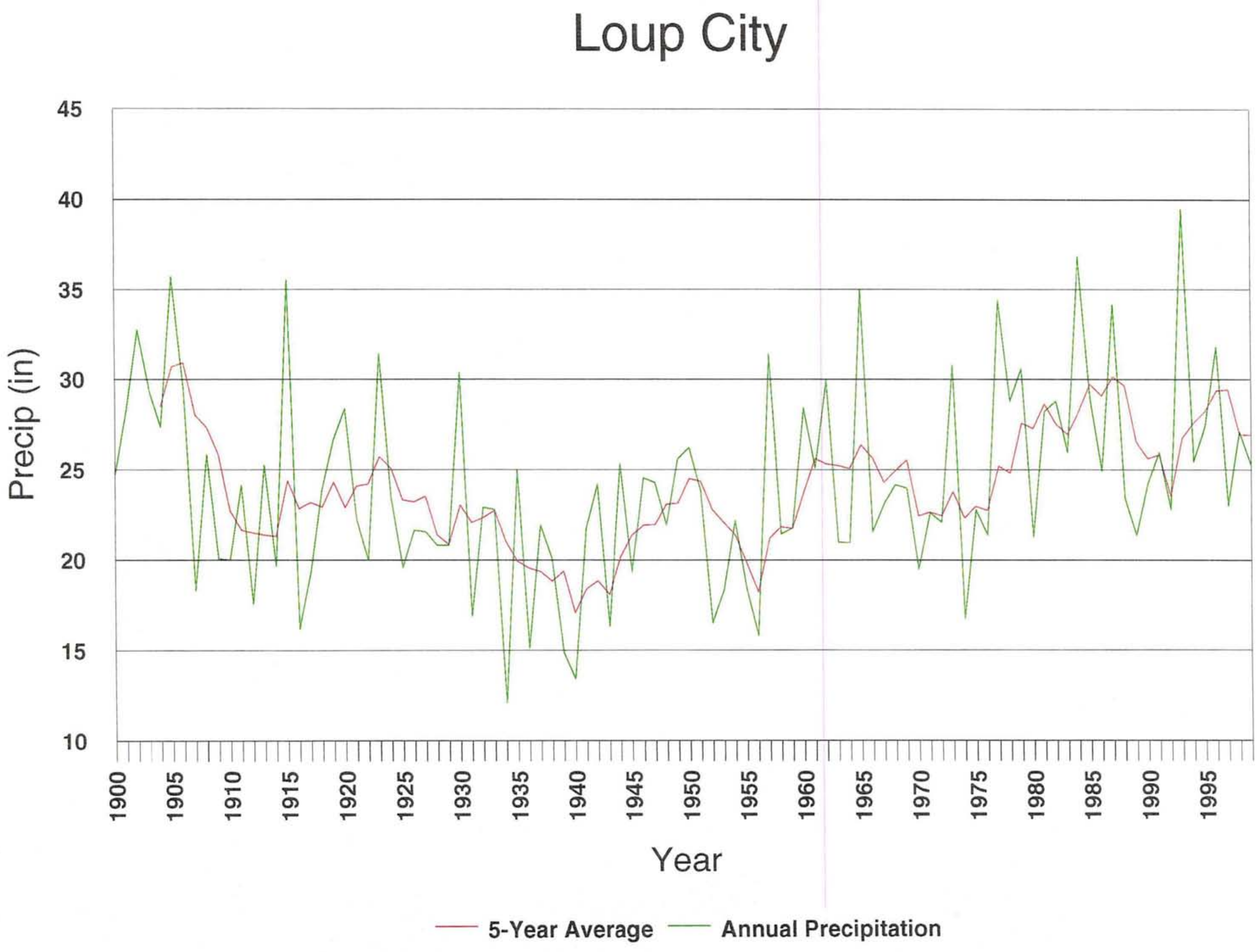
Elwood

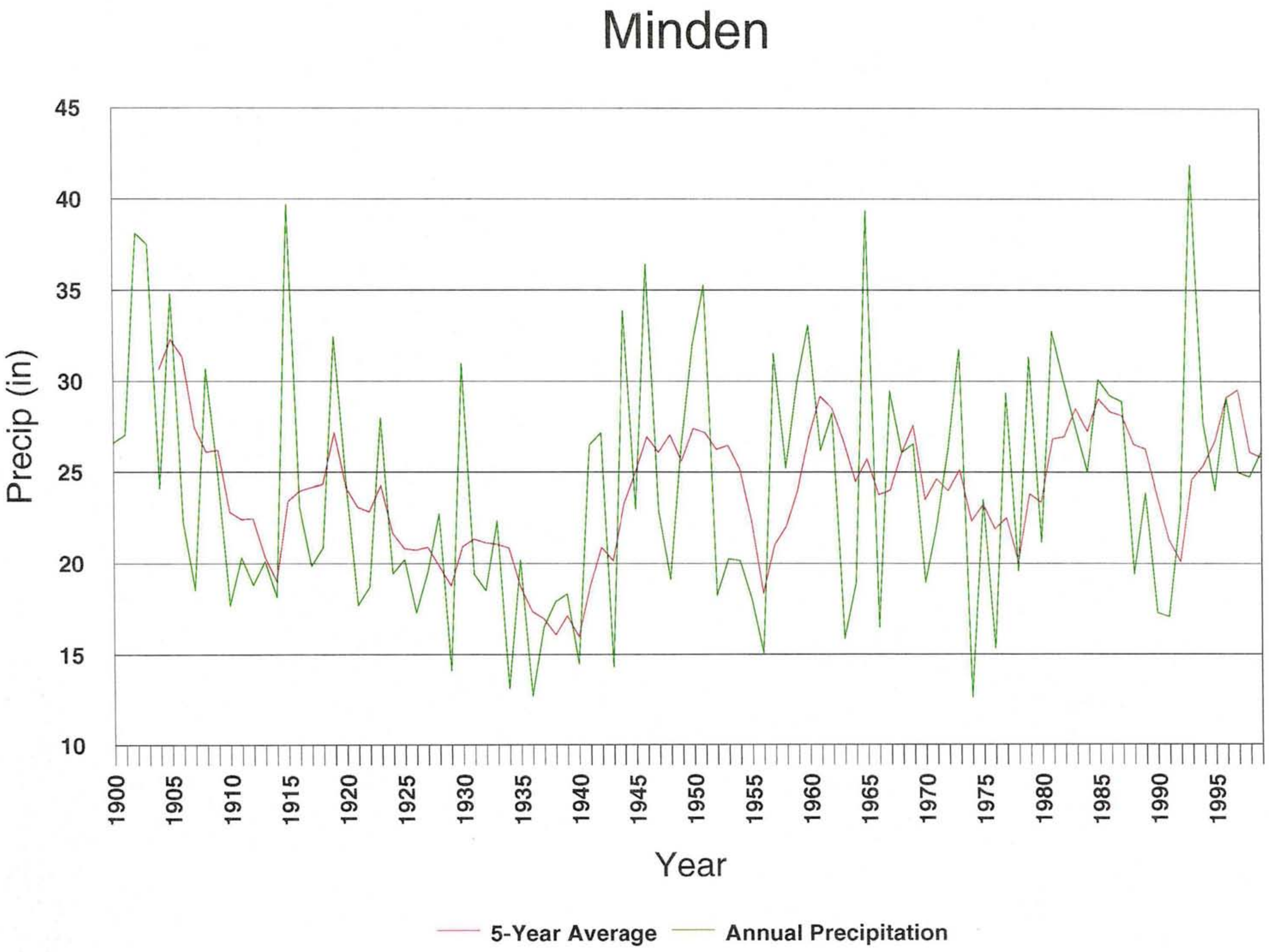

Precip (in)
40
35
30
25
20
15
10
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation

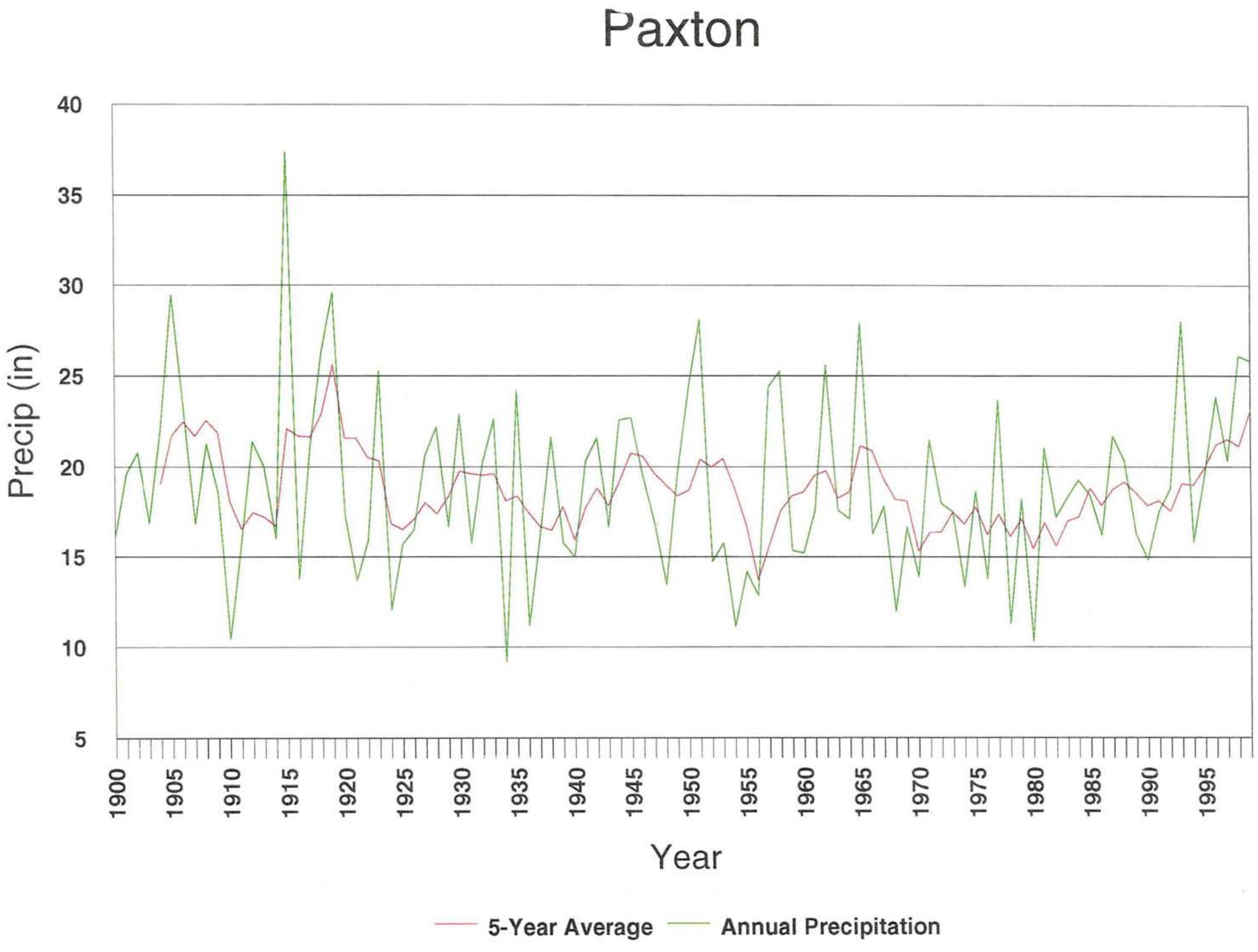

Fullerton
Precip (in)
50
45
40
35
30
25
20
15
10
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation

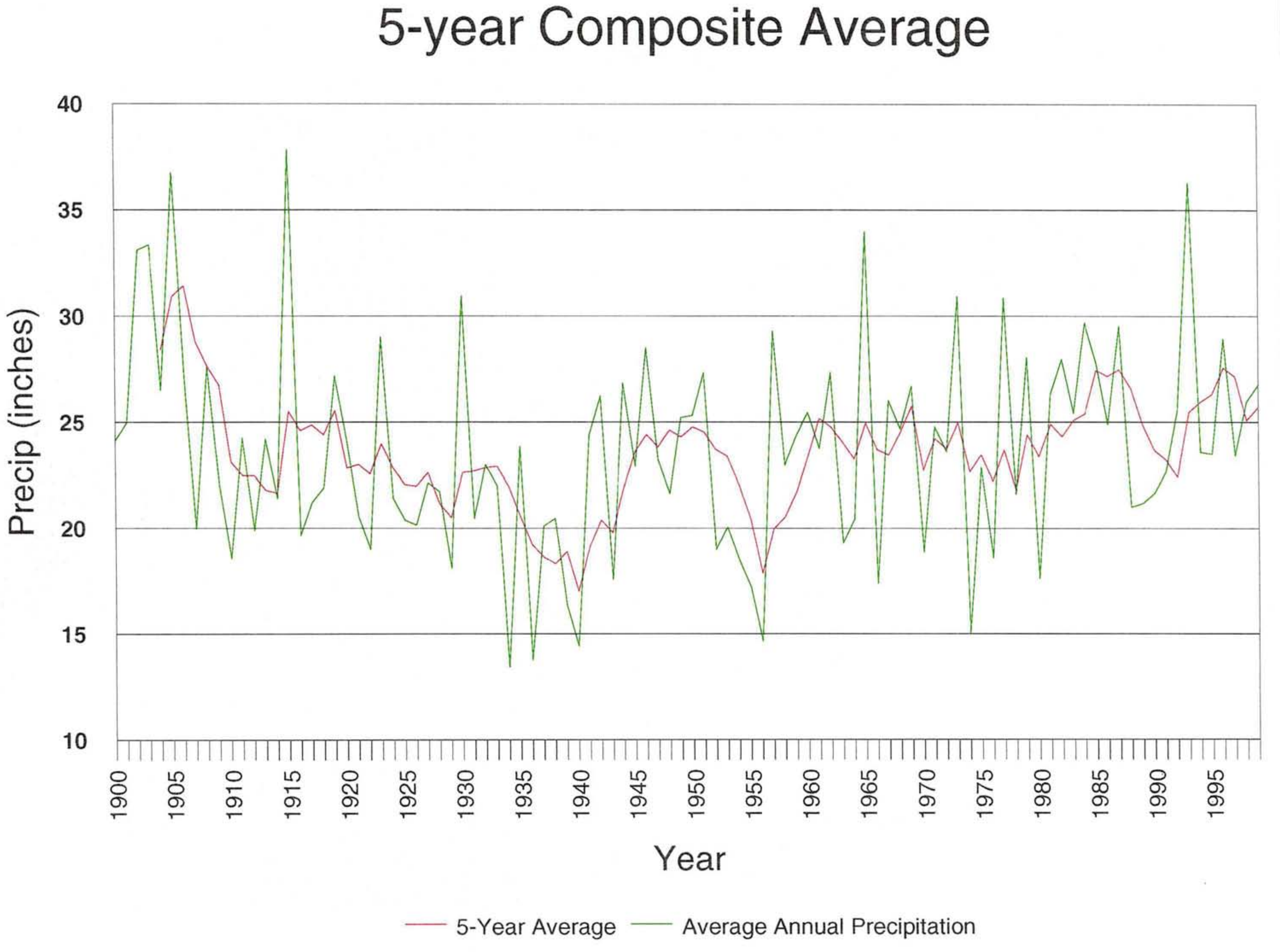


Holdrege
Precip (in)
50
40
30
20
10
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation


Loup City
Precip (in)
45
40
35
30
25
20
15
10
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation


Minden
45
40
35
30
25
20
15
10
Precip (in)
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation


Paxton
Precip (in)
40
35
30
25
20
15
10
5
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Annual Precipitation



5-year Composite Average
Precip (inches)
40
35
30
25
20
15
10
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
5-Year Average
Average Annual Precipitation

Cumulative Departure from Average

Includes all 11 Stations

Weather Station	Surplus 1980-99	Ave per year	Surplus 1990-99	Ave per year
Paxton	20	1.1	26	2.9
Gothenburg	26	1.4	12	1.3
Elwood	32	1.7	16	1.8
Holdrege	54	2.8	44	4.9
Kearney	32	1.7	21	2.3
Minden	43	2.3	22	2.4
Ravenna	50	2.6	24	2.7
Loup City	67	3.5	31	3.4
Grand Island	42	2.2	23	2.6
Central City	48	2.5	14	1.6
Fullerton	37	1.9	23	2.6
Average	41	2.2	23	2.6
Maximum	67	3.5	44	4.9
Minimum	20	1.1	12	1.3

APPENDIX F

WELL TRANSECTS AND DATA

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.

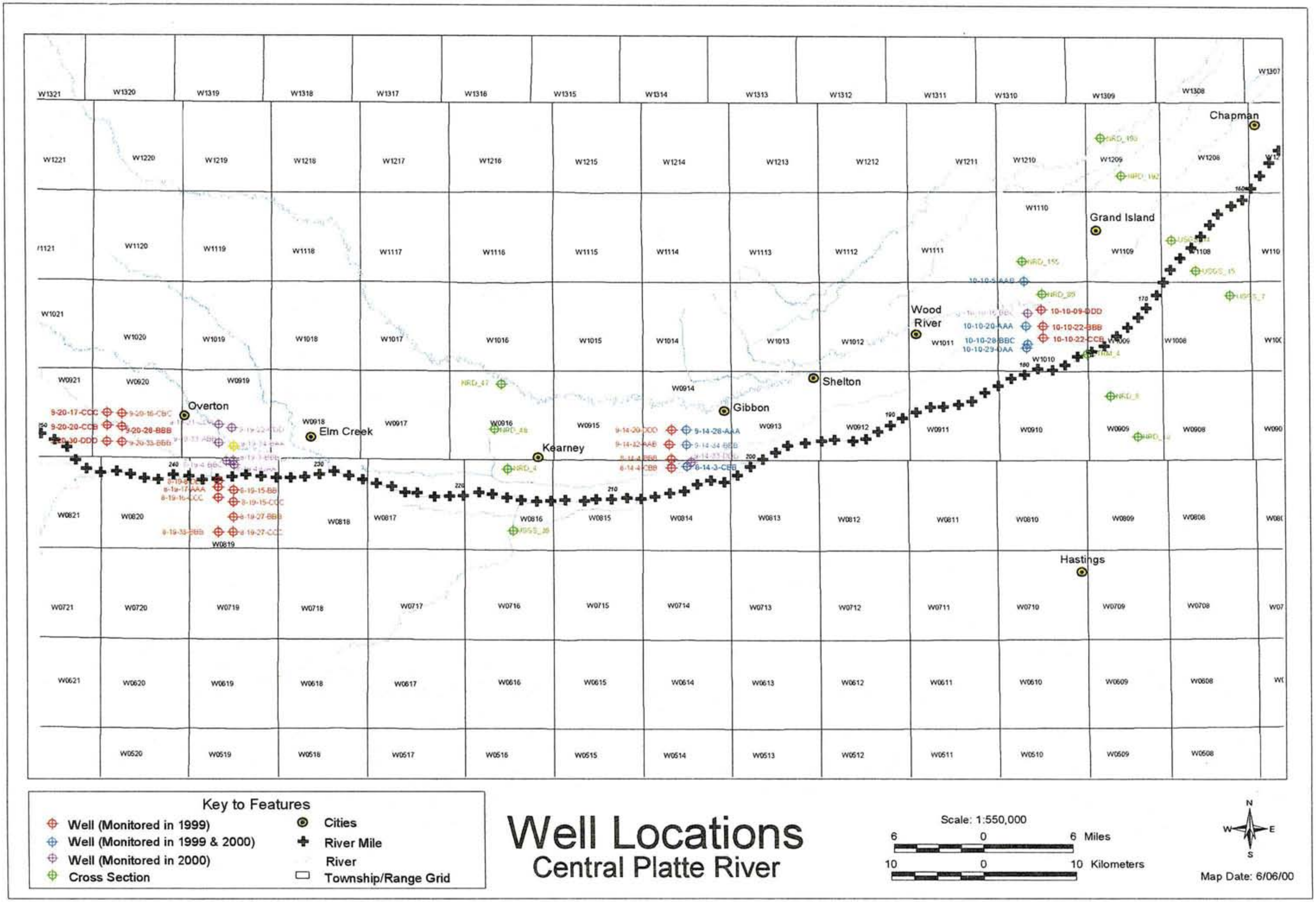
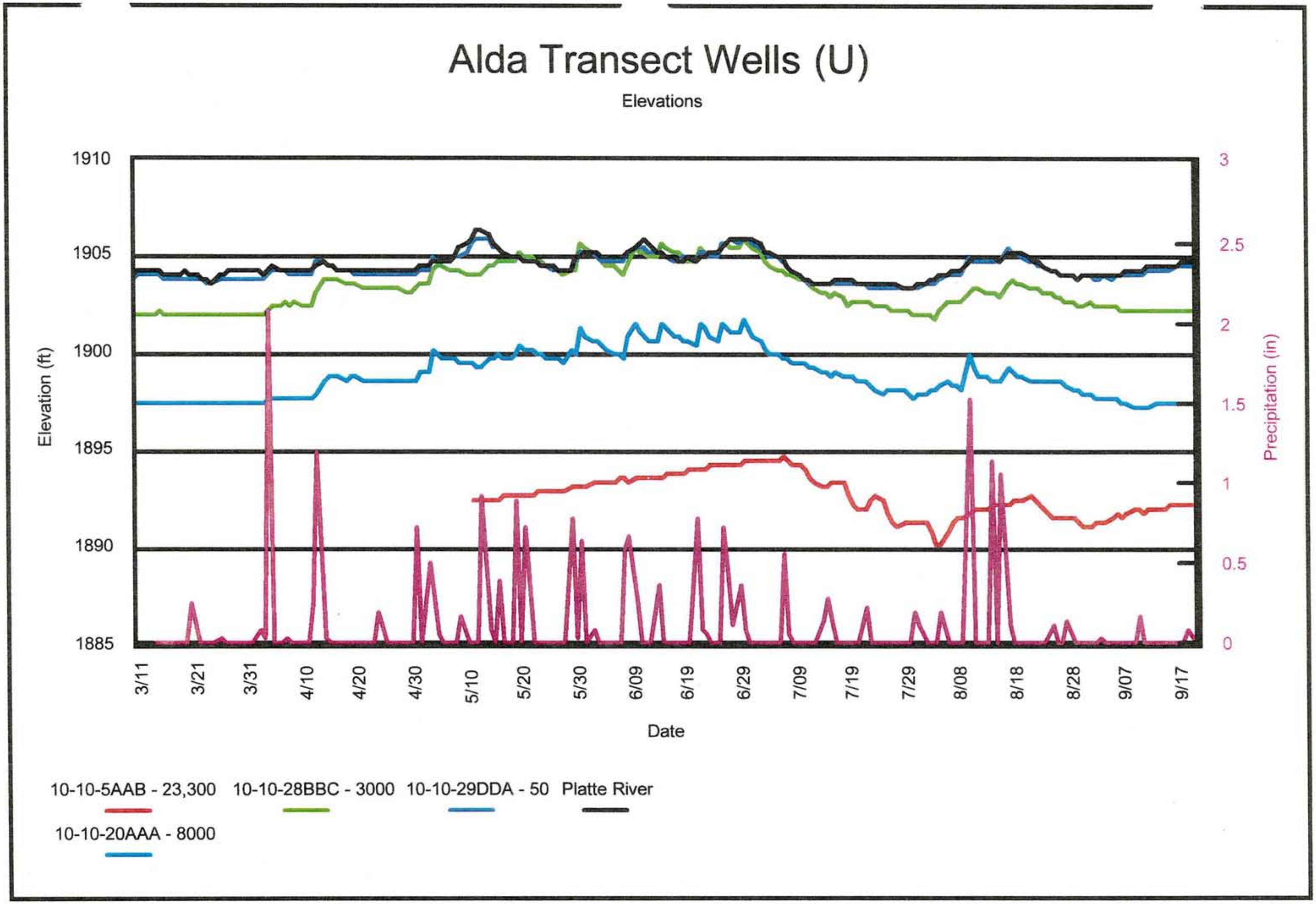

Well Locations
Central Platte River
Key to Features
Well (Monitored in 1999)
Well (Monitored in 1999 & 2000)
Well (Monitored in 2000)
Cross Section
Cities
River Mile
River
Township/Range Grid
Scale: 1:550,000
6 0 6 Miles
10 0 10 Kilometers
N
W
E
S
Map Date: 6/06/00
Chapman
Grand Island
Wood River
Shelton
Gibbon
Kearney
Elm Creek
Overton
Hastings
9-20-17-CCC
9-20-20-CCB
9-20-30-DDD
9-20-16-CBC
9-20-28-BBB
9-20-33-BBB
8-19-17-AAA
8-19-16-CCC
8-19-15-BB
8-19-15-CCC
8-19-27-BBB
8-19-33-BBB
8-19-27-CCC
9-14-20-DDD
9-14-32-AAB
9-14-28-AAA
9-14-34-BBB
8-14-4-CBB
8-14-3-CBB
10-10-5-AAB
10-10-09-DDD
10-10-20-AAA
10-10-22-BBB
10-10-28-BBC
10-10-29-DAA
10-10-22-CCB
NRD_47
NRD_48
NRD_4
USGS_38
NRD_155
NRD_89
NRD_193
NRD_192
USGS_15
USGS_7
NRD_8
160
170
180
190
200
210
220
230
240
250
W1321
W1320
W1319
W1318
W1317
W1316
W1315
W1314
W1313
W1312
W1311
W1310
W1309
W1308
W1307
W1221
W1220
W1219
W1218
W1217
W1216
W1215
W1214
W1213
W1212
W1211
W1210
W1209
W1208
W1120
W1119
W1118
W1117
W1116
W1115
W1114
W1113
W1112
W1111
W1110
W1109
W1108
W1021
W1020
W1019
W1018
W1017
W1016
W1015
W1014
W1013
W1012
W1011
W1010
W1009
W1008
W0921
W0920
W0919
W0918
W0917
W0916
W0915
W0914
W0913
W0912
W0911
W0910
W0909
W0908
W0821
W0820
W0819
W0818
W0817
W0816
W0815
W0814
W0813
W0812
W0811
W0810
W0809
W0808
W0721
W0720
W0719
W0718
W0717
W0716
W0715
W0714
W0713
W0712
W0711
W0710
W0709
W0708
W0621
W0620
W0619
W0618
W0617
W0616
W0615
W0614
W0613
W0612
W0611
W0610
W0609
W0608
W0520
W0519
W0518
W0517
W0516
W0515
W0514
W0513
W0512
W0511
W0510
W0509
W0508

Figure 7.

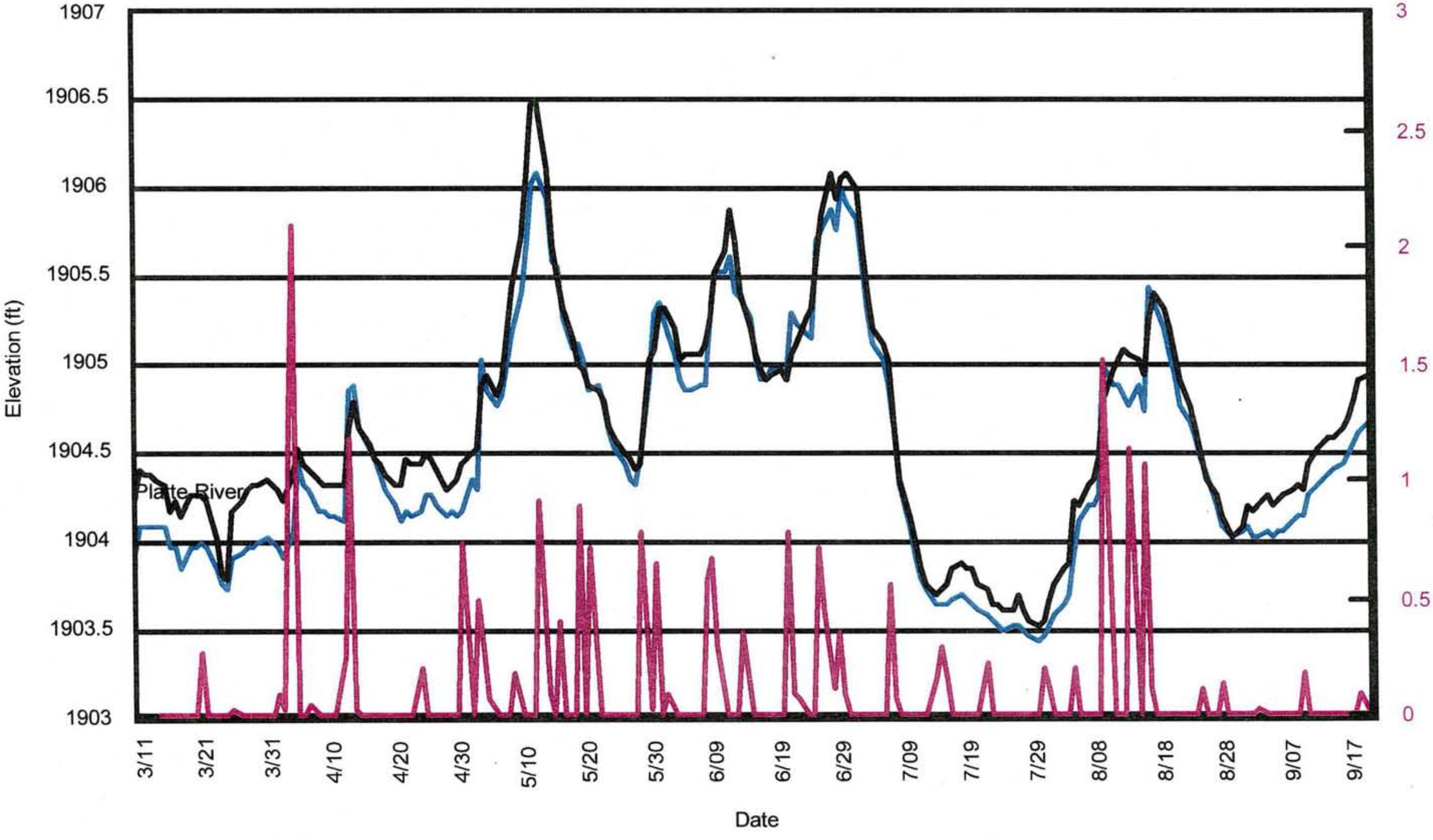


Alda Transect Wells (U)

Elevations

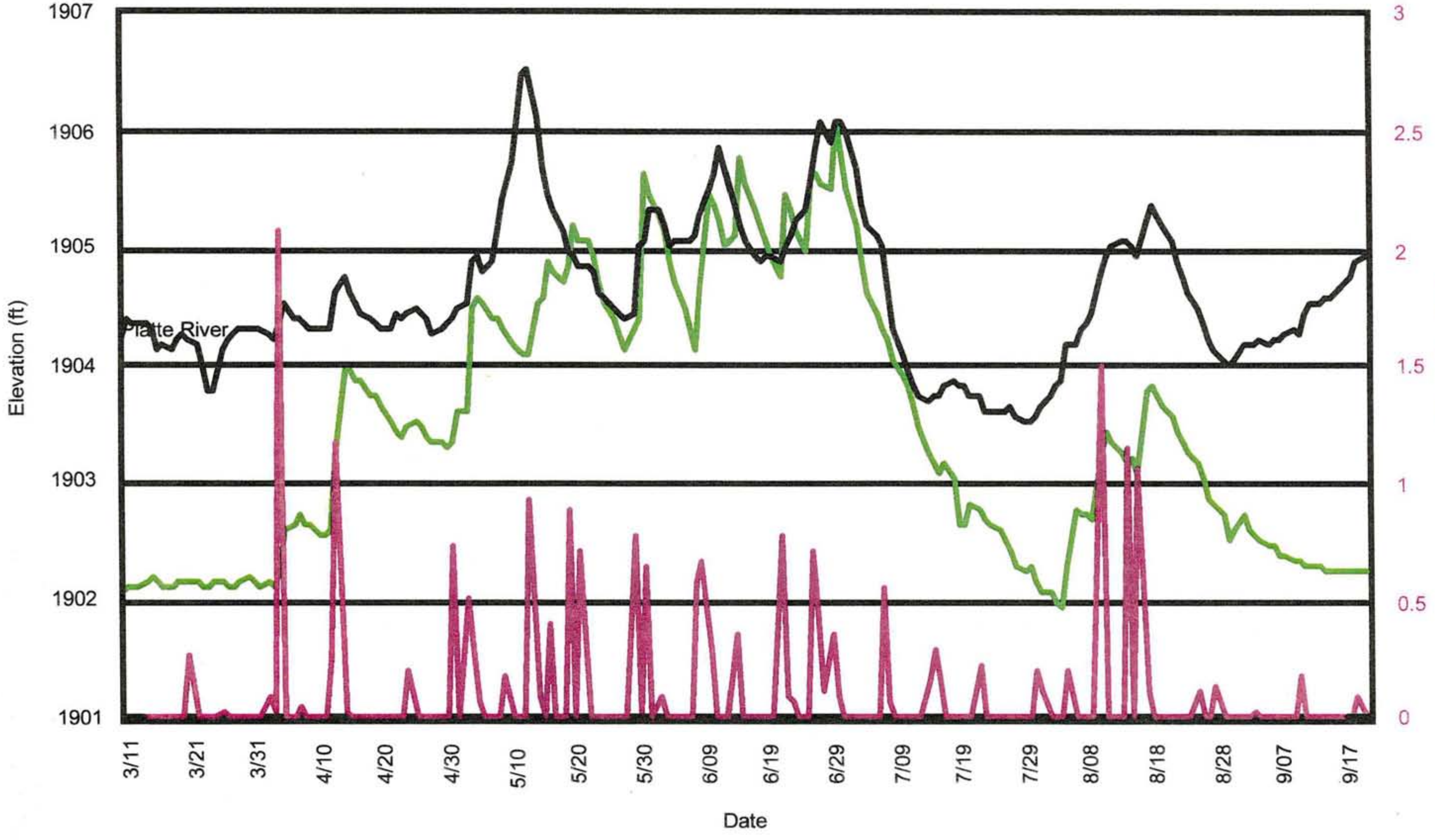
Alda Transect Wells (U)

Elevations
Well #10-10-29DDA - 50



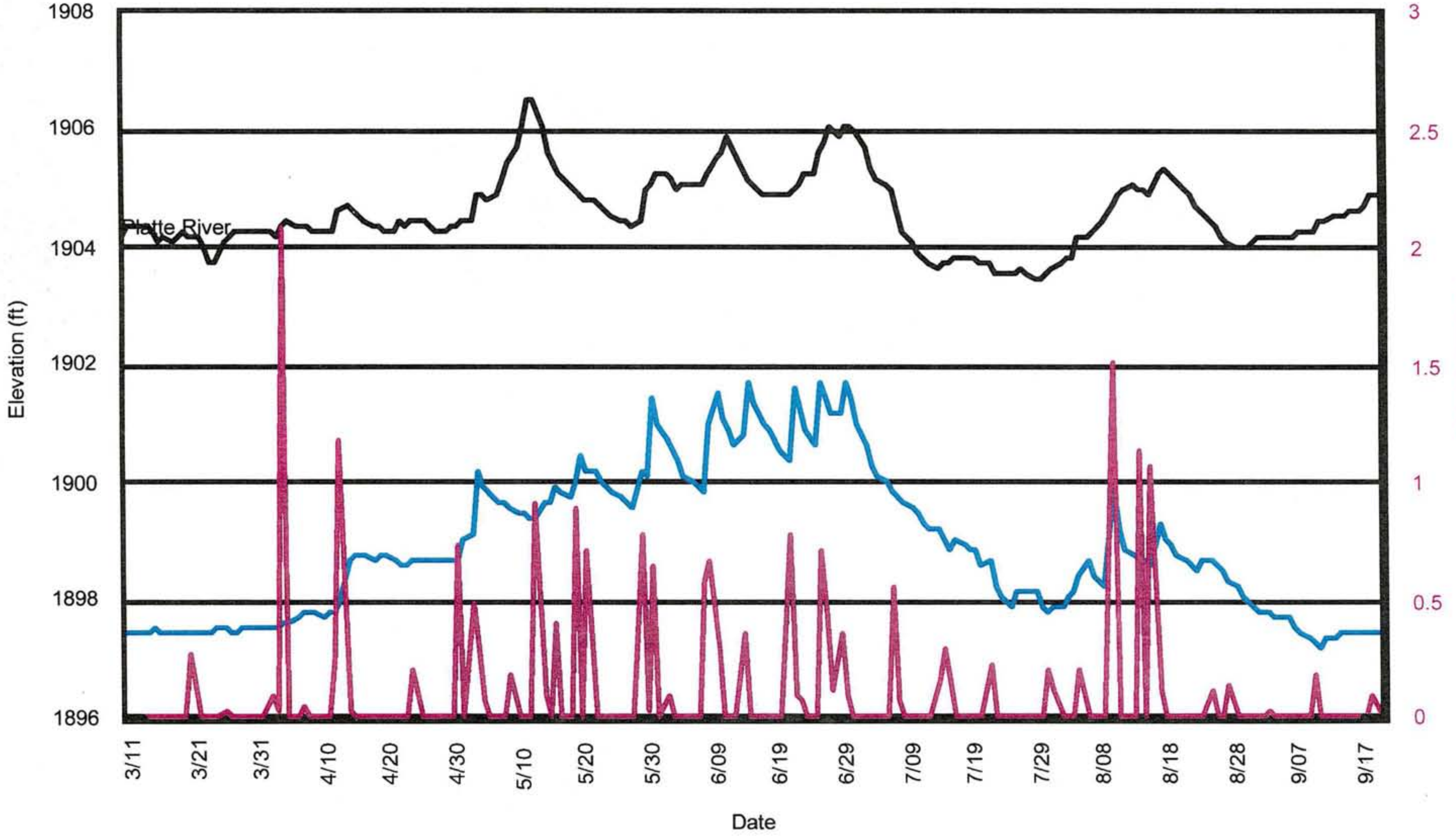
Alda Transect Wells (U)

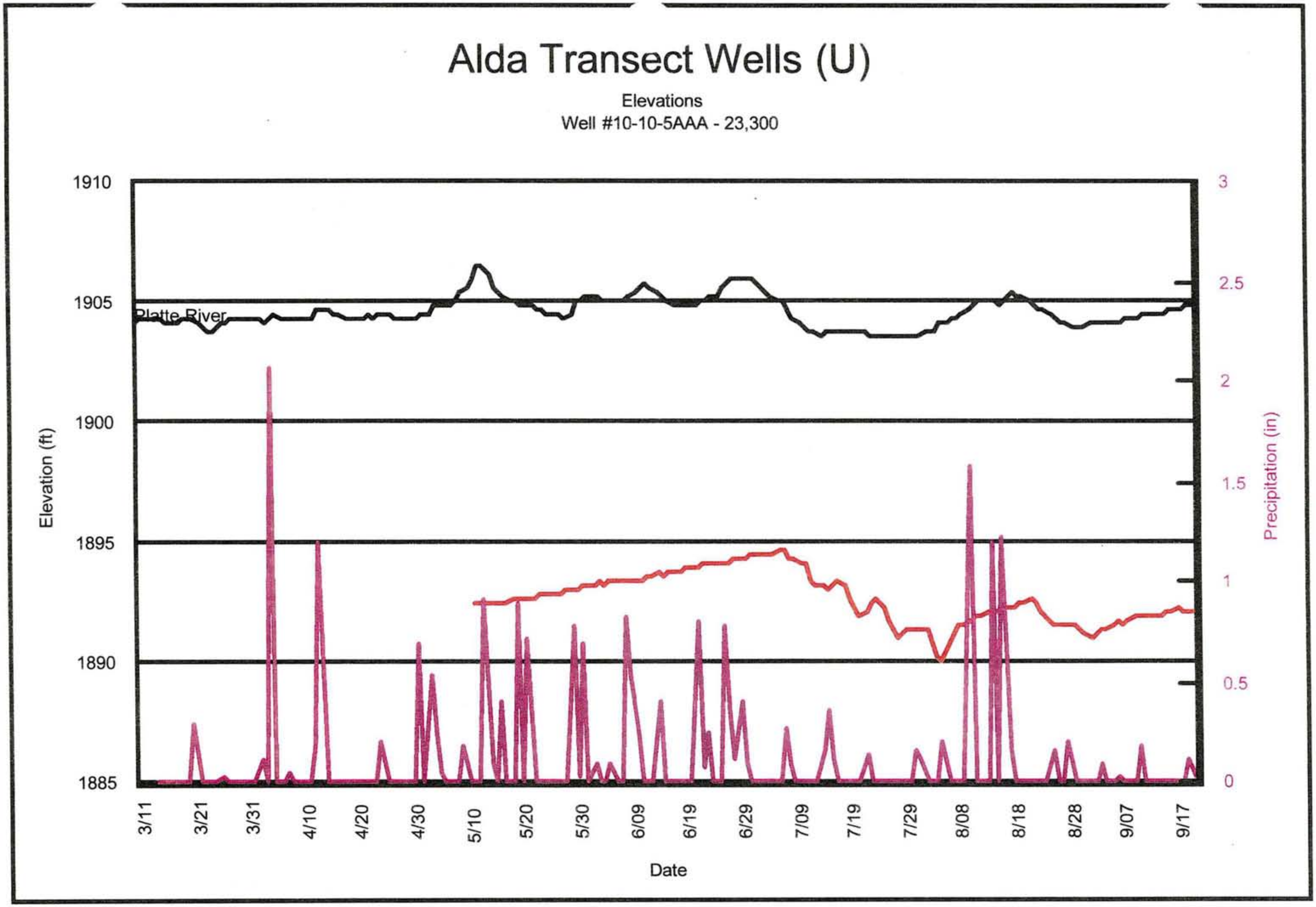
Elevations
Well #10-10-28BBC - 3000



Alda Transect Wells (U)

Elevations
Well #10-10-20AAA - 8000

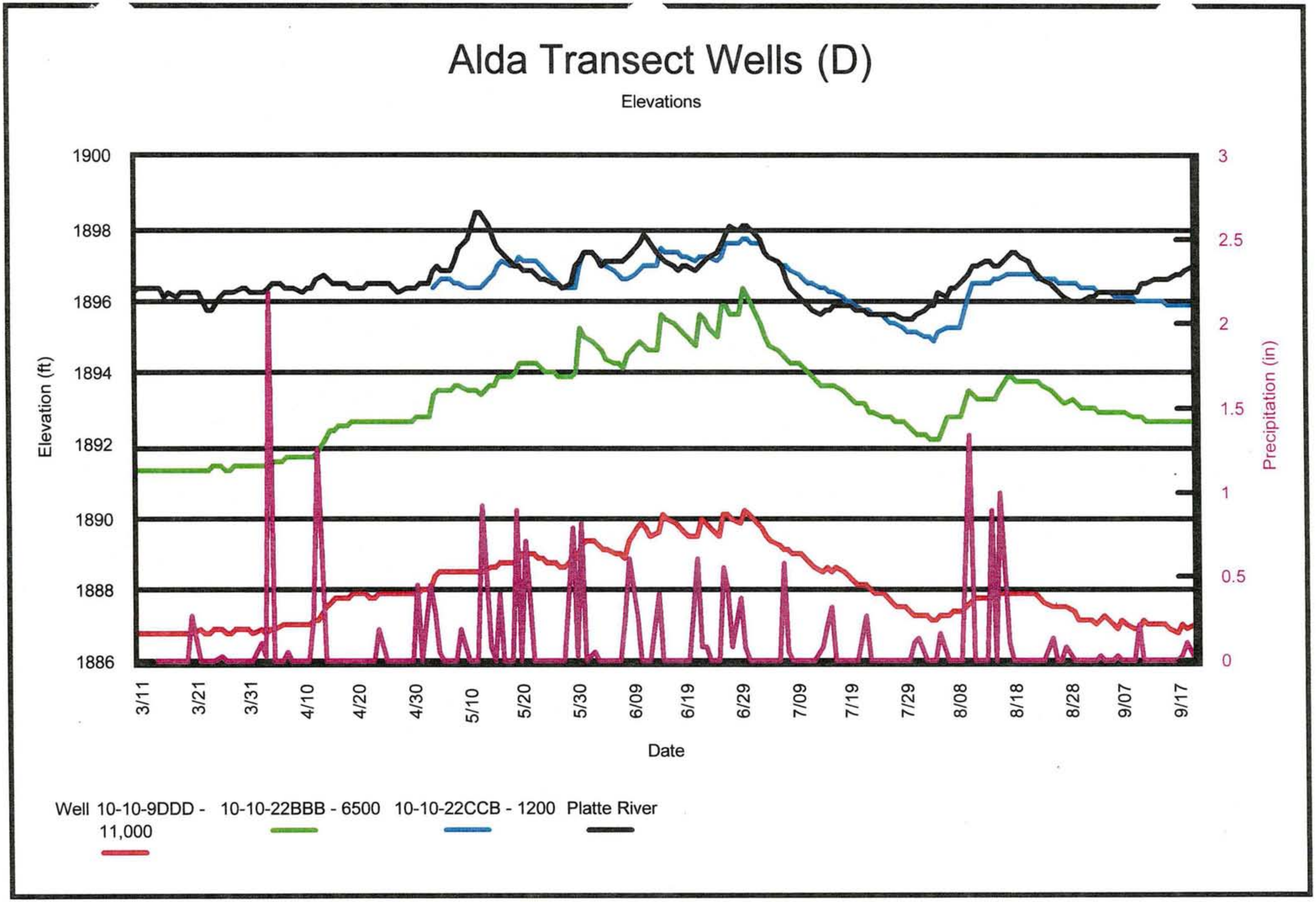




Alda Transect Wells (U)

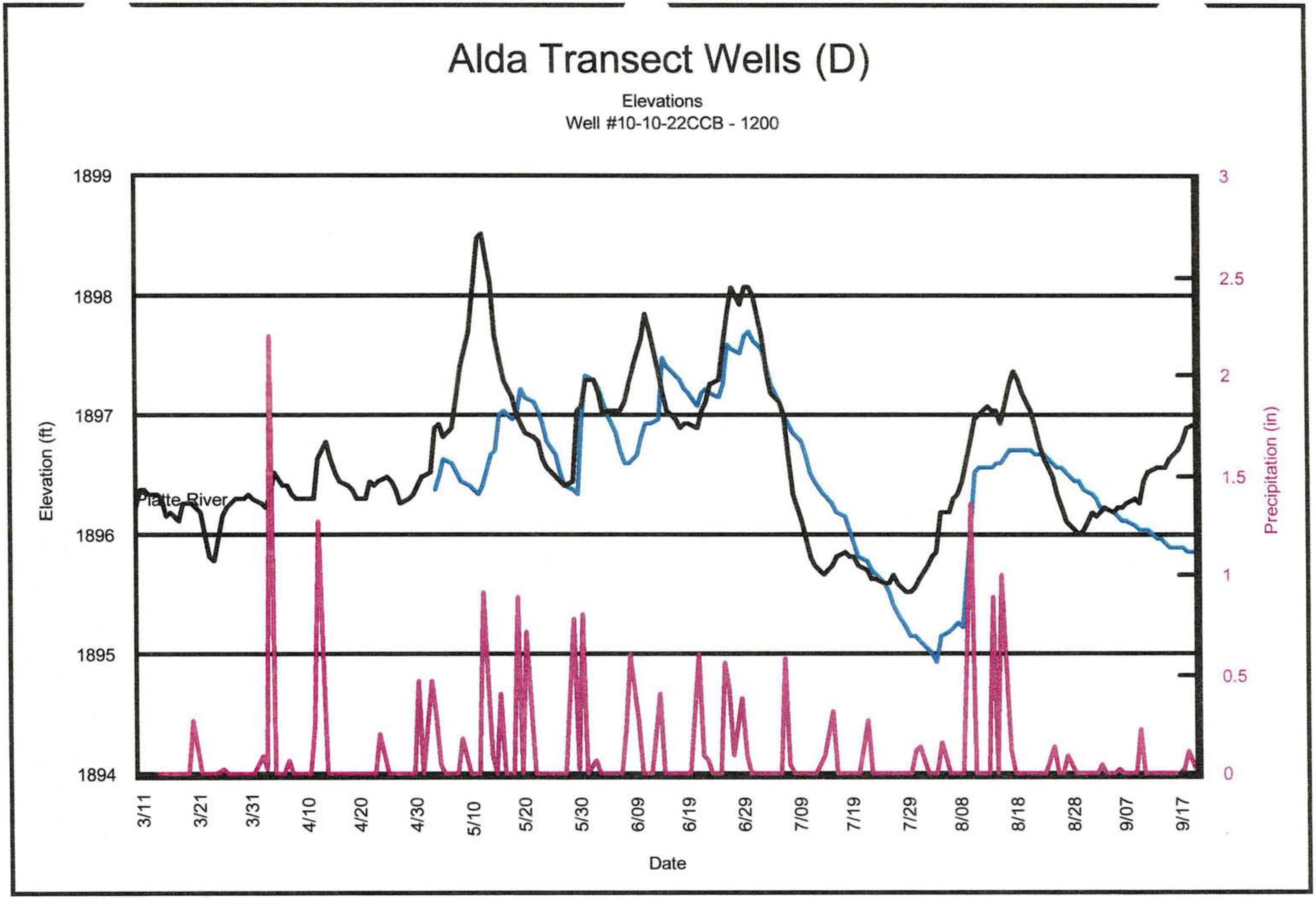
Elevations

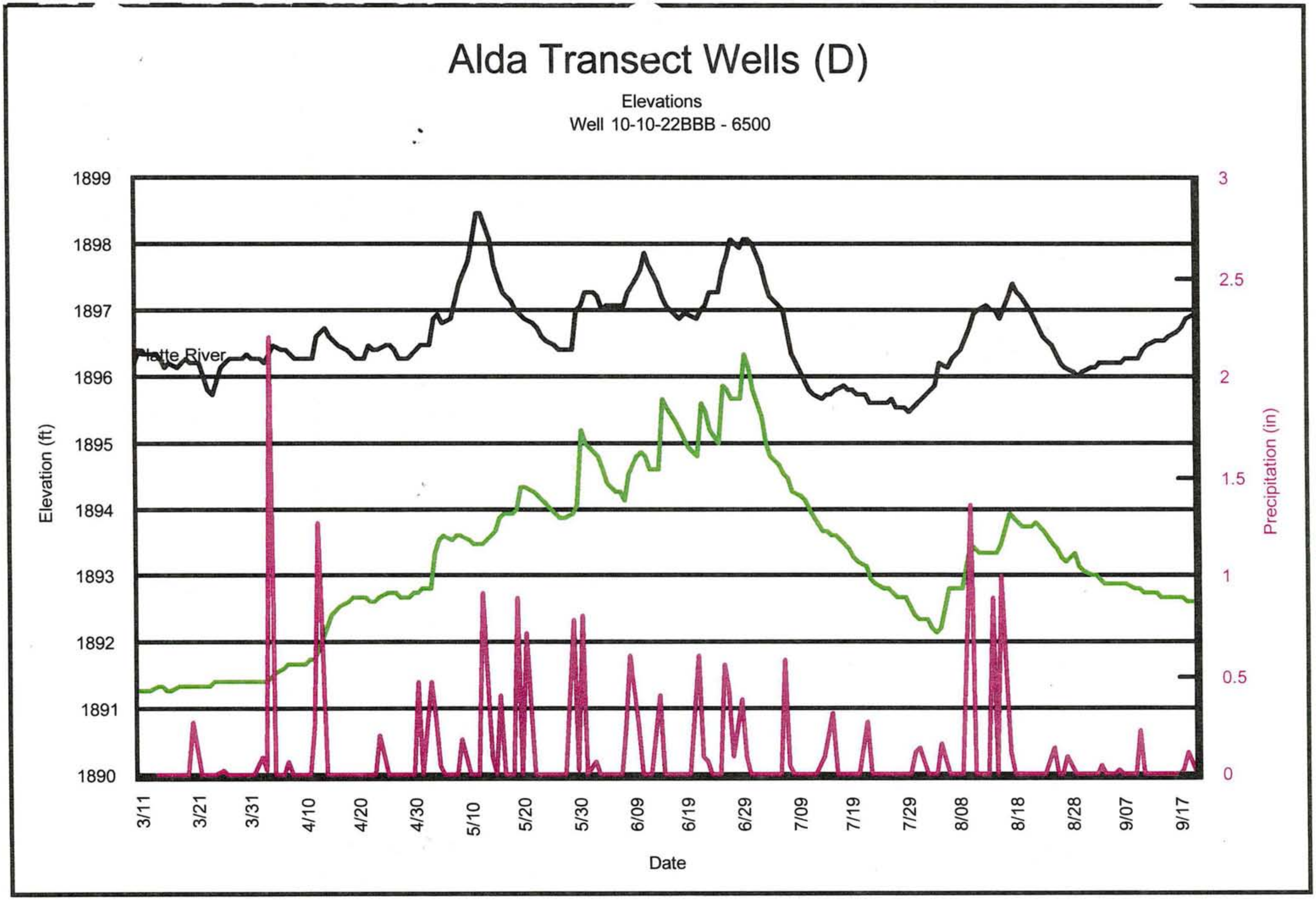
Well #10-10-5AAA - 23,300



Alda Transect Wells (D)

Elevations

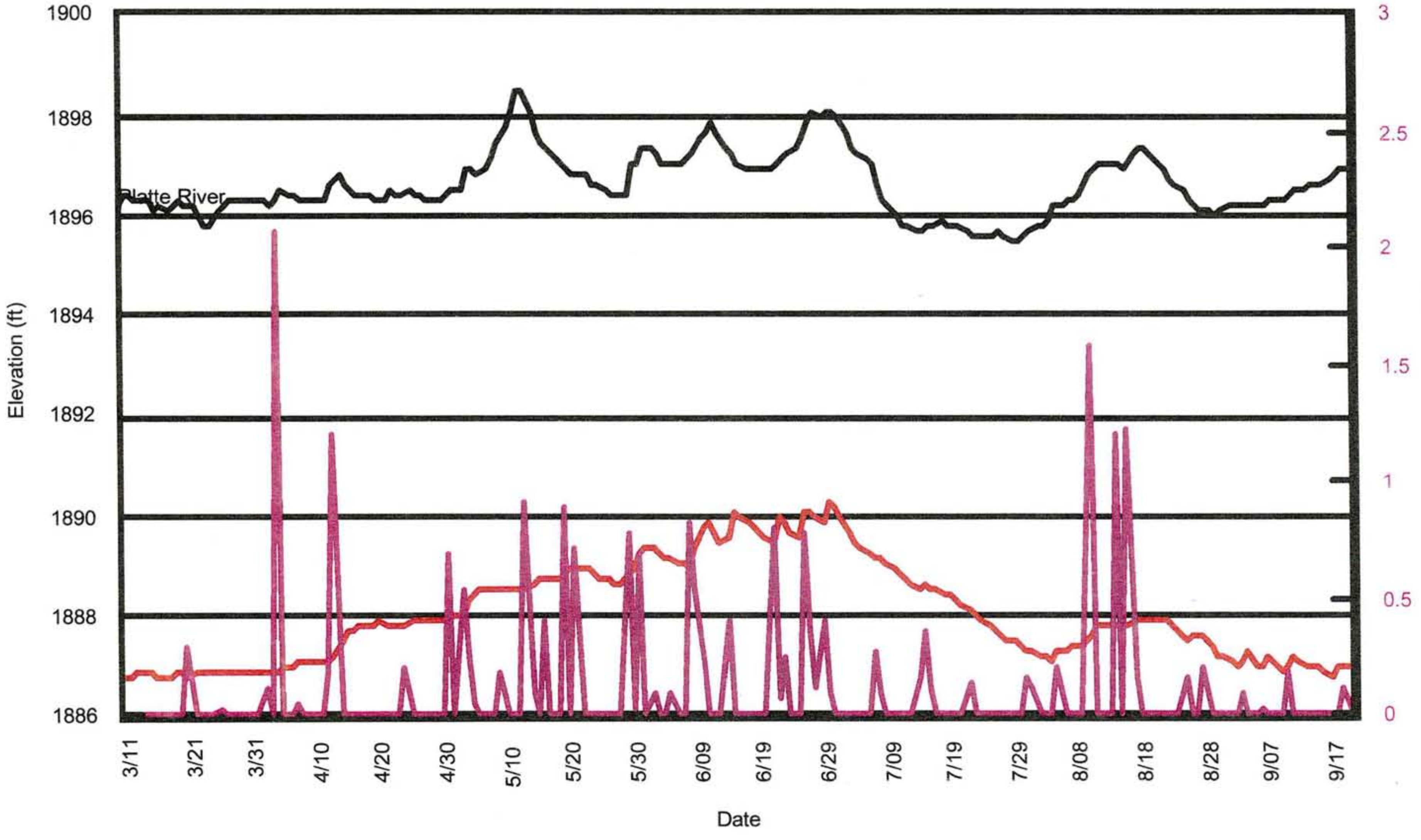

Alda Transect Wells (D)
Elevations
Well #10-10-22CCB - 1200
Elevation (ft)
1899
1898
1897
1896
1895
1894
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
Platte River
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date


Alda Transect Wells (D)
Elevations
Well 10-10-22BBB - 6500
Platte River
Elevation (ft)
Precipitation (in)
Date
1899
1898
1897
1896
1895
1894
1893
1892
1891
1890
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

Alda Transect Wells (D)

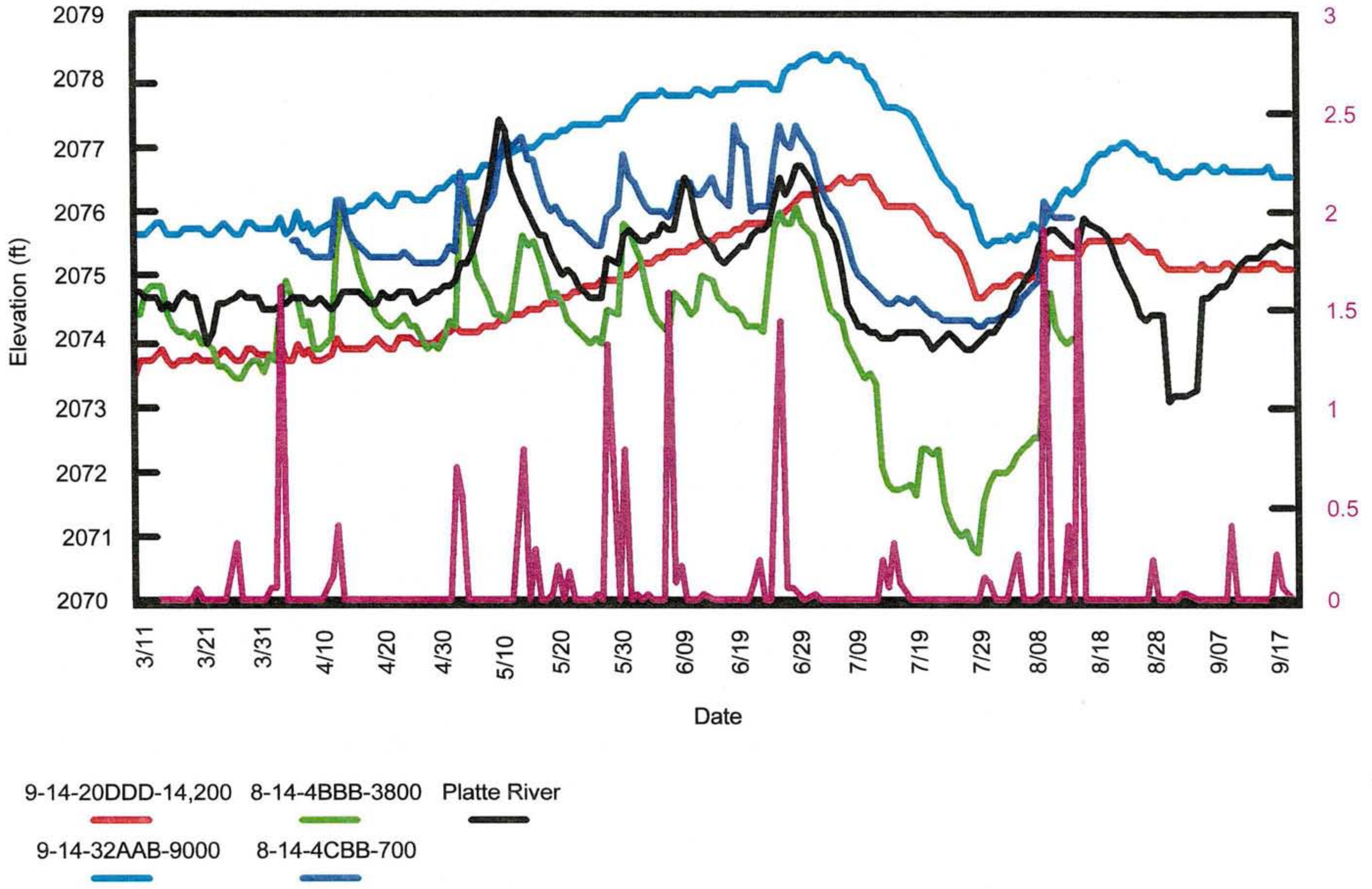
Elevations

Well #10-10-9DDD - 11,000



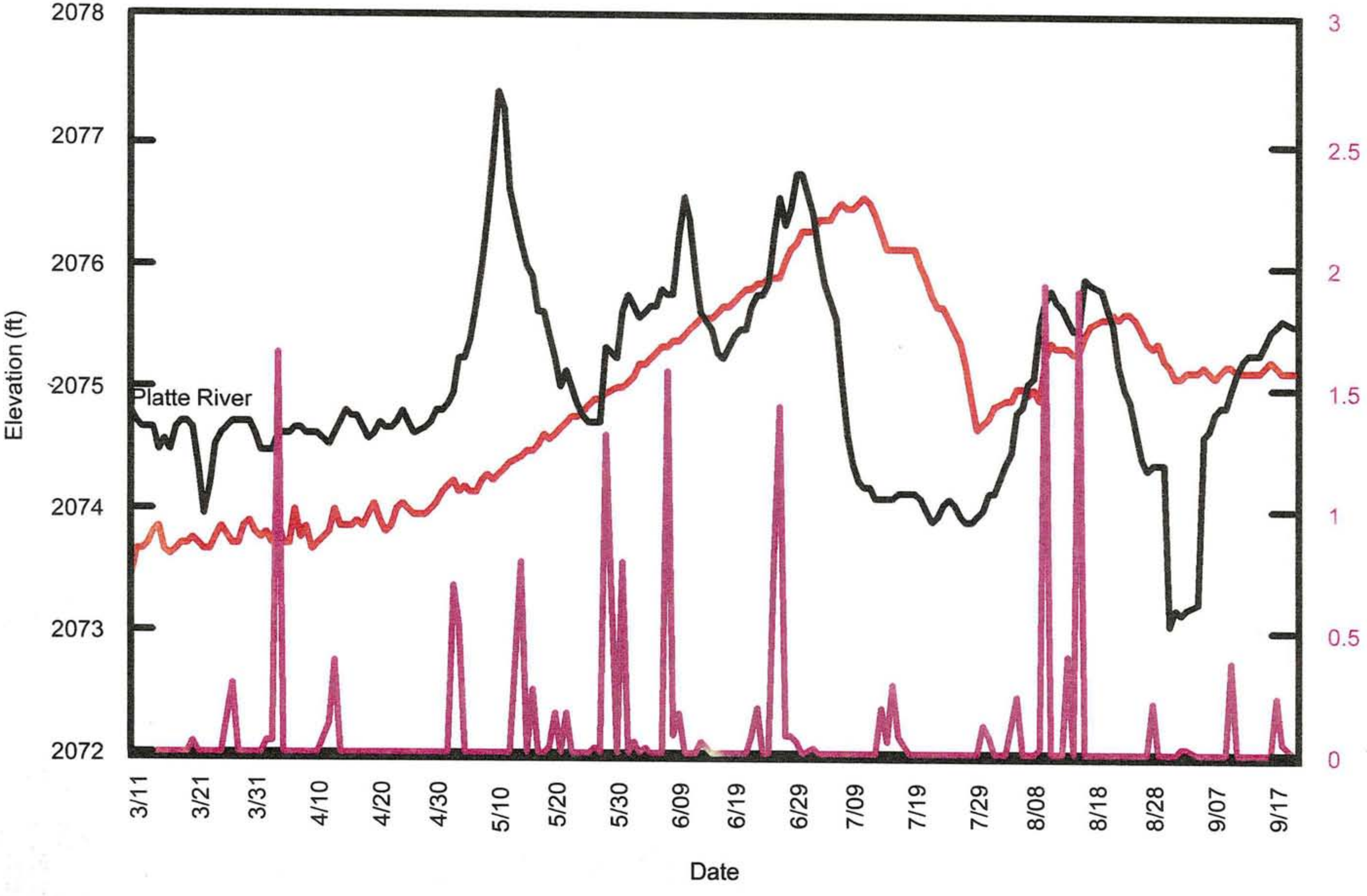
Minden Transect Wells (U)

Elevations



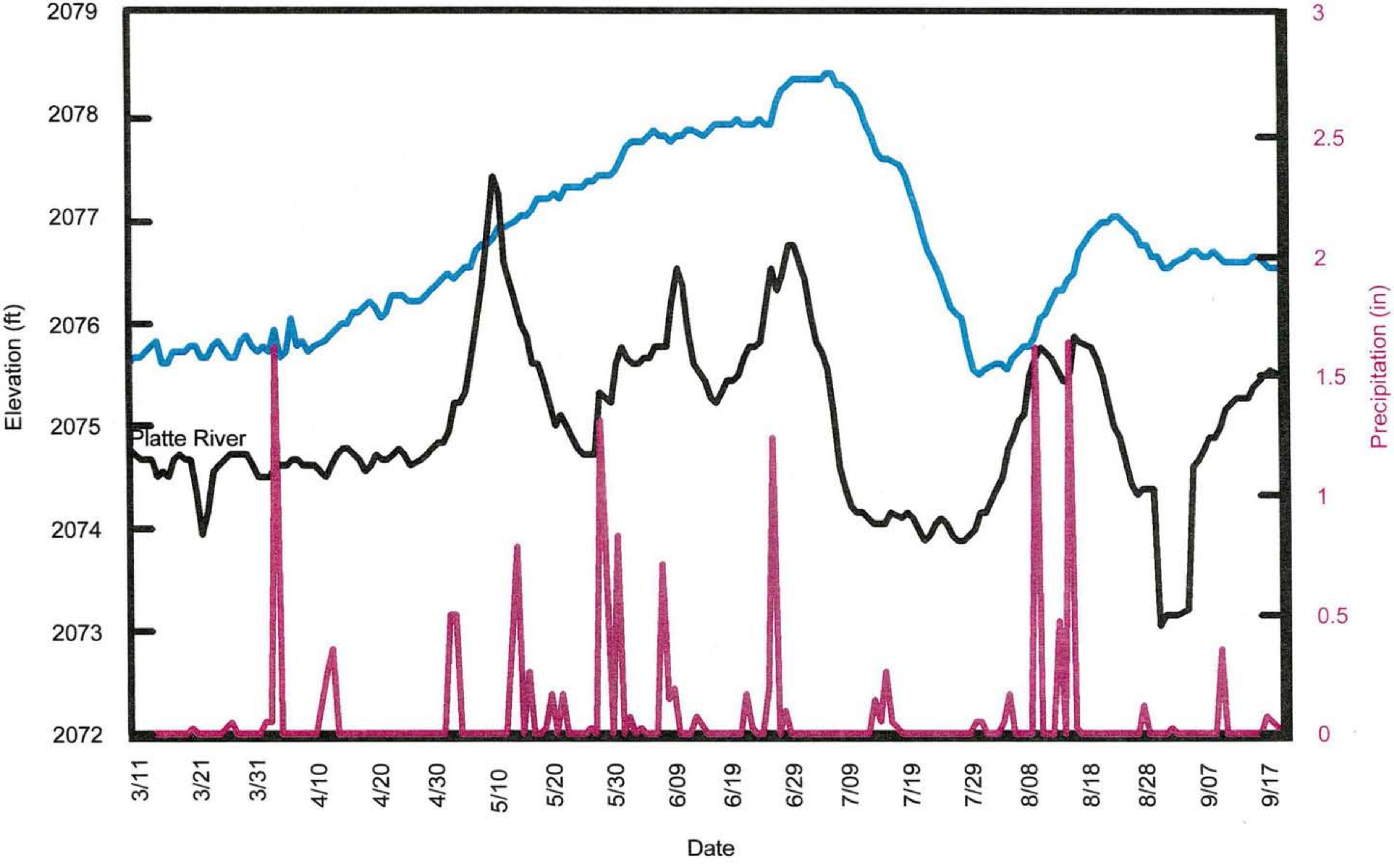
Minden Transect Wells (U)

Elevations
Well #9-14-20DDD - 14,200



Minden Transect Wells (U)

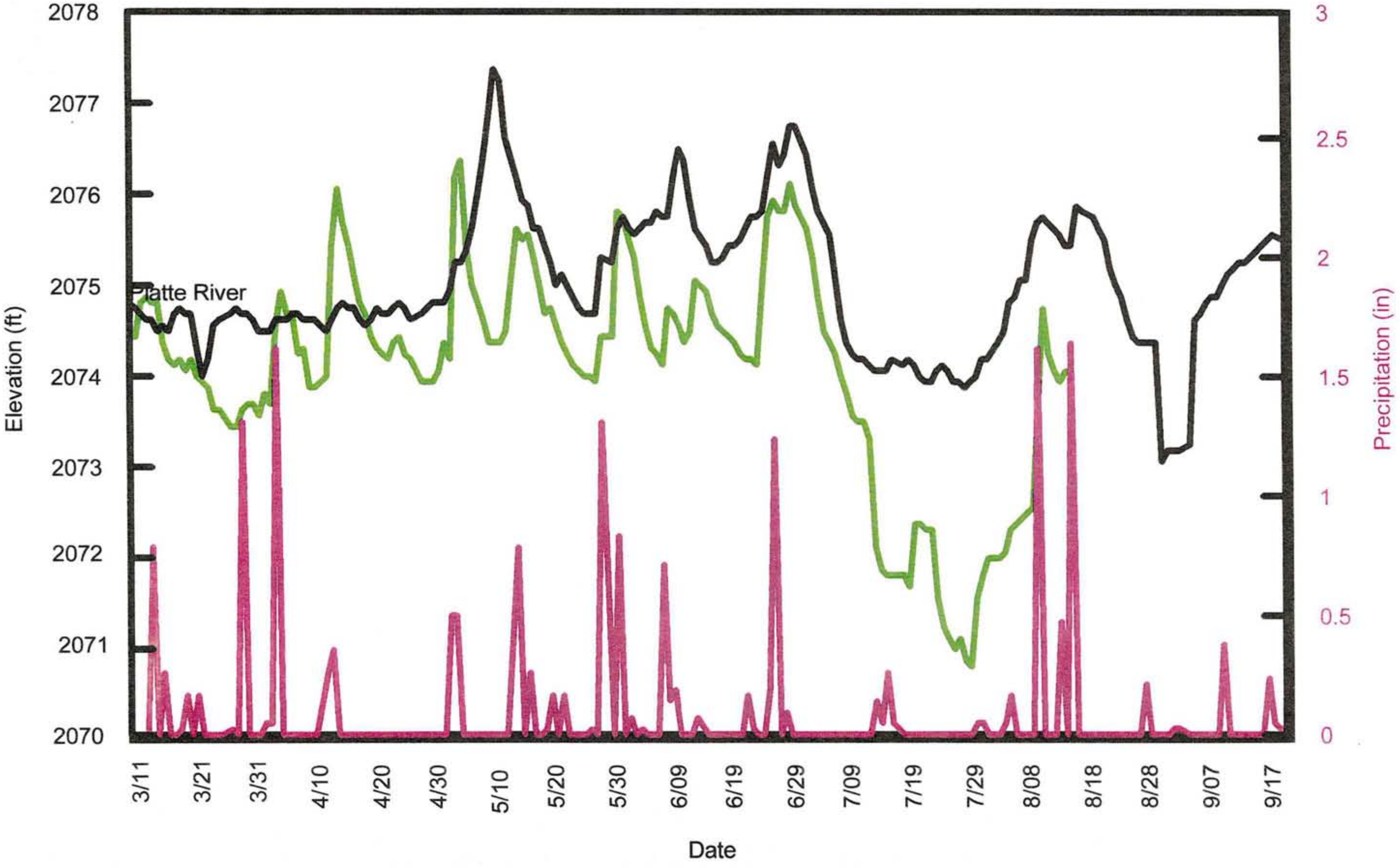
Elevations
Well #9-14-32AAB - 9000



Minden Transect Wells (U)

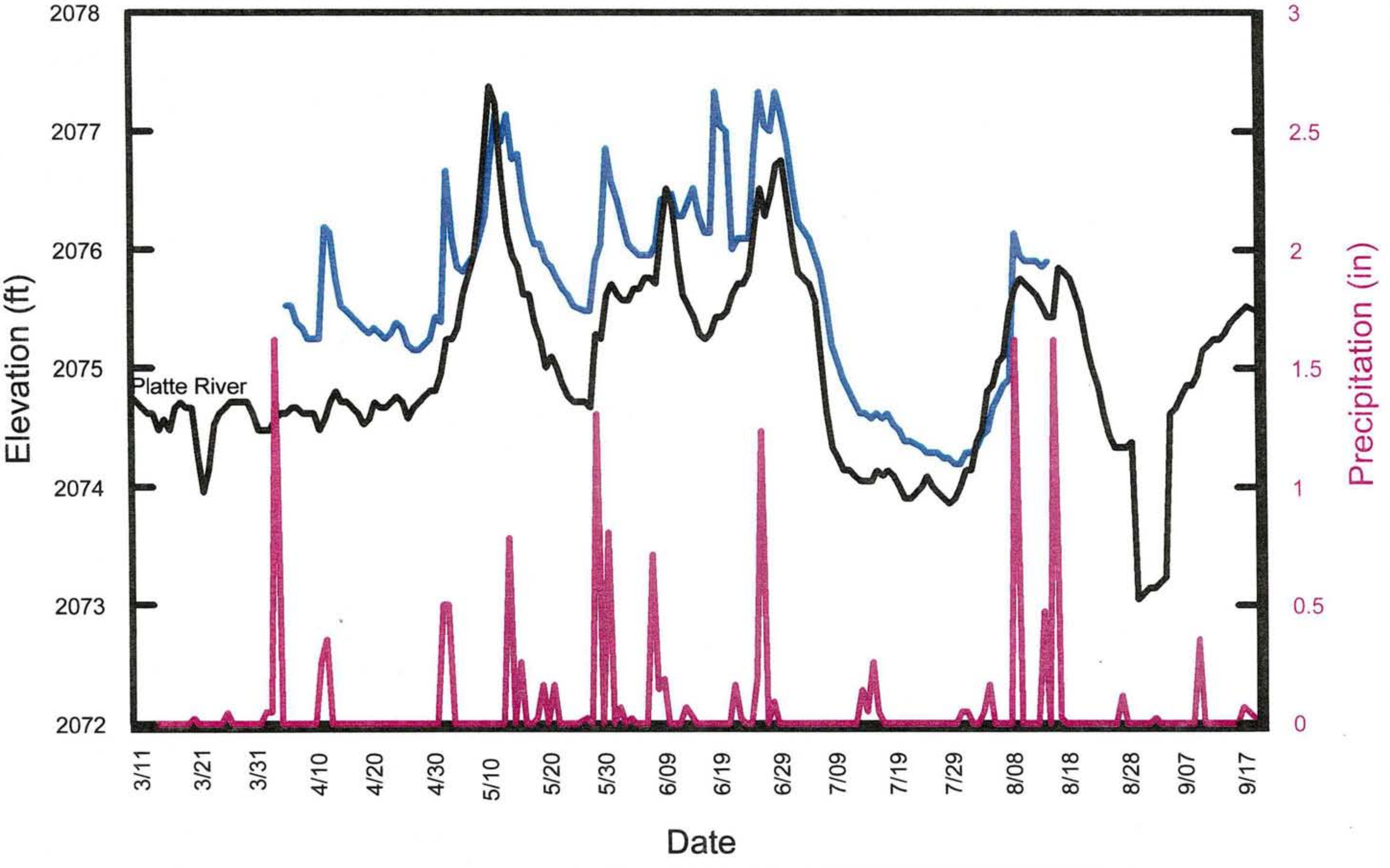
Elevations

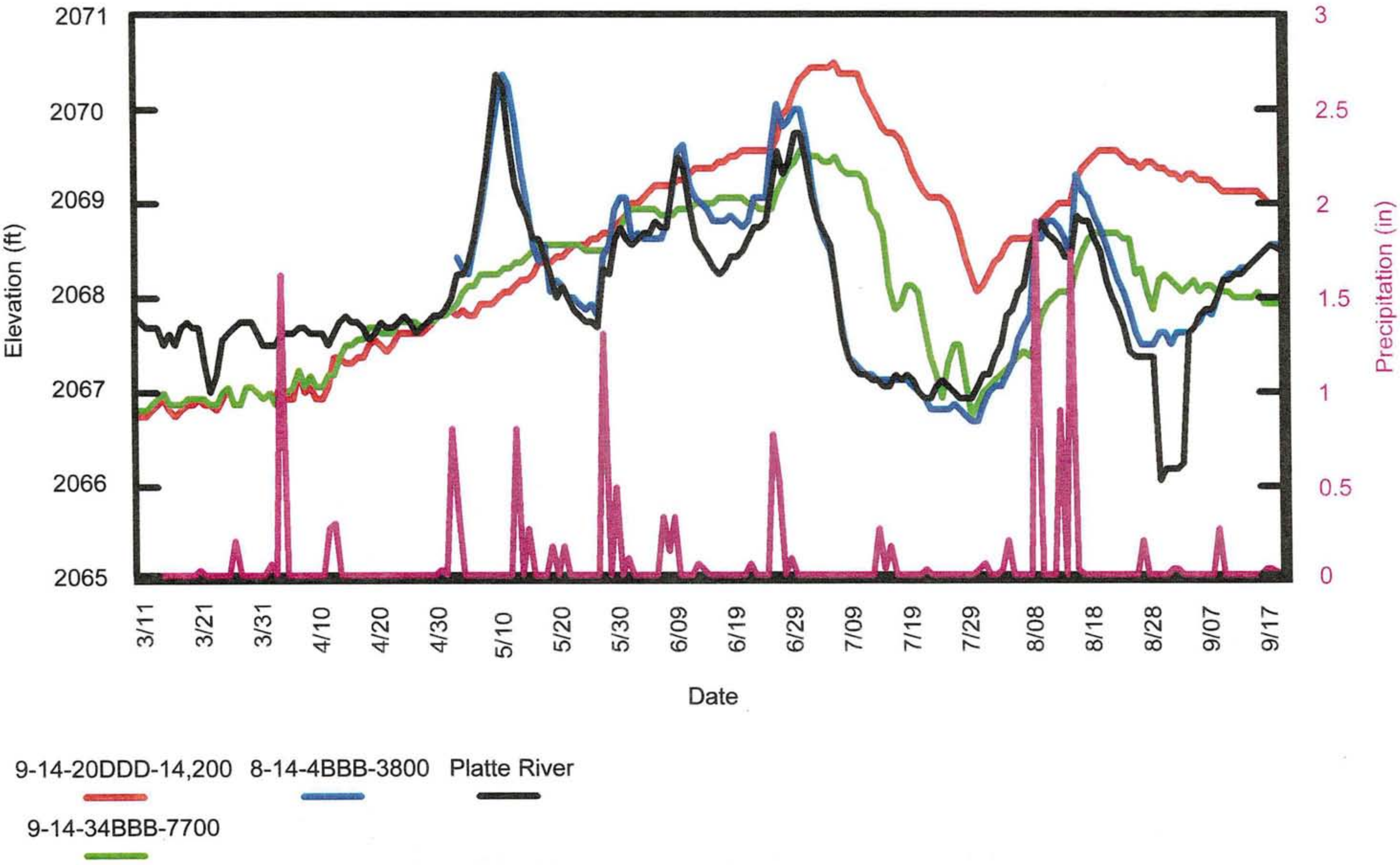
Well #8-14-4BBB - 3800



Minden Transect Wells (U)

Elevations
Well #8-14-4CBB - 700



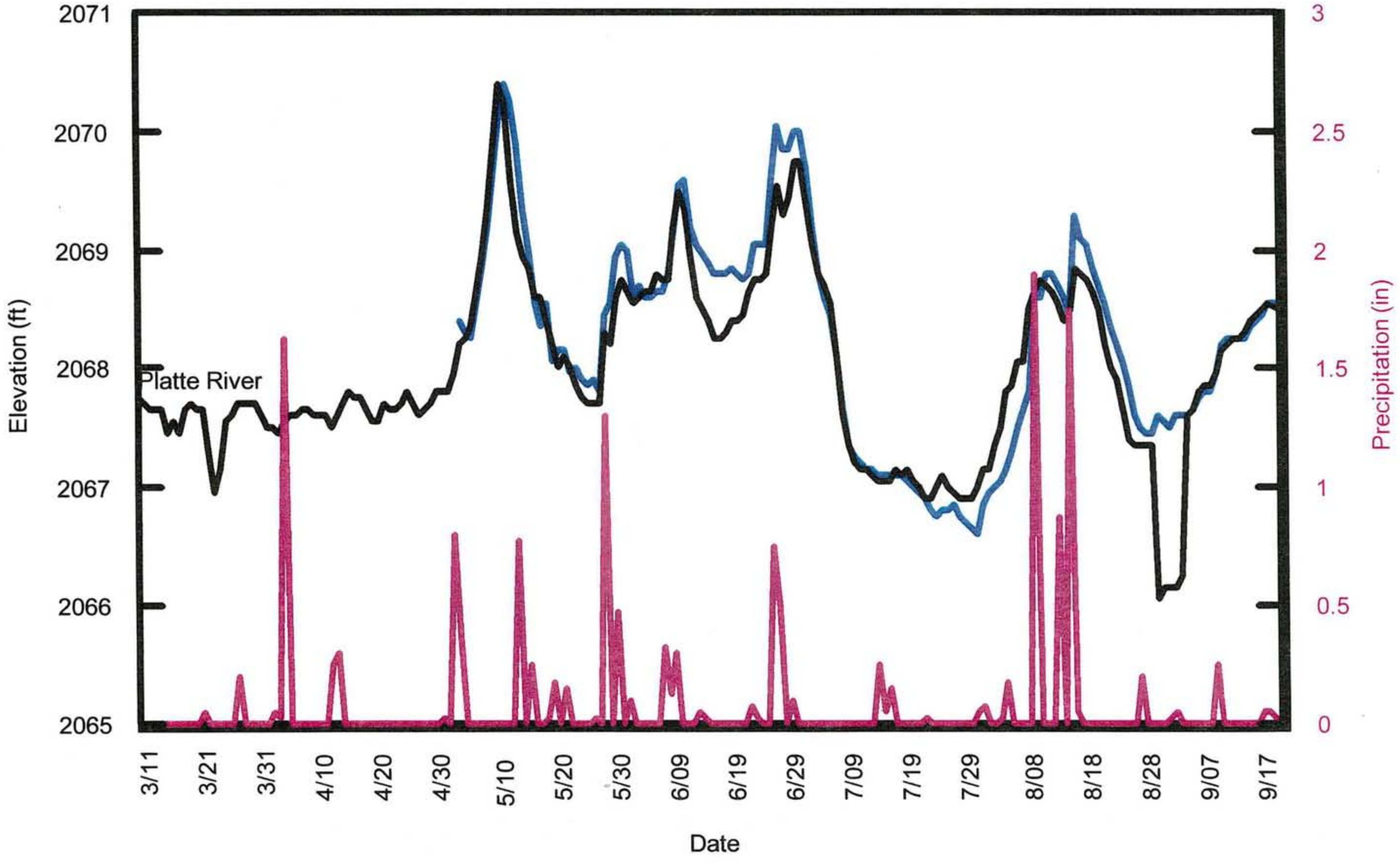


Minden Transect Wells (D)

Elevations

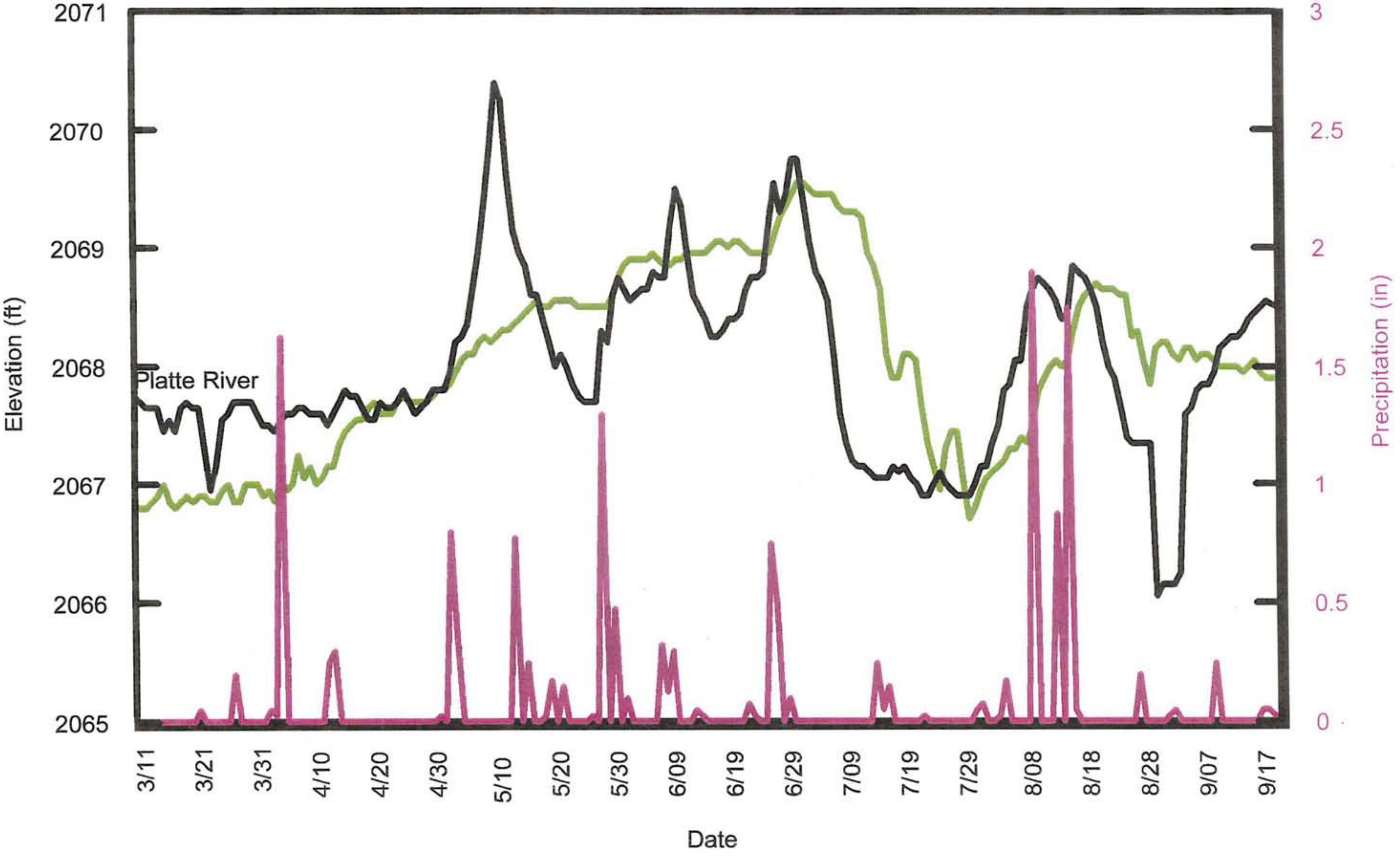
Minden Transect Wells (D)

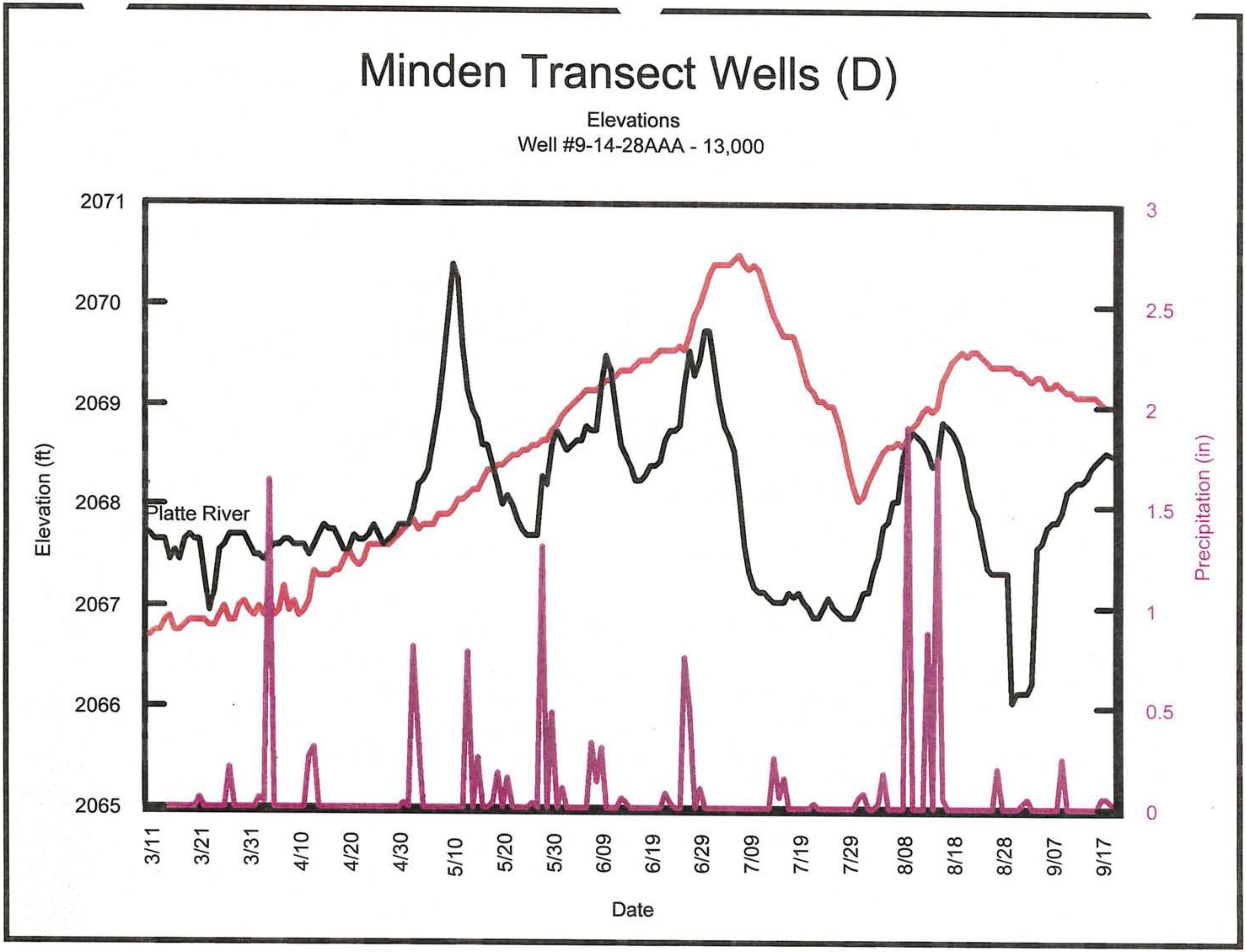
Elevations
Well #8-14-3CBB - 100

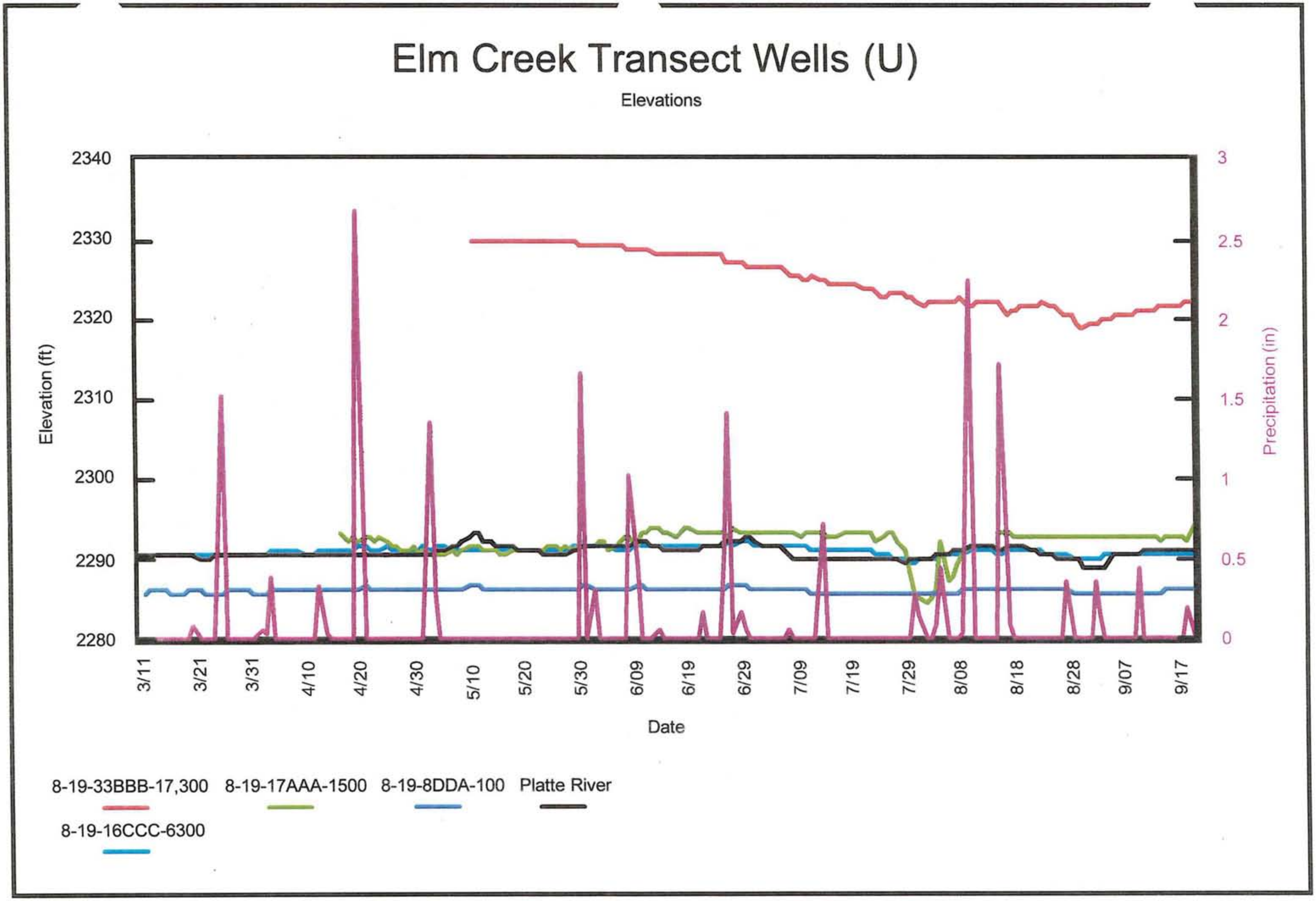


Minden Transect Wells (D)

Elevations
Well #9-14-34BBB - 7700

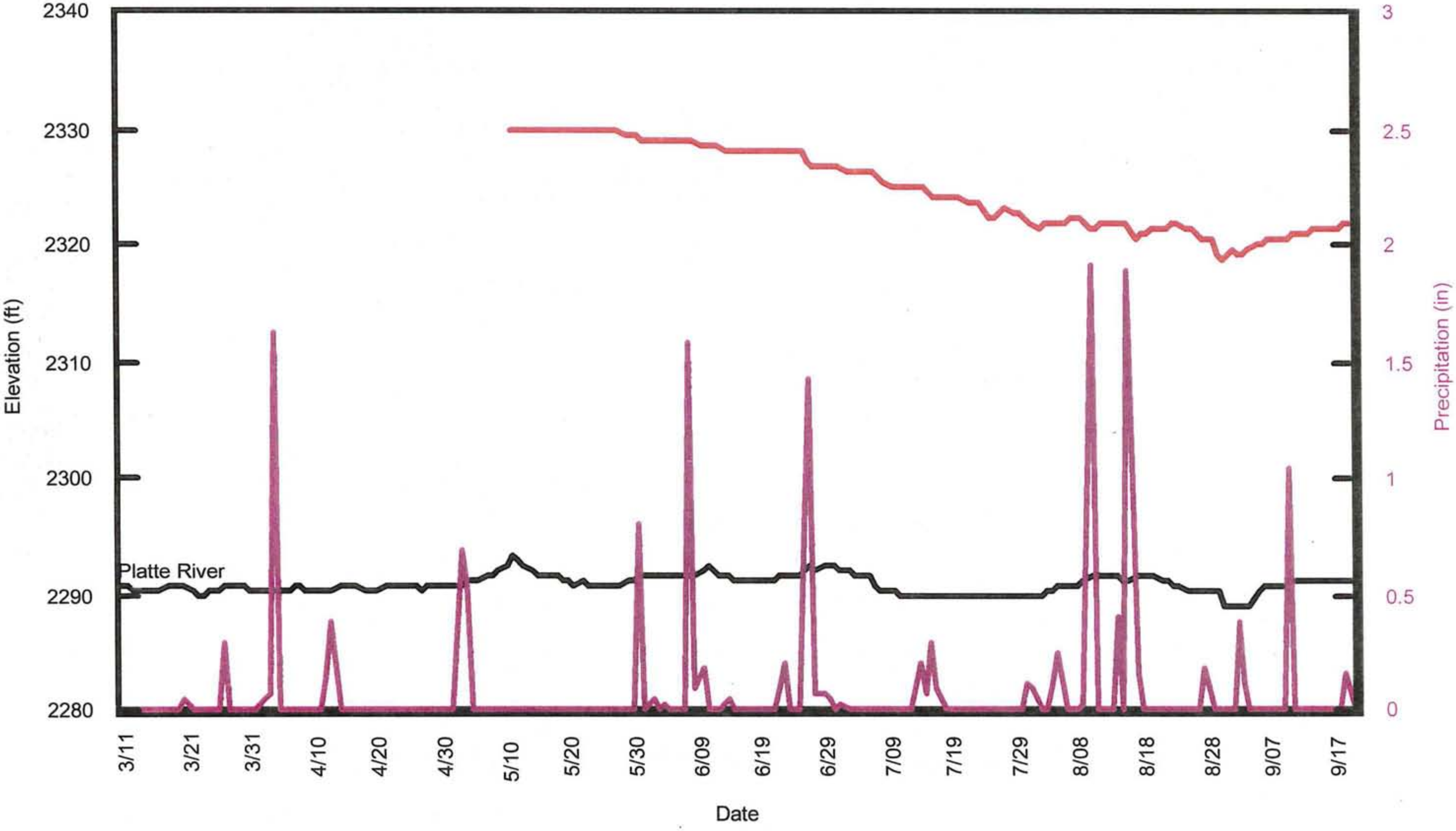


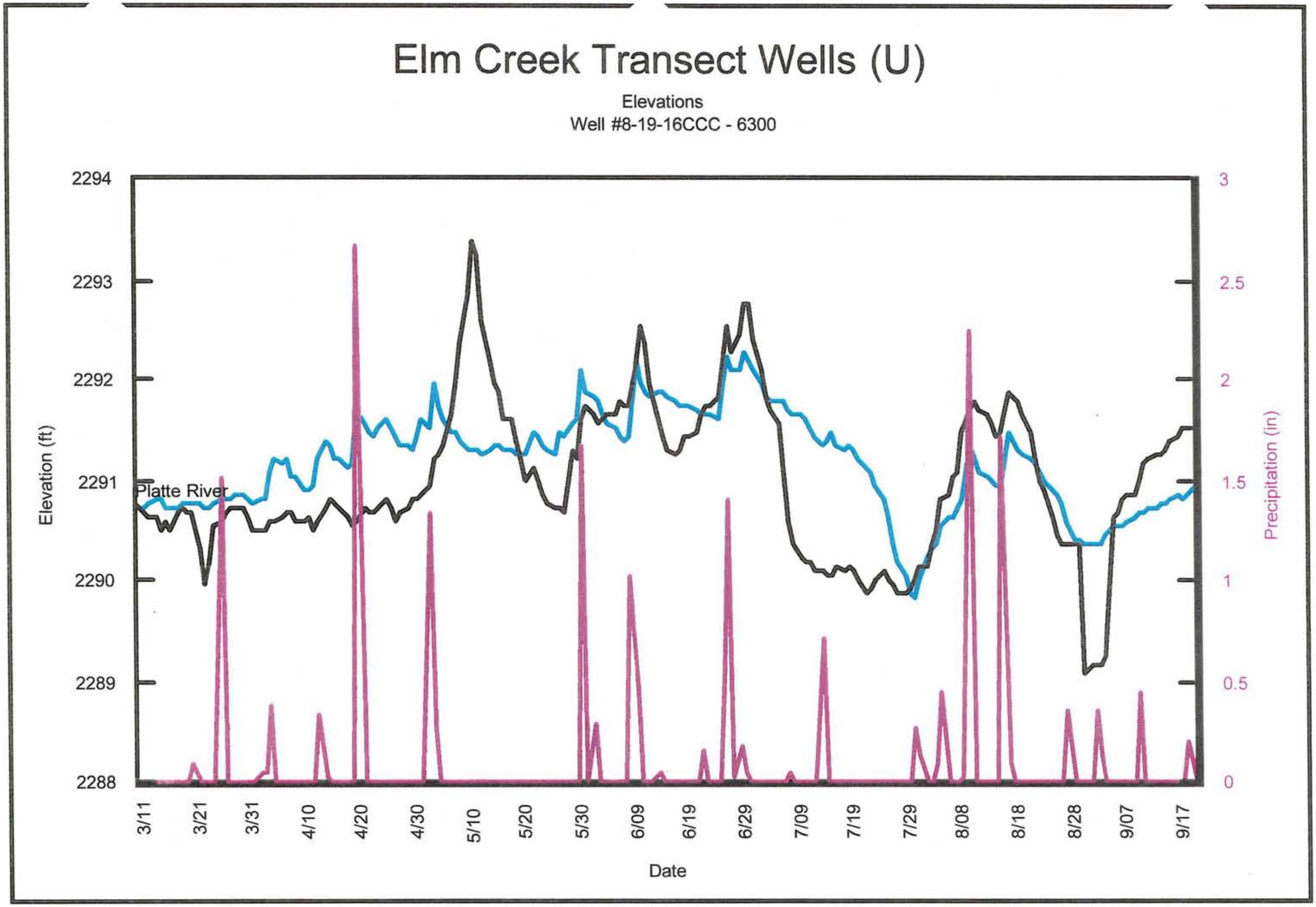

Minden Transect Wells (D)
Elevations
Well #9-14-28AAA - 13,000
Elevation (ft)
2071
2070
2069
2068
2067
2066
2065
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date


Elm Creek Transect Wells (U)
Elevations
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)

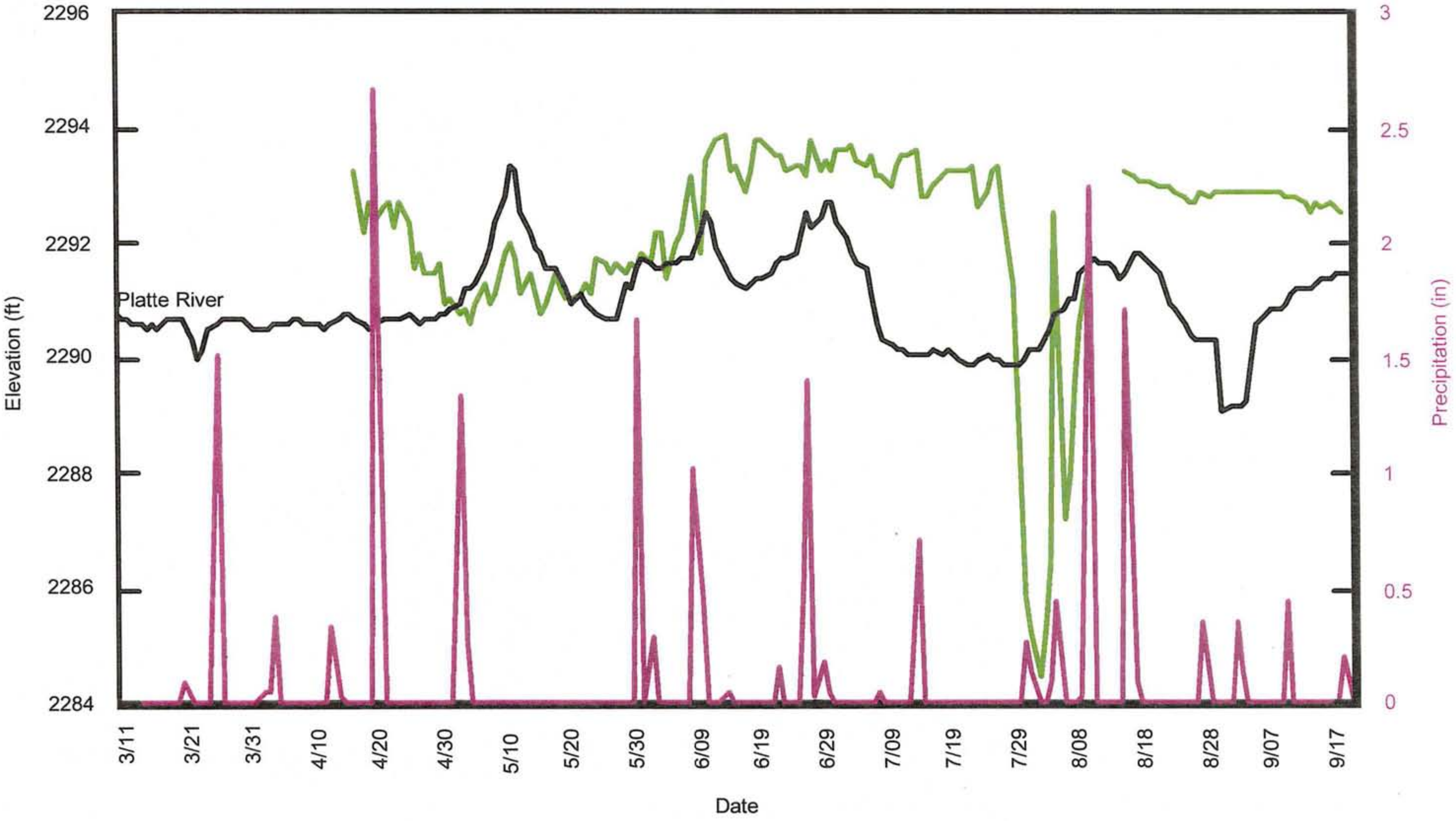
Elevations
Well #8-19-33BBB - 17,300

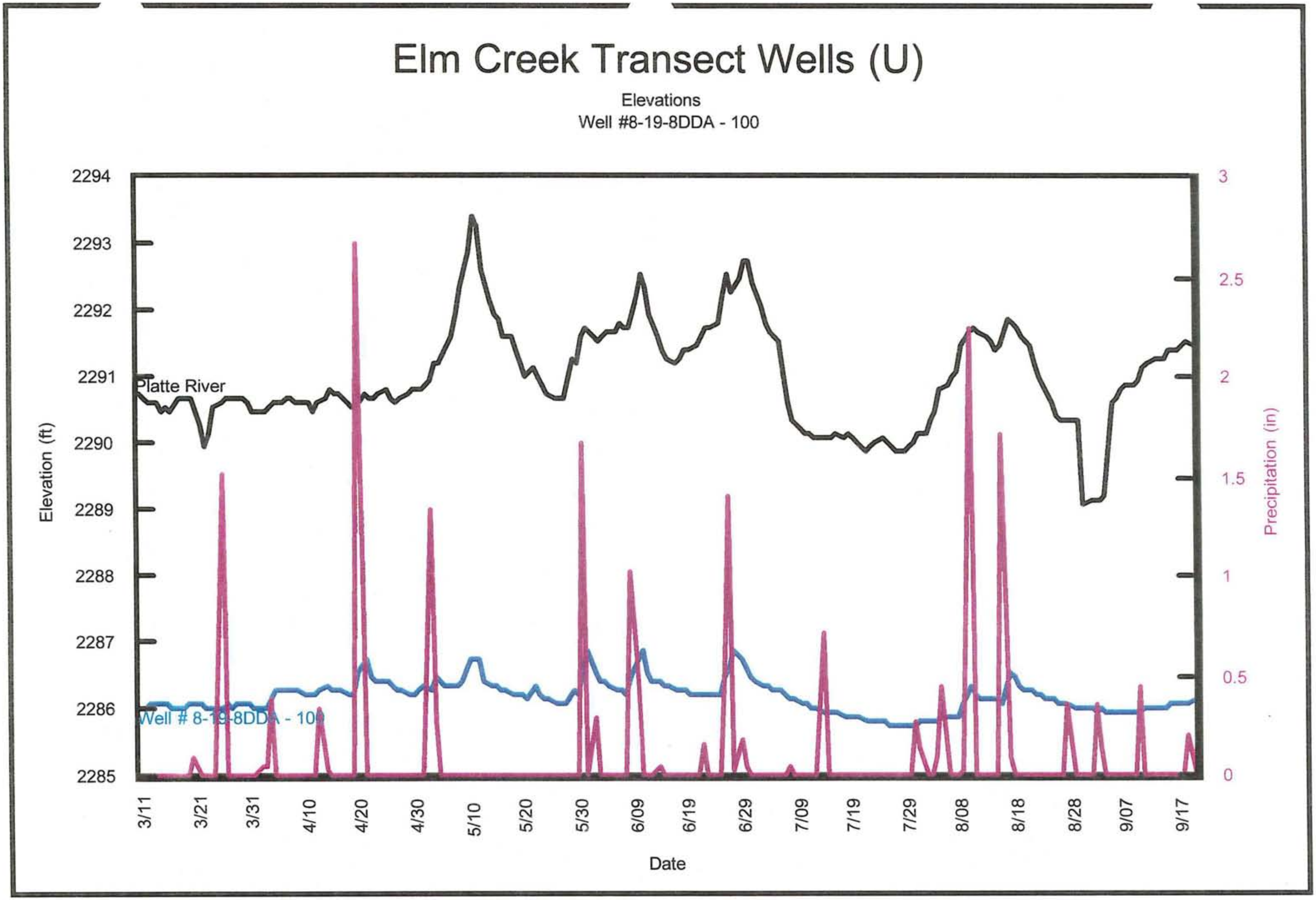


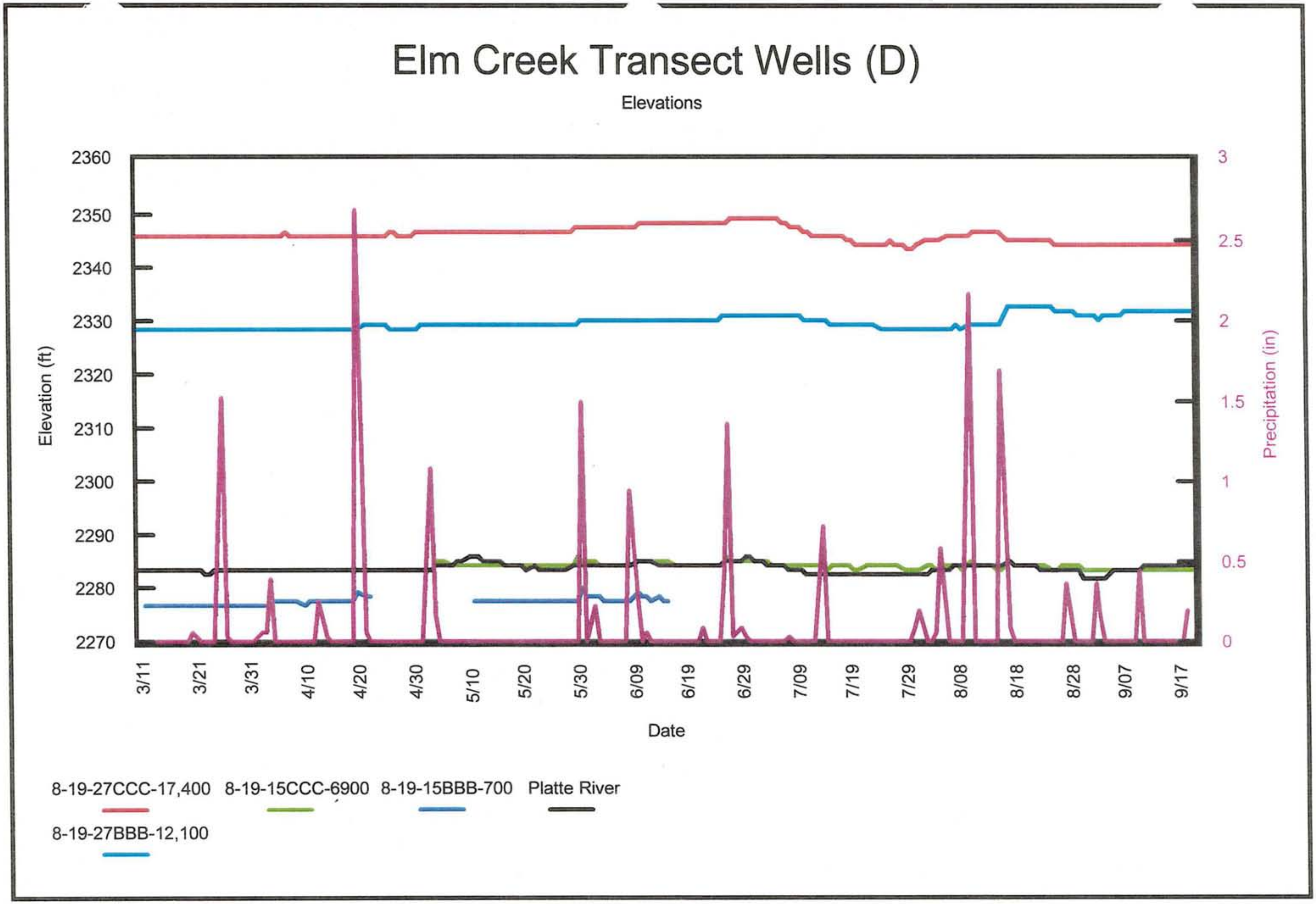

Elm Creek Transect Wells (U)
Elevations
Well #8-19-16CCC - 6300
Elevation (ft)
2294
2293
2292
2291
2290
2289
2288
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date

Elm Creek Transect Wells (U)

Elevations
Well #8-19-17AAA - 1500




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
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



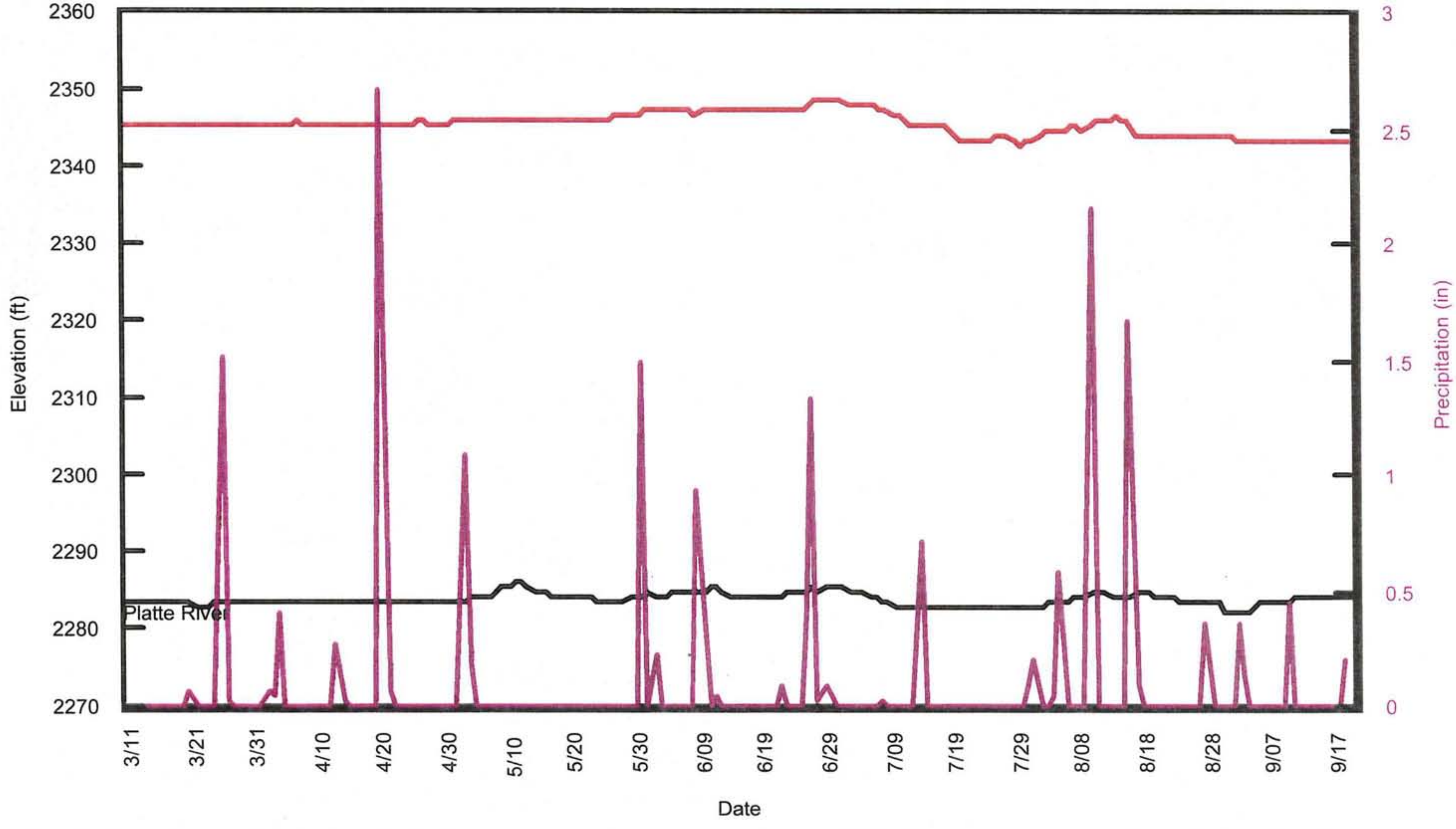
Elm Creek Transect Wells (D)

Elevations

Elm Creek Transect Wells (D)

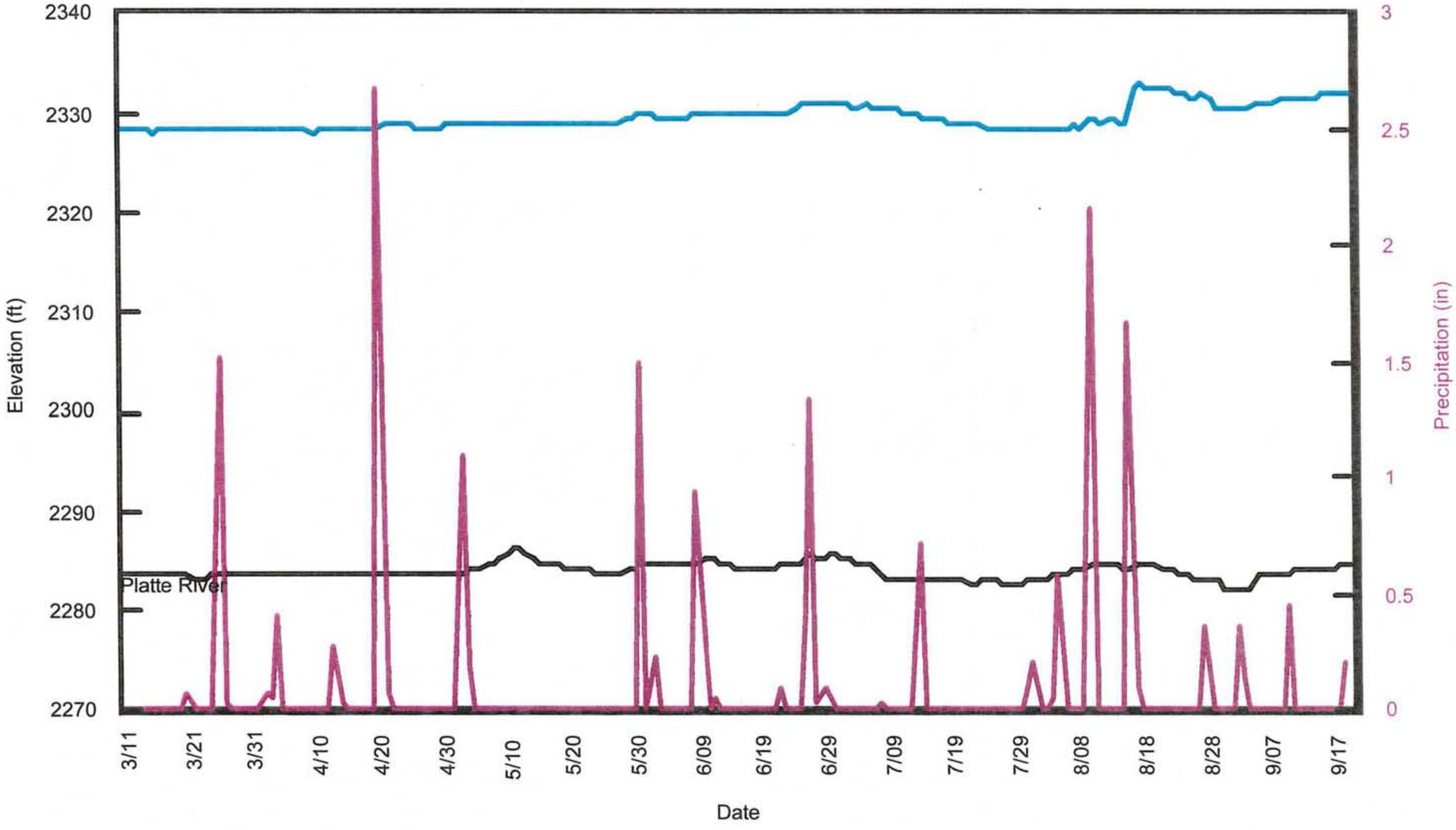
Elevations

Well #8-19-27CCC - 17,400



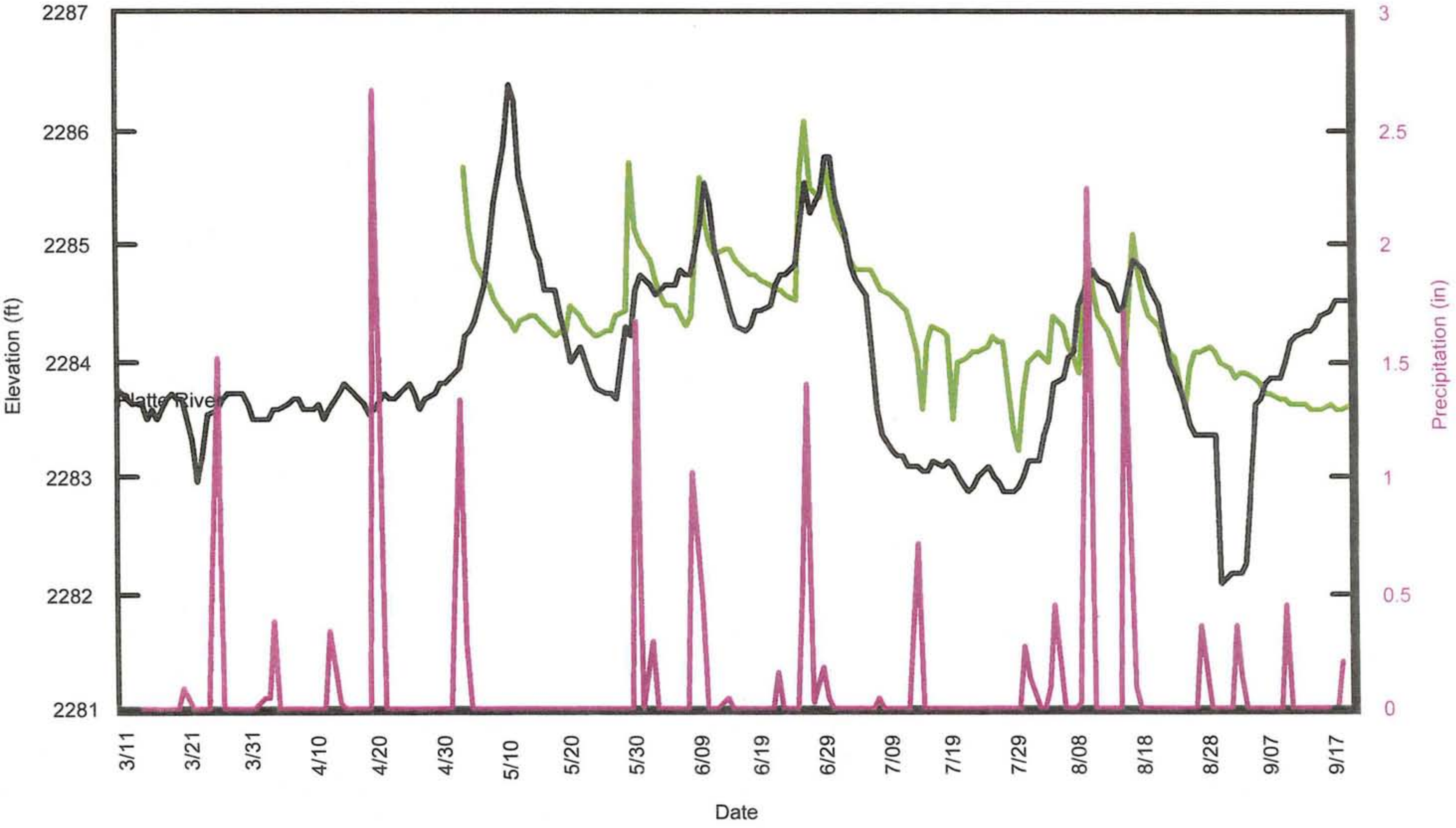
Elm Creek Transect Wells (D)

Elevations
Well #8-19-27BBB - 12,100



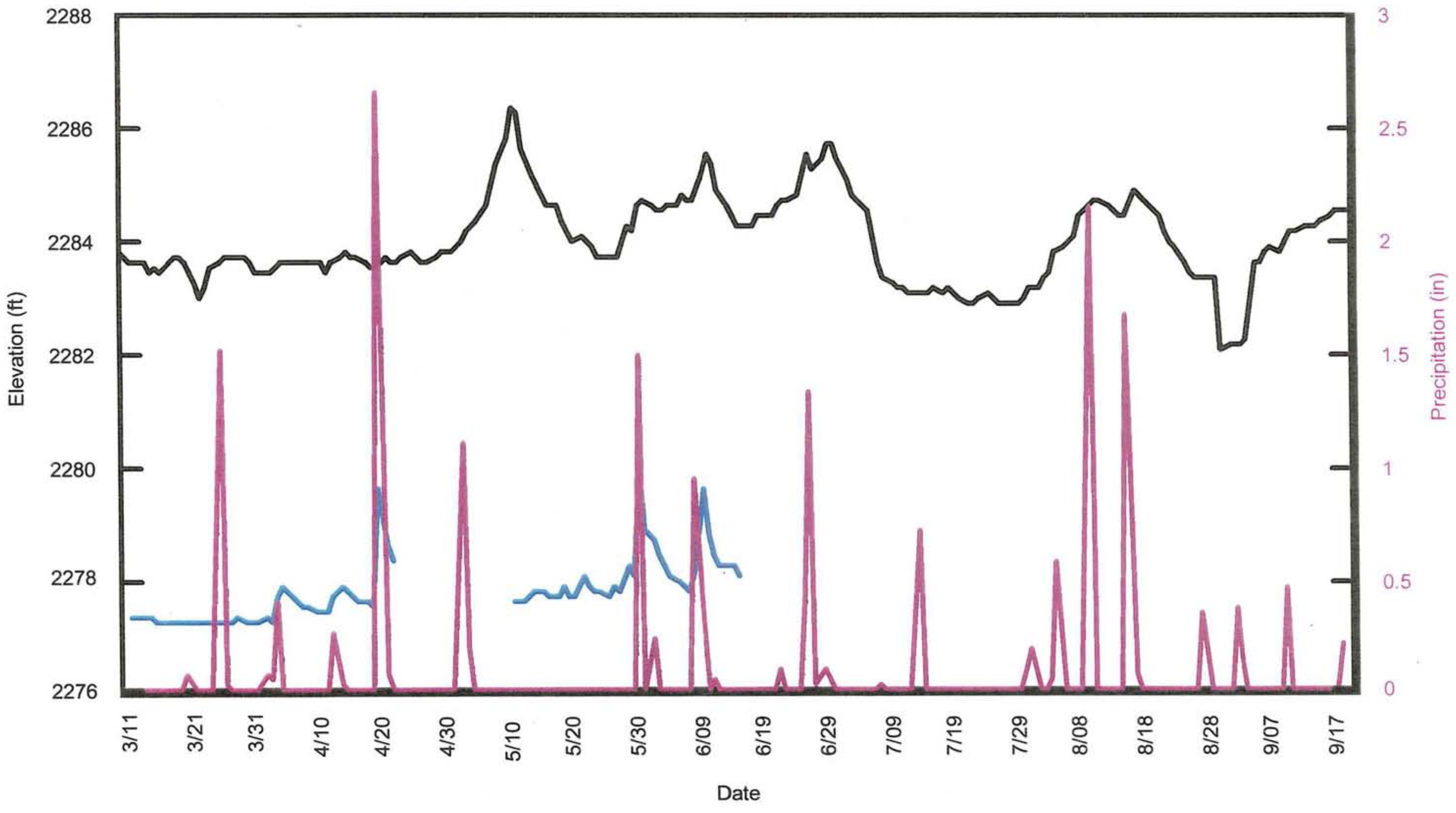
Elm Creek Transect Wells (D)

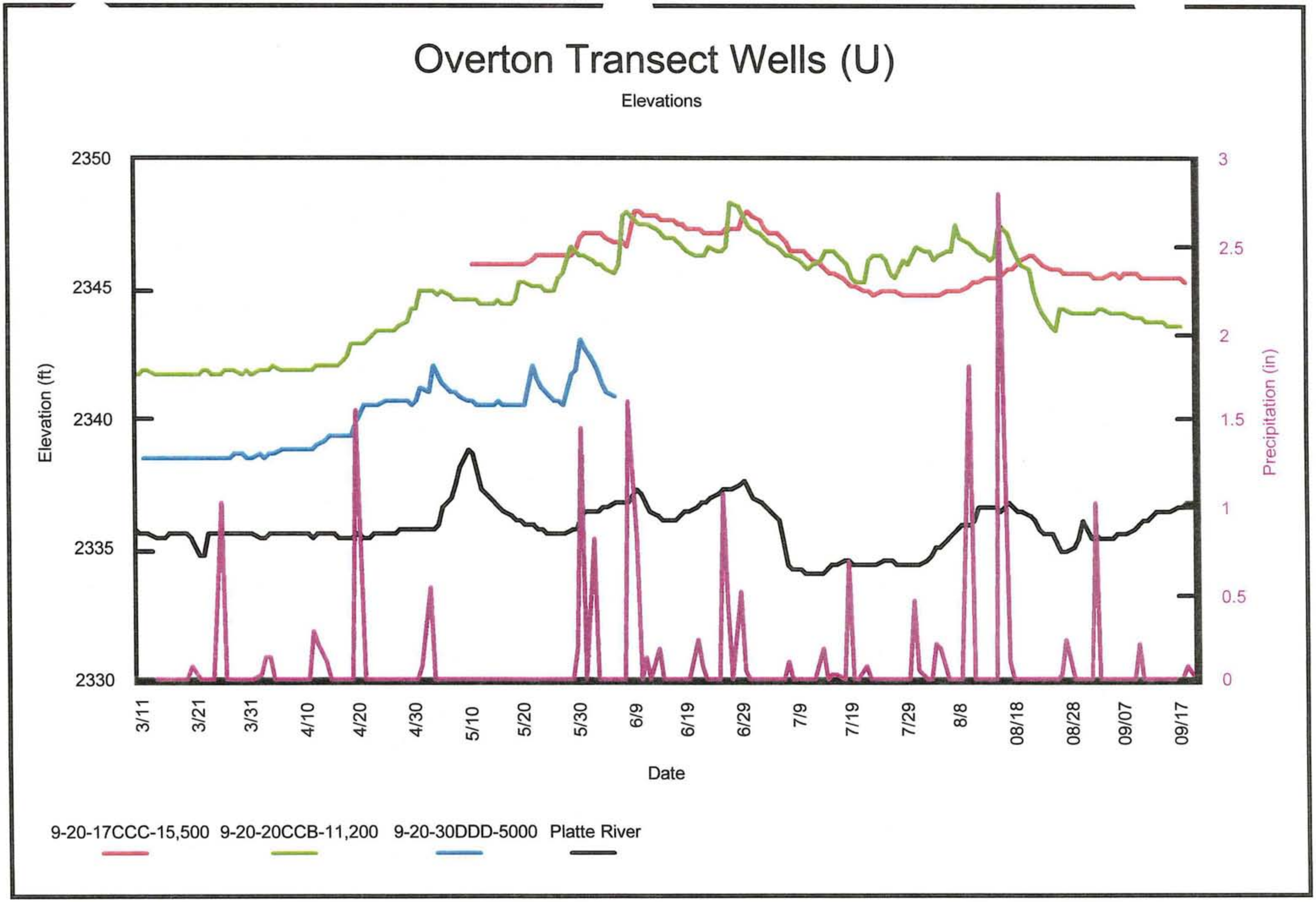
Elevations
Well #8-19-15CCC - 6900



Elm Creek Transect Wells (D)

Elevations
Well #8-19-15BBB - 700





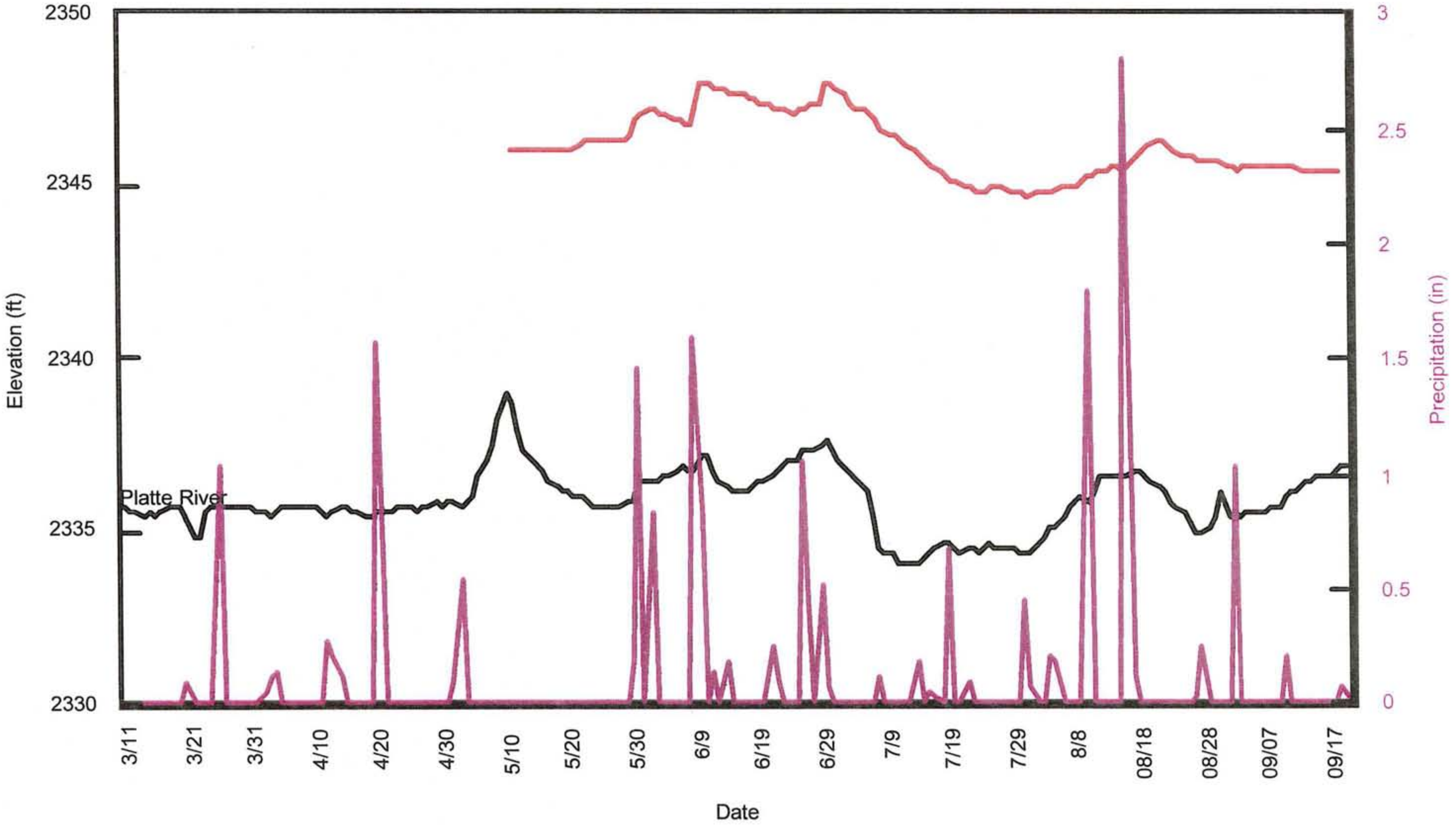
Overton Transect Wells (U)

Elevations

Overton Transect Wells (U)

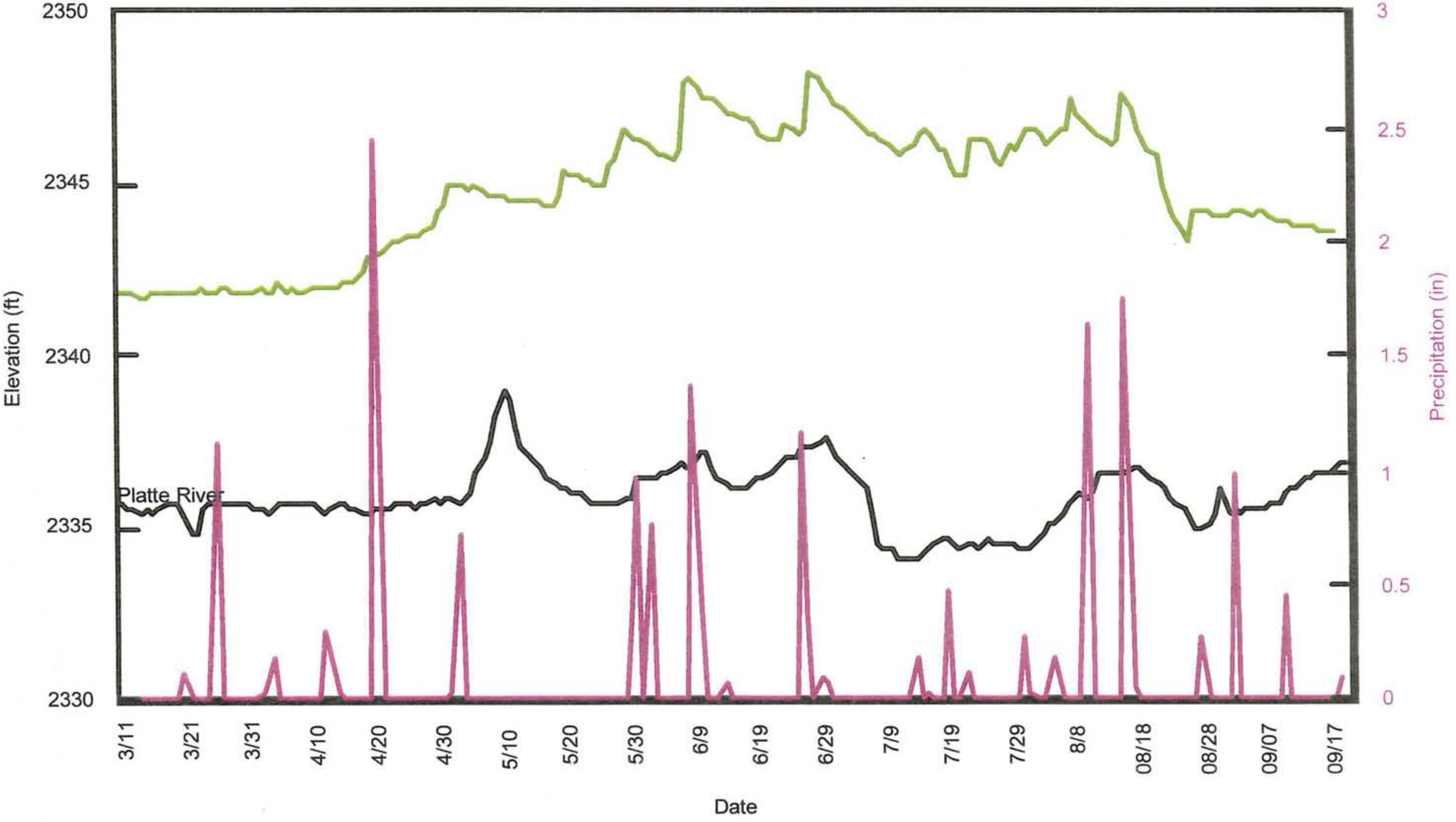
Elevations

WEll #9-20-17CCC - 15,500



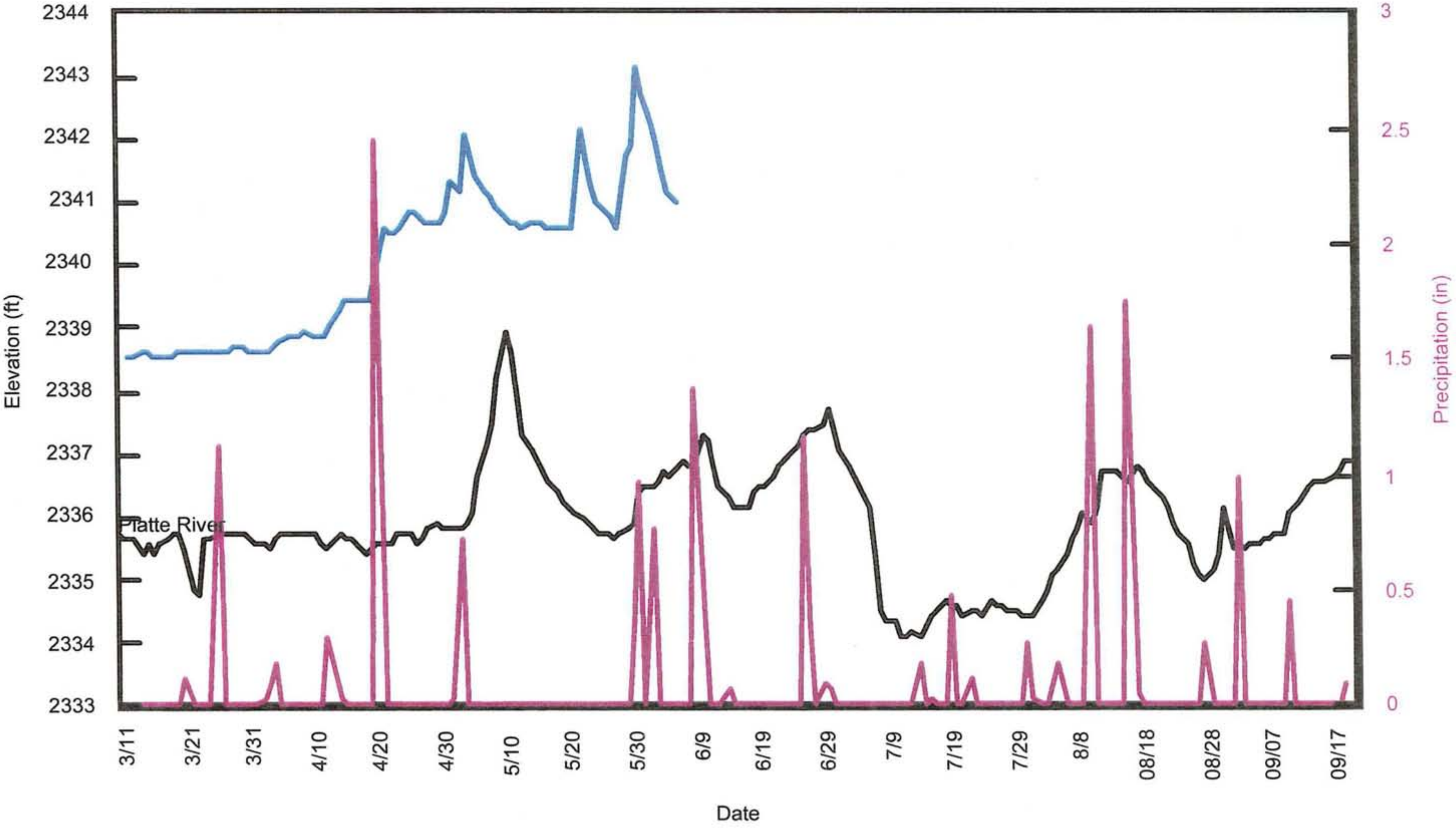
Overton Transect Wells (U)

Elevations
Well #9-20-20CCB - 11,200



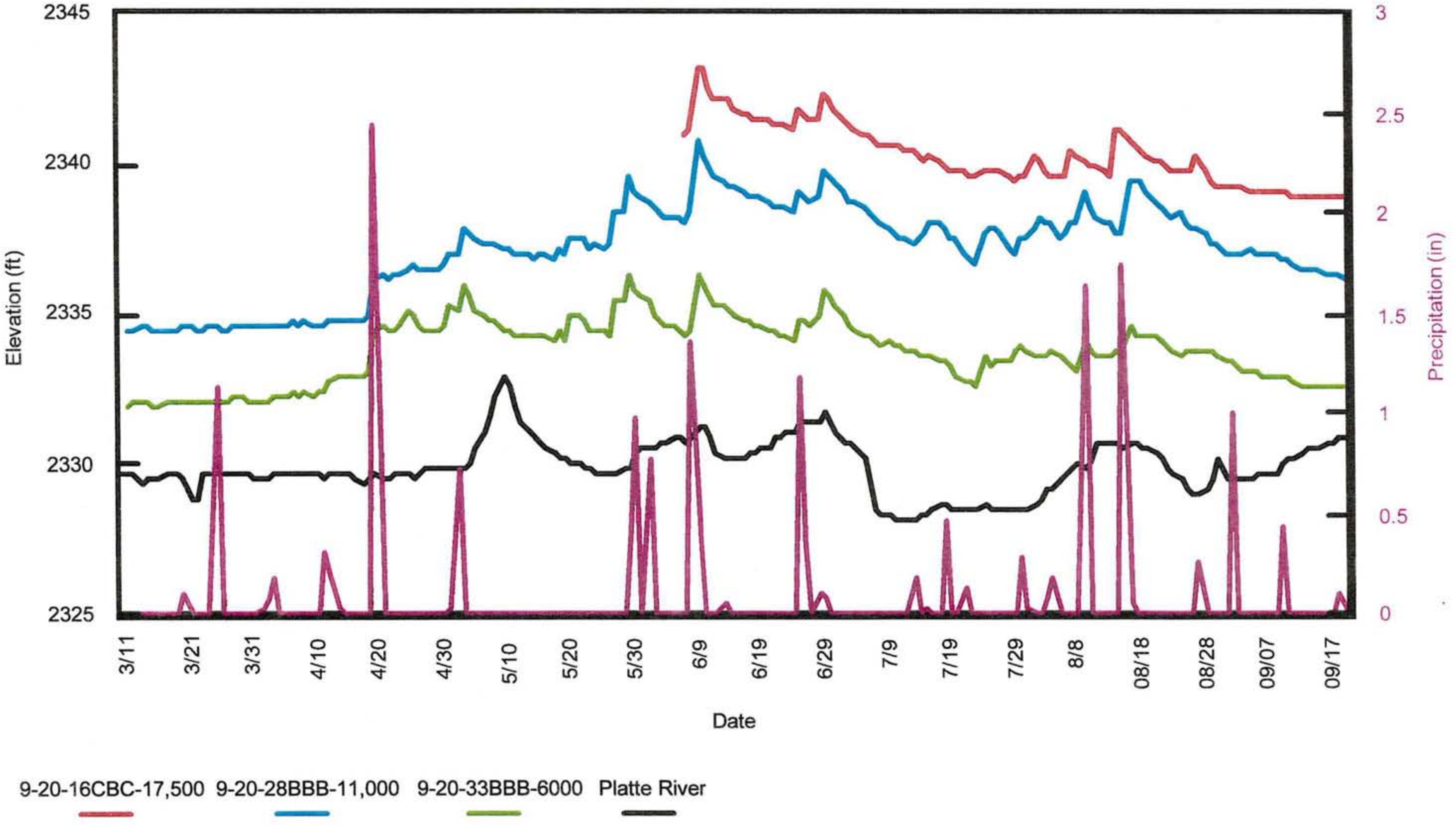
Overton Transect Wells (U)

Elevations
Well #9-20-30DDD - 5000



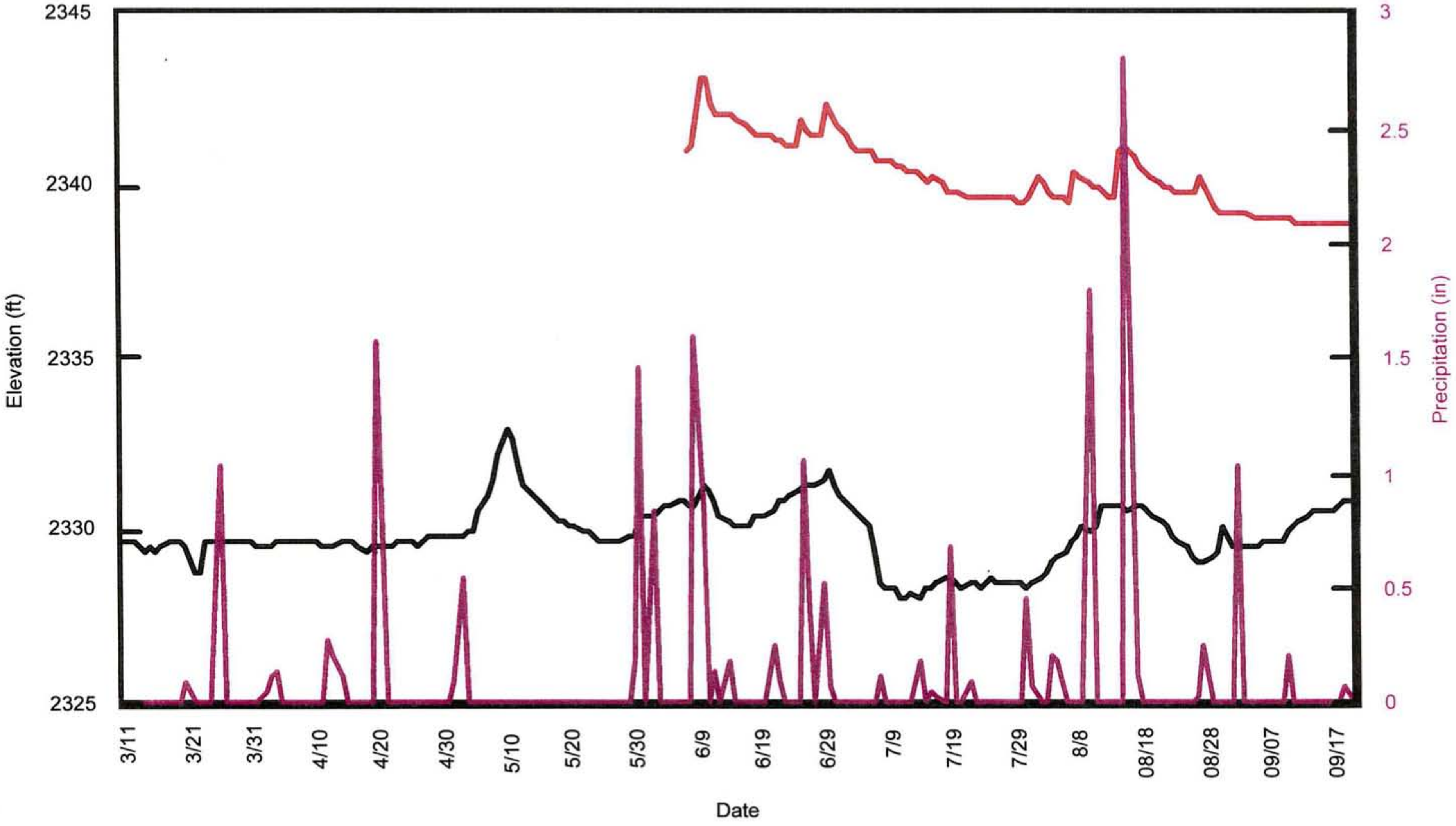
Oveton Transect Wells (D)

Elevations



Oveton Transect Wells (D)

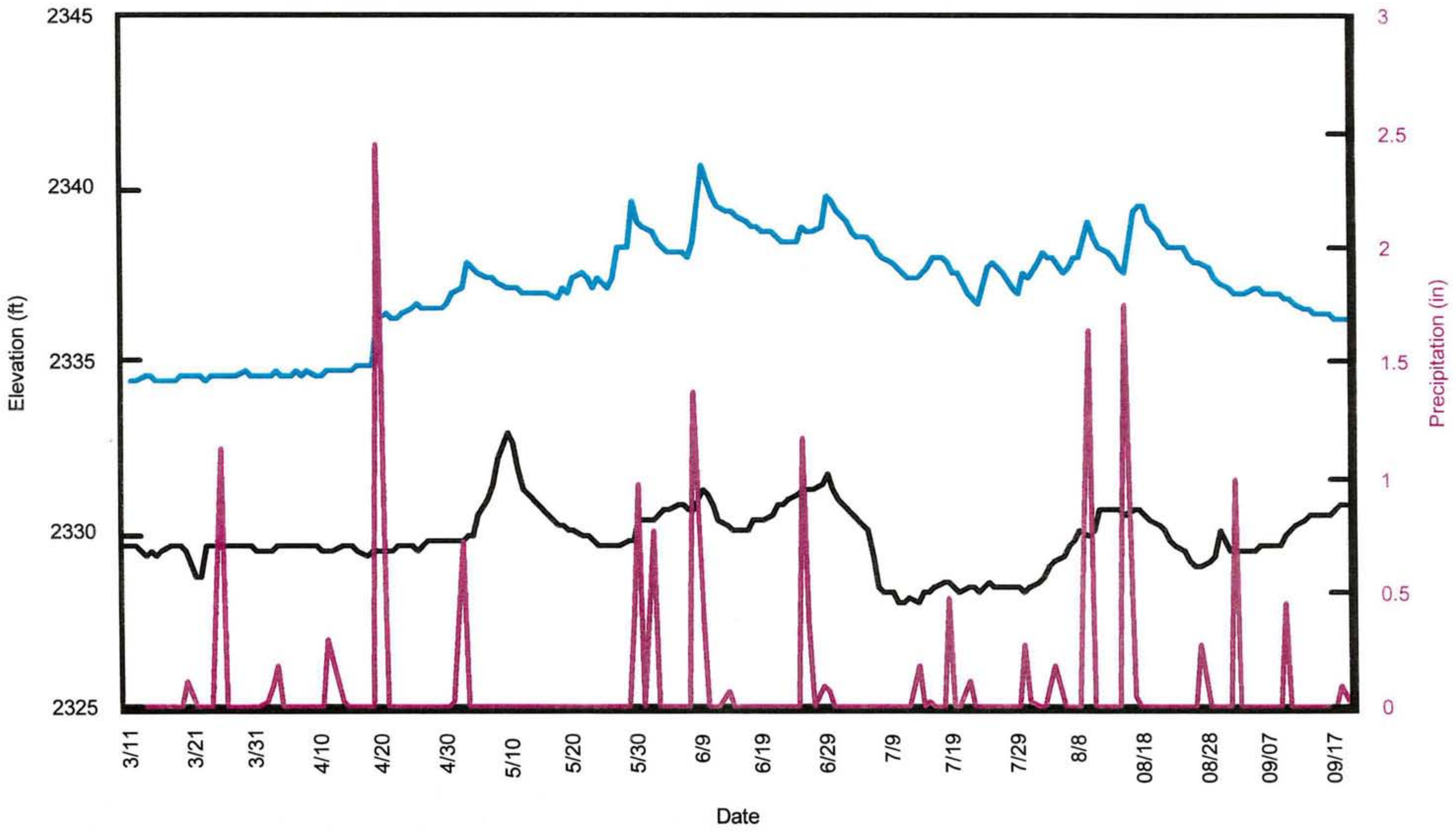
Elevations
Well #9-20-16CBC - 17,500



Oveton Transect Wells (D)

Elevations

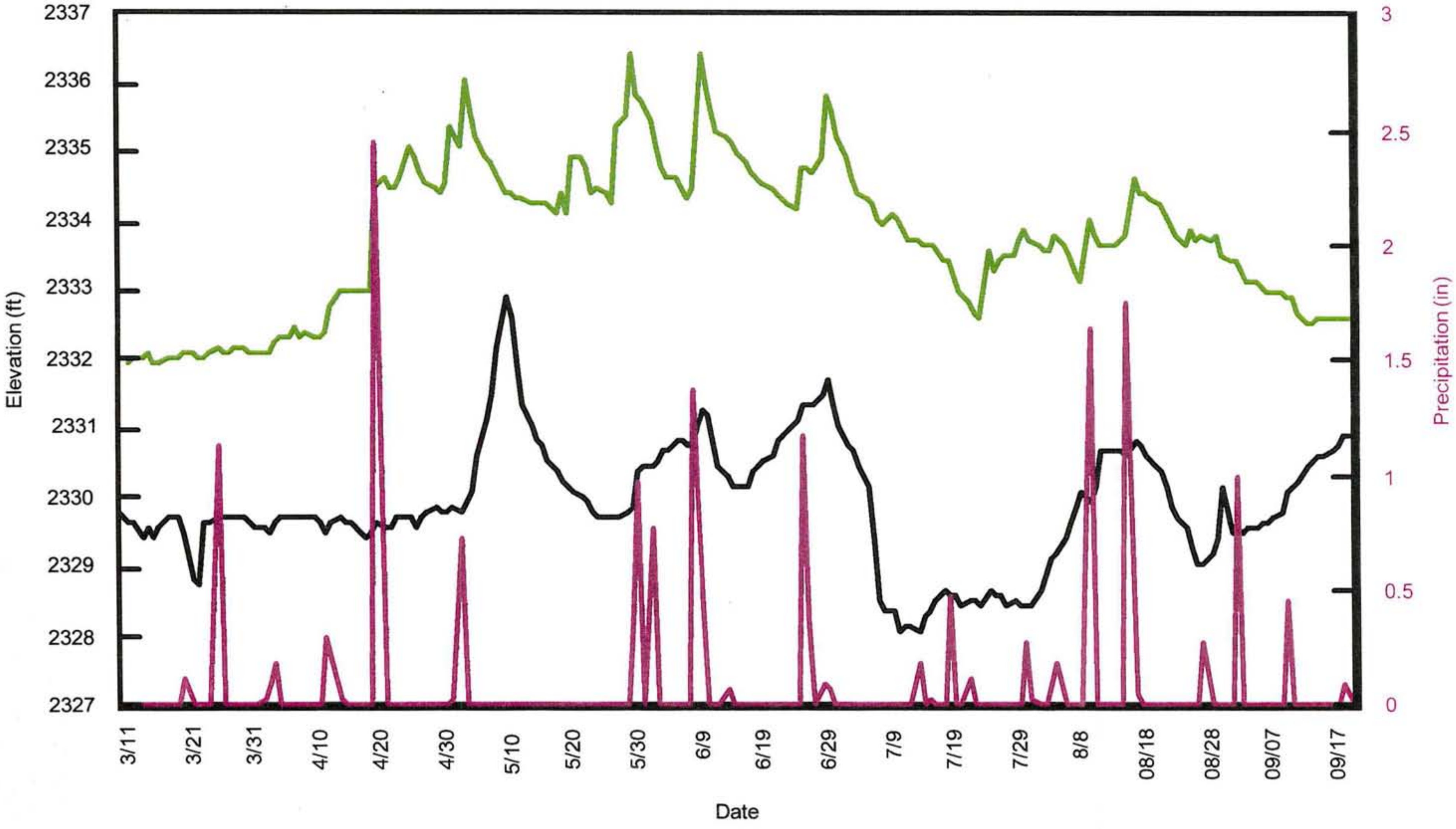
Well #9-20-28BBB - 11,000



Oveton Transect Wells (D)

Elevations

Well #9-20-33BBB - 6000



APPENDIX G

SOURCE INFORMATION ON PRECIPITATION DATA

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. Location of the cells representing all of the monitored wells.

2-5. Location of the cells for each transect of wells showing sample precipitation data.

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.

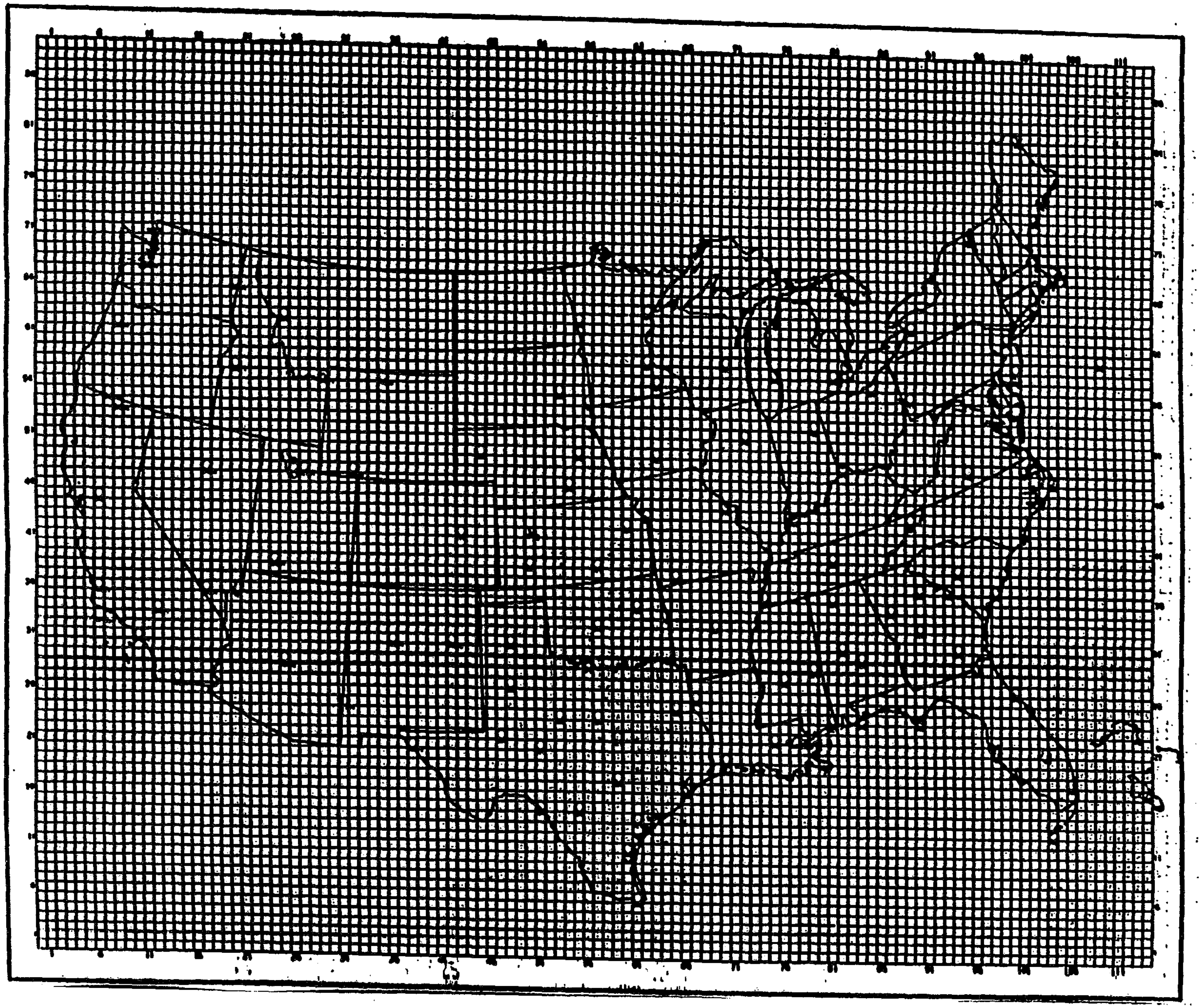
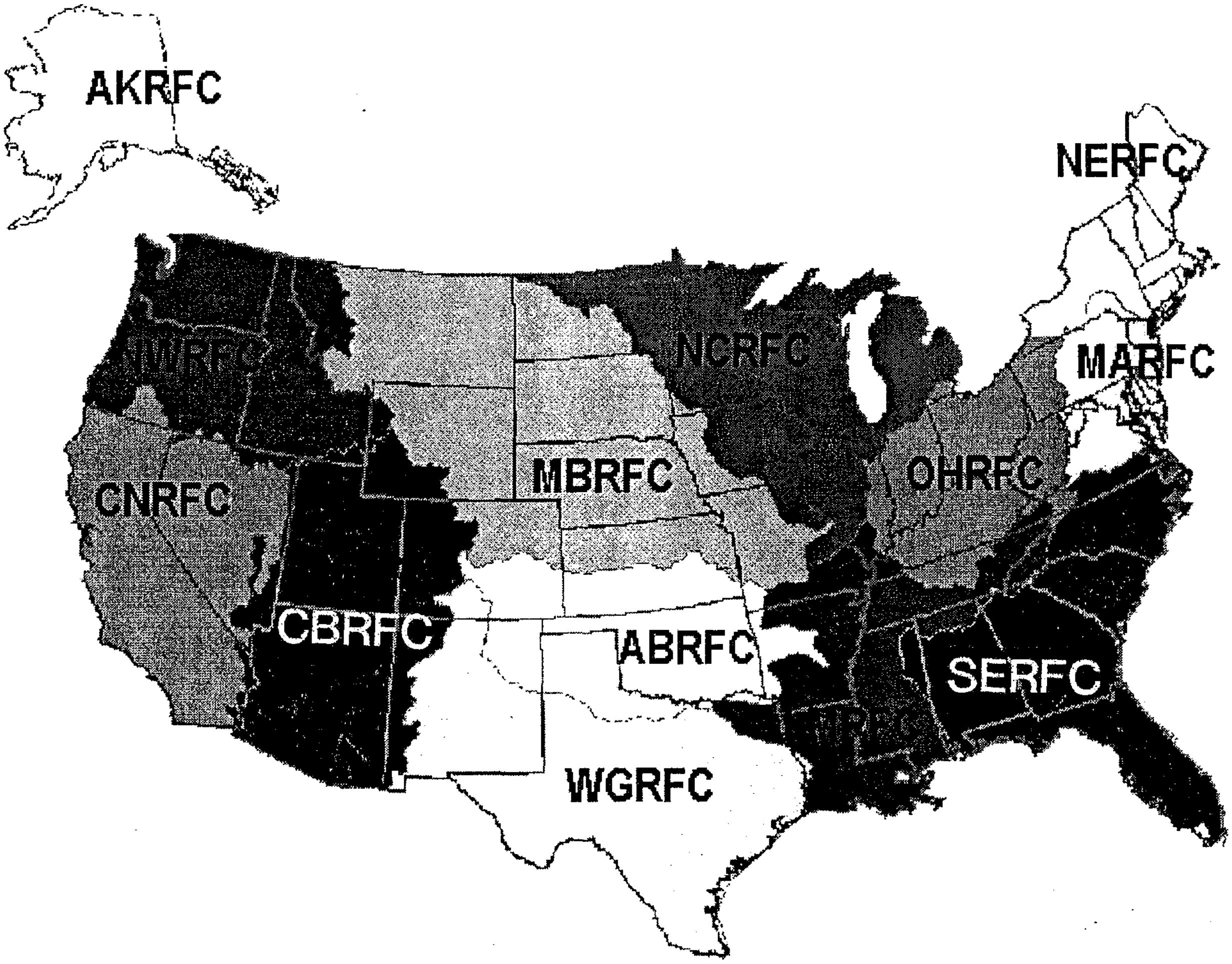


Figure 1. - NWS Manually Digitized Radar (MDR) box location map of the United States.


AKRFC
NERFC
NWRFC
NCRFC
MARFC
MBRFC
OHRFC
CNRFC
CBRFC
ABRFC
SERFC
MRFC
WGRFC

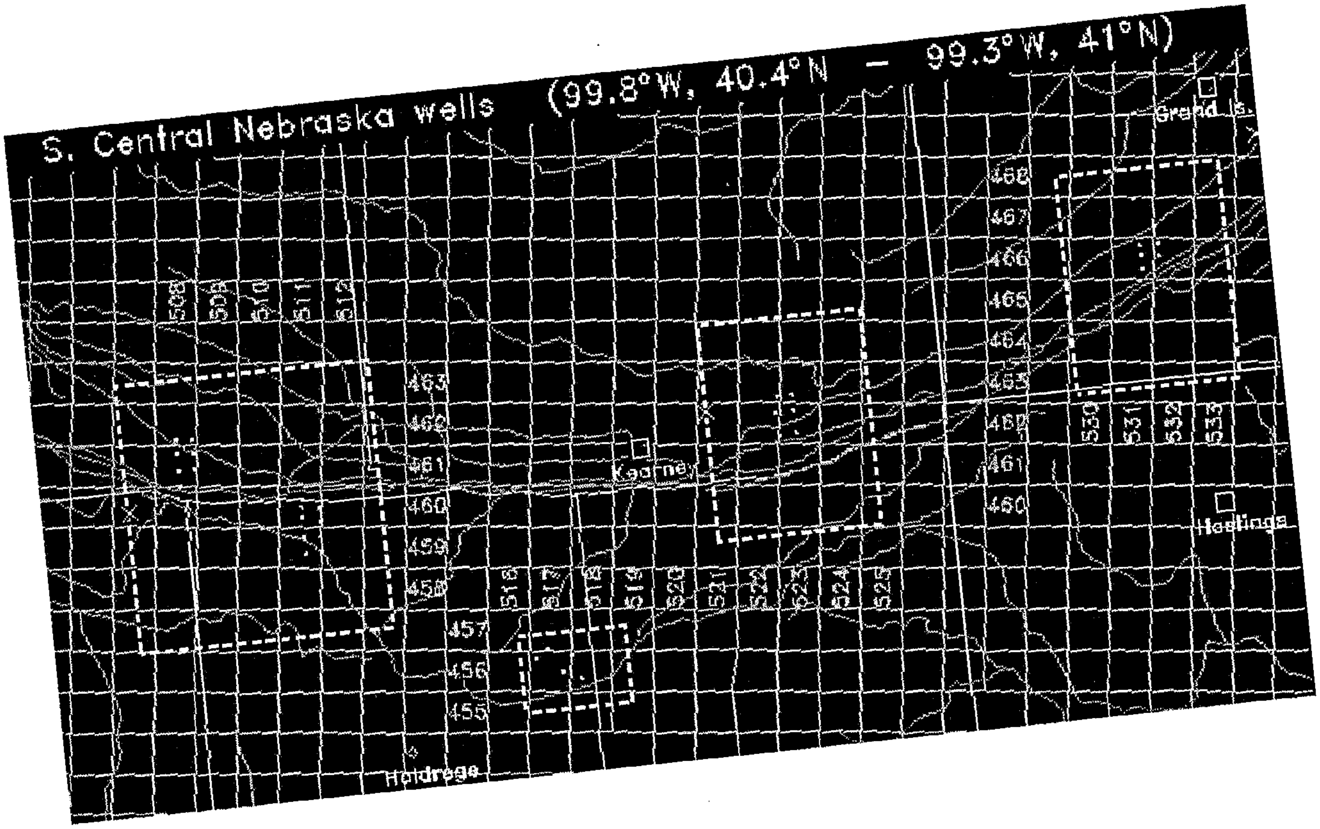


Figure 3. The three larger boxes are the location of the monitoring wells in this study. The numbers show the HRAP numbering system for the grid cells. The "Xs" mark the location of the National Weather stations.

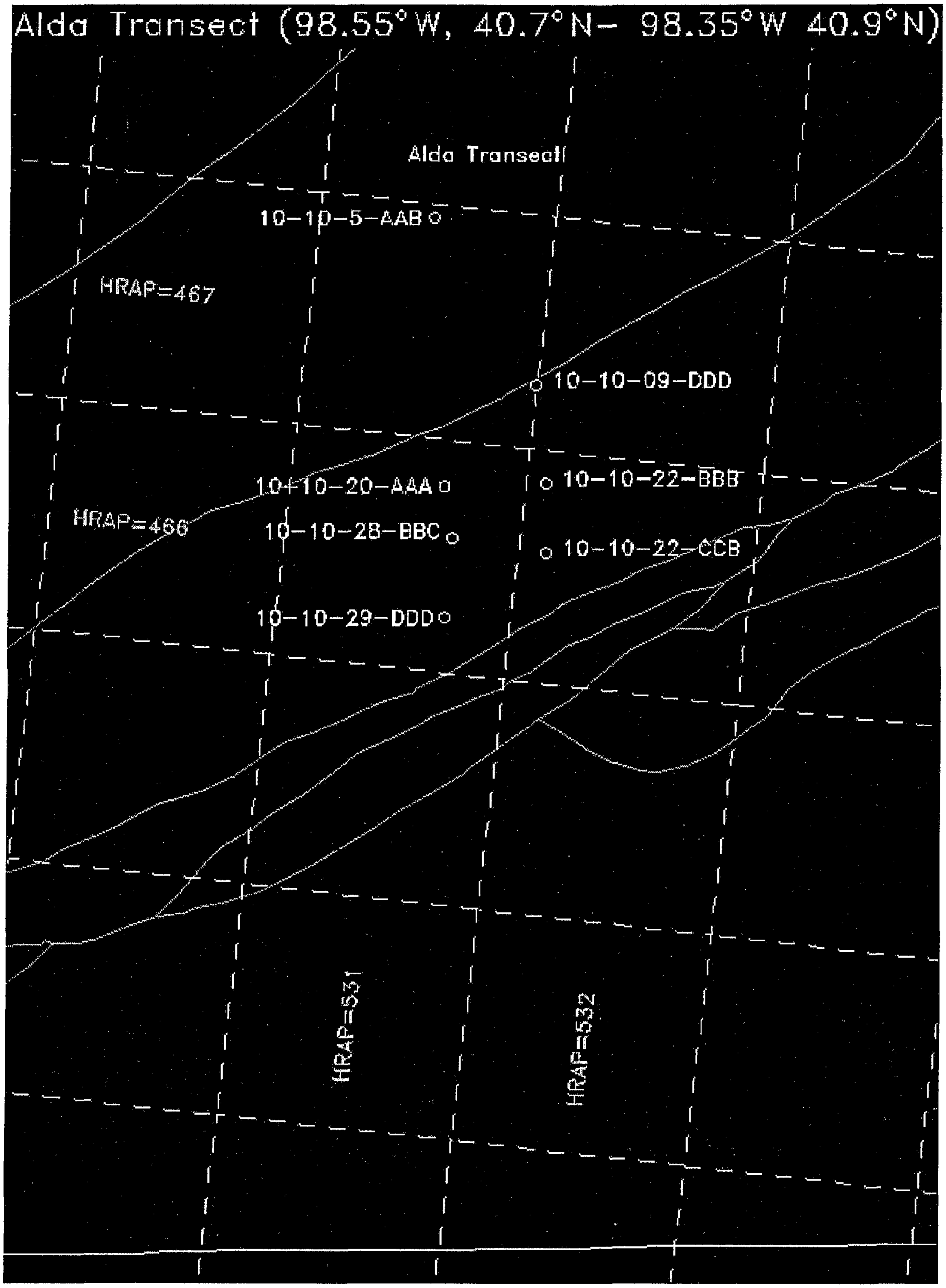


Figure 4. The wells in the Alda transect on the HRAP grid cell system.

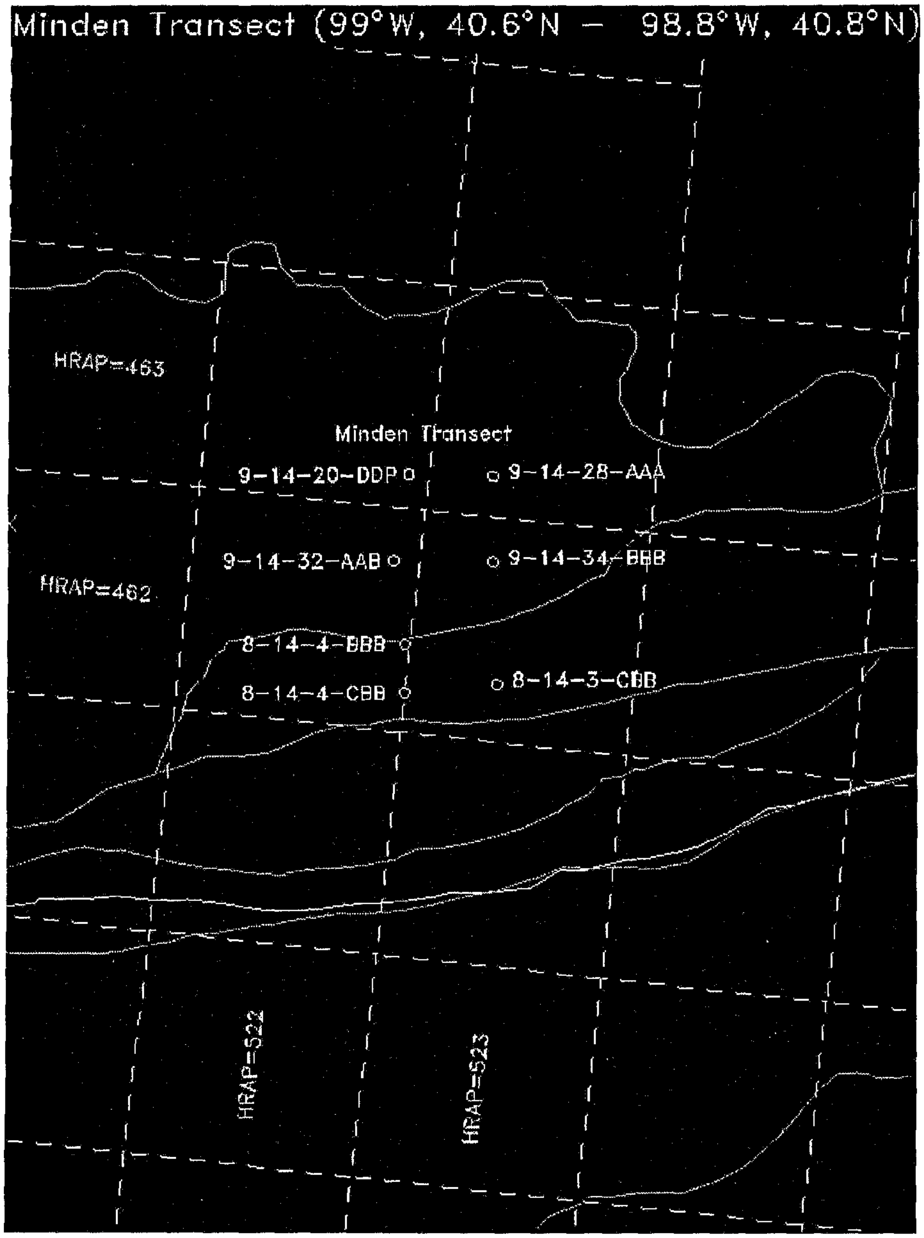


Figure 5. Wells in the Minden transect on the HRAP grid cell system.

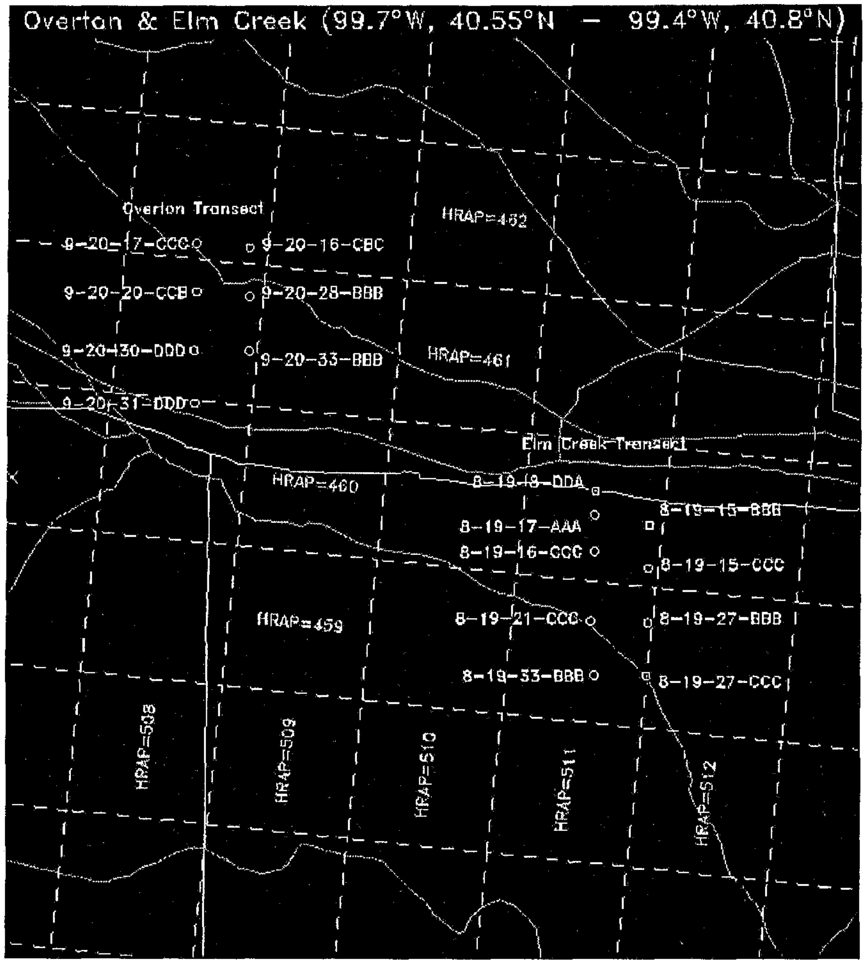


Figure 6. Wells in the Elm Creek and Overton transects on the HRAP grid cell system.

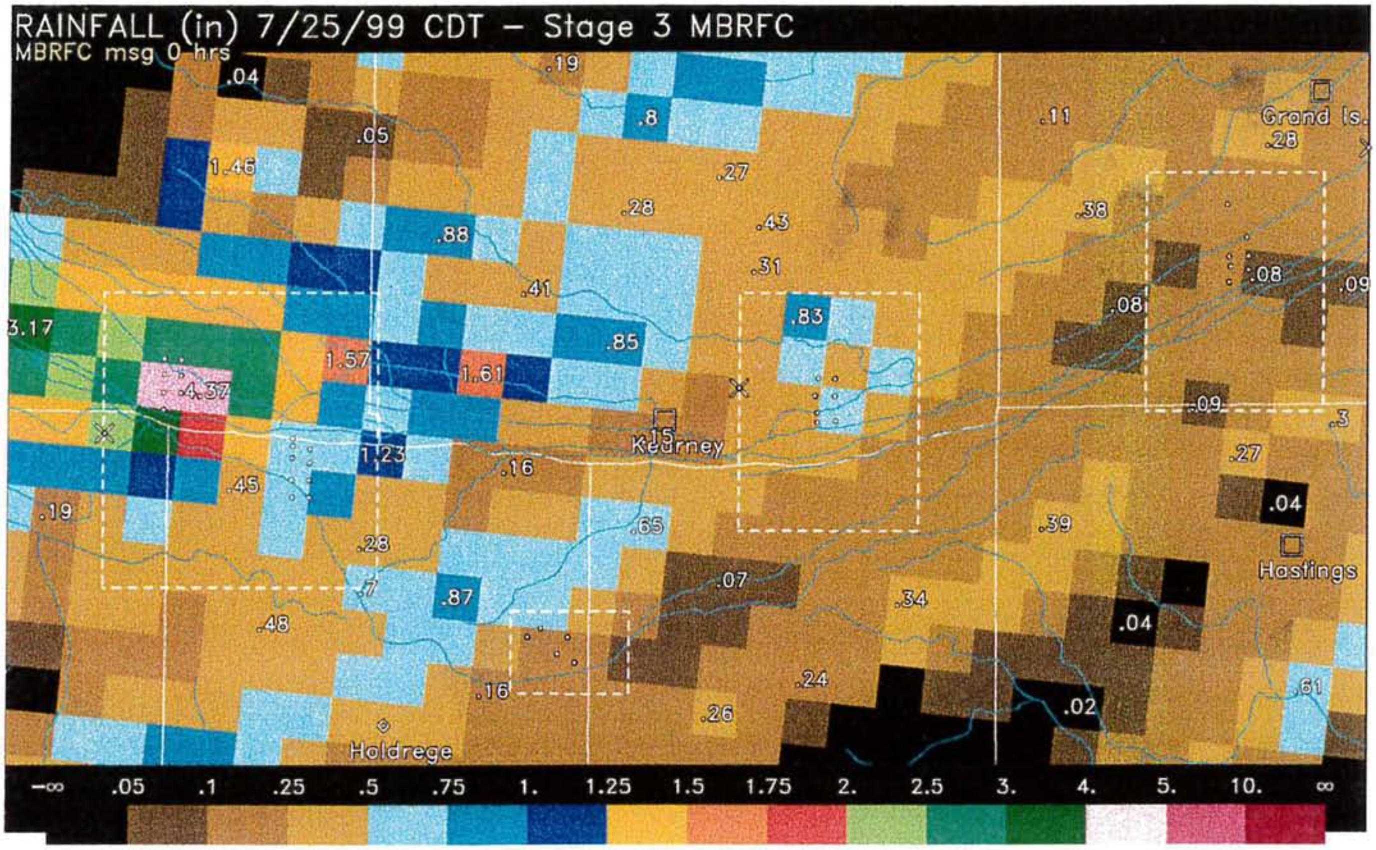


Figure 7. - Rainfall for the wells on July 25, 1999, one of the wettest days of 1999 in this area.

APPENDIX H

YEAR 2000 MONITORING RESULTS

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.

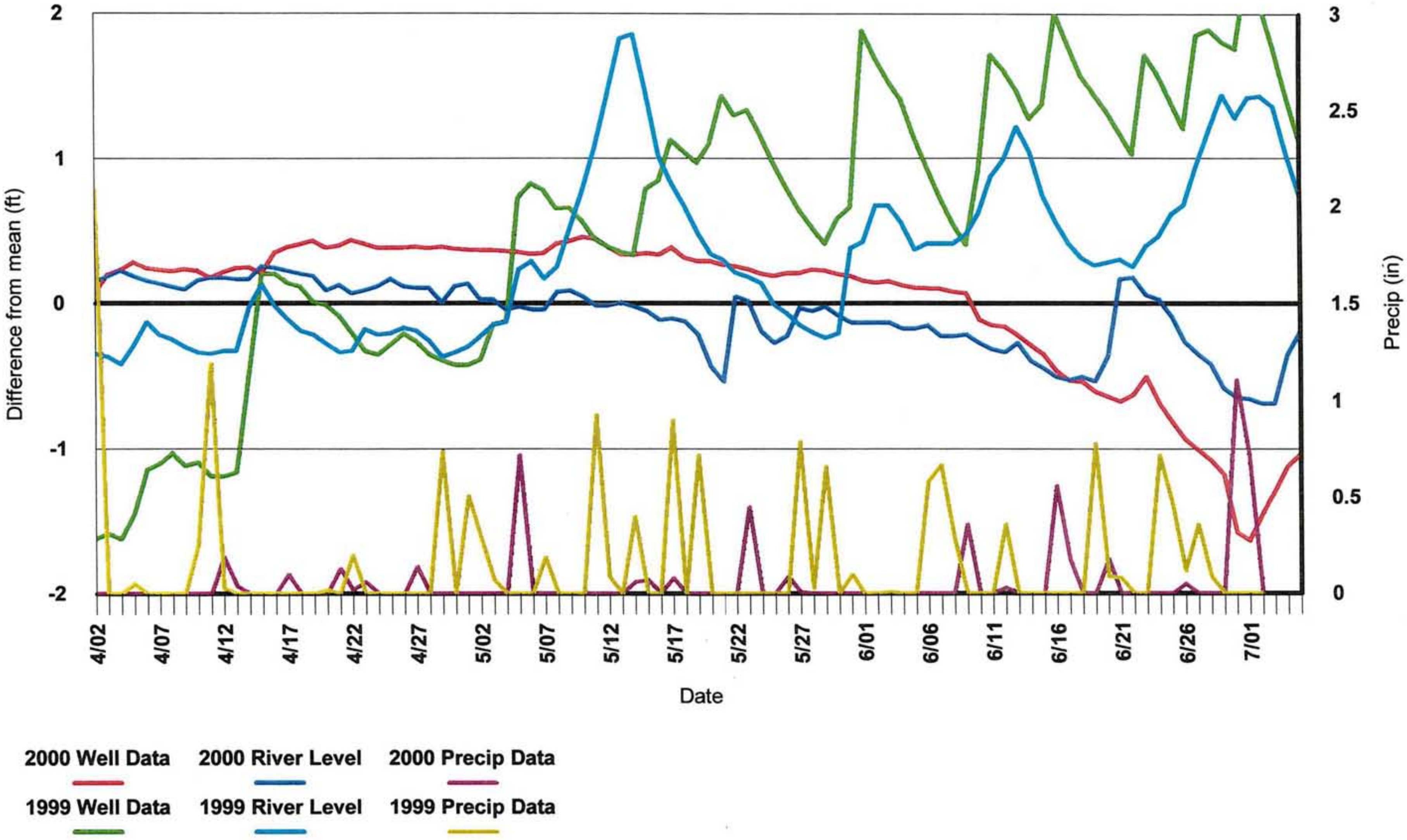
The hydrographs contained in this appendix show the relative elevations of each well and the river at the transect location. The NEXRAD precipitation estimate is included on each hydrograph. Wells that were monitored in 1999 and 2000 have the 1999 data shown along with the respective river elevations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

Well #10-10-28BBC

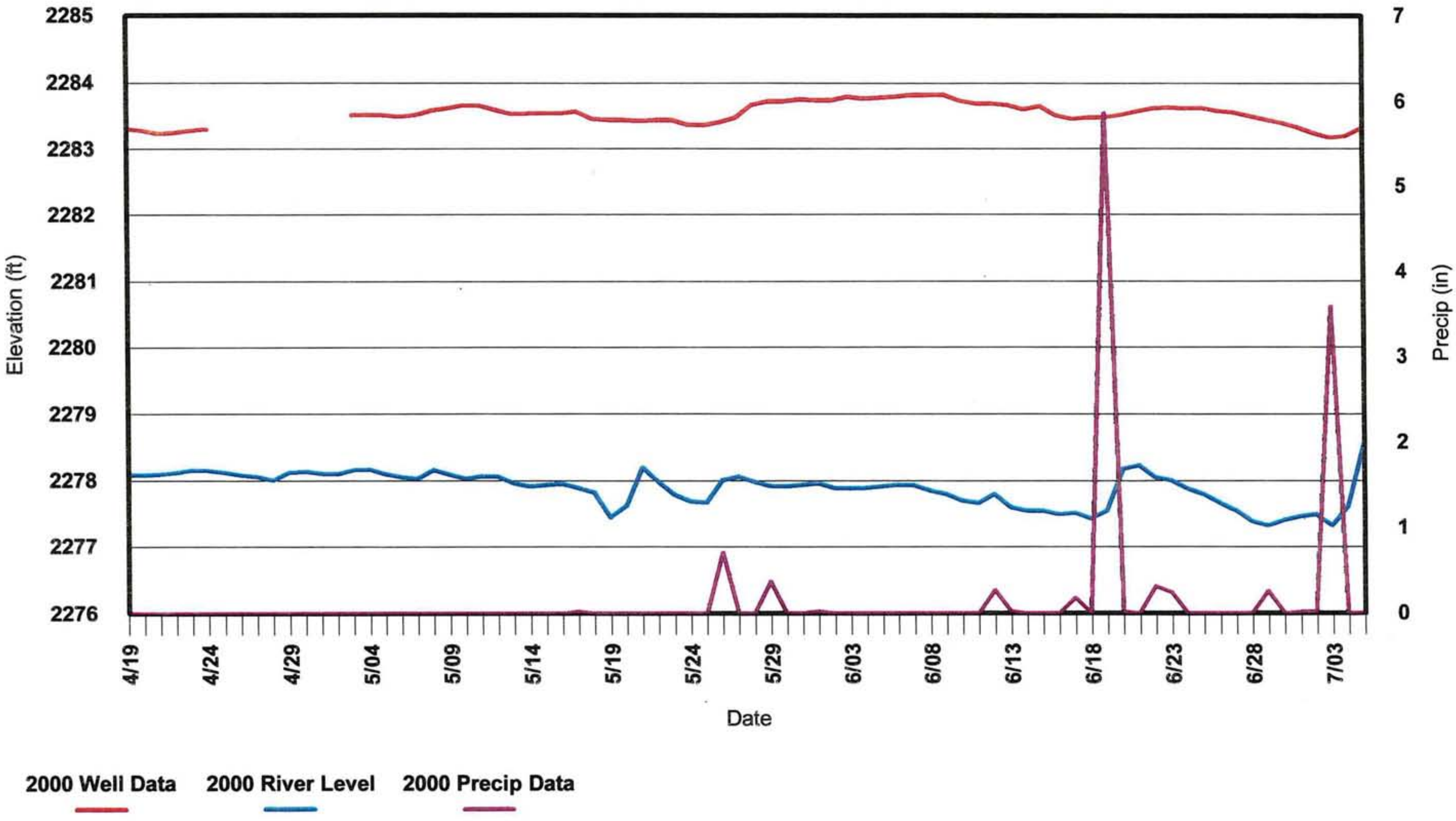
Alda Transect - 3,000 Feet from River

Difference from Mean



Well #9-19-34BAA

Elm Creek DownstreamTransect - 7,000 Feet from River

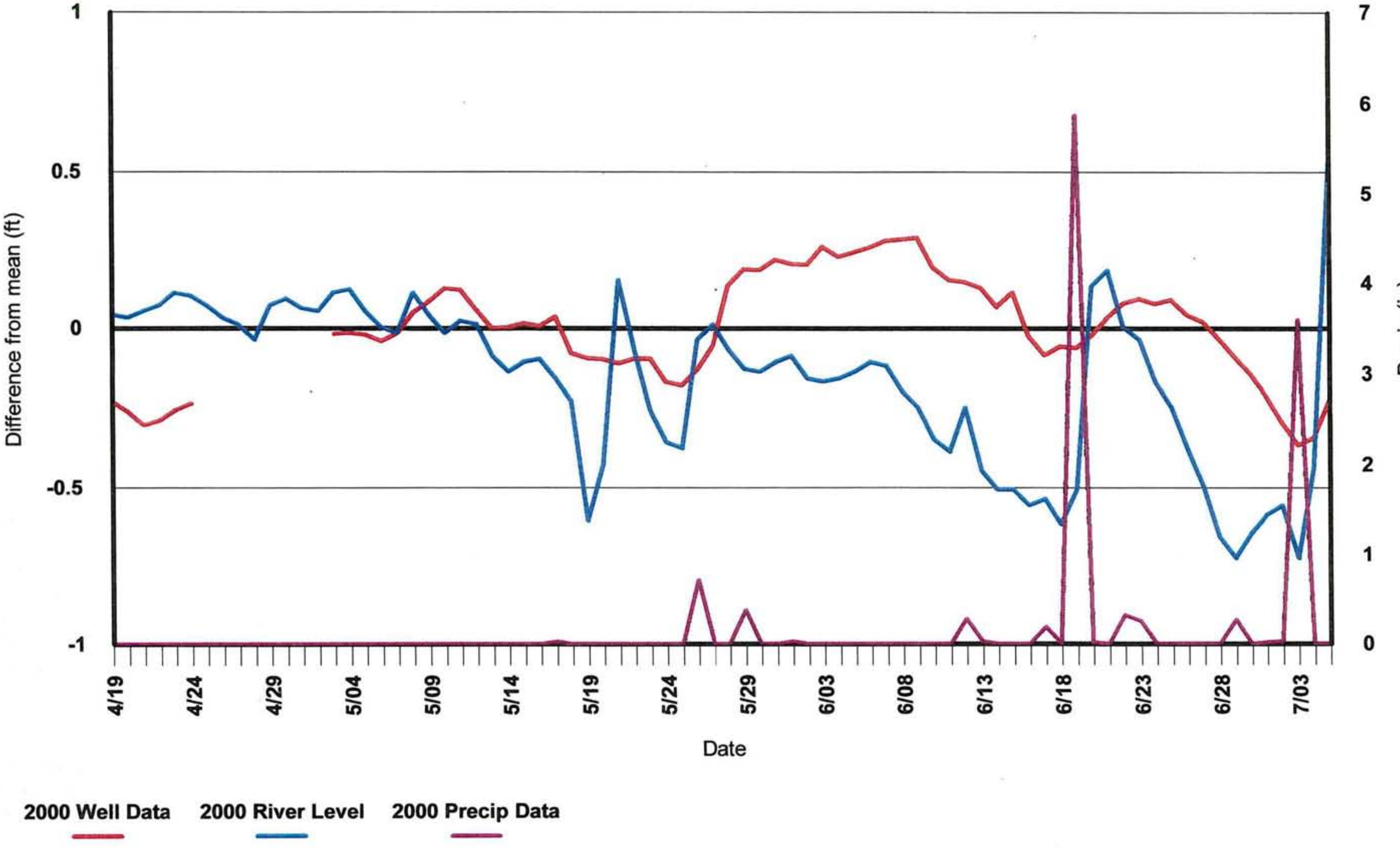


Manual Reading on 6/6/00 = Elevation 2283.86

Well #9-19-34BAA

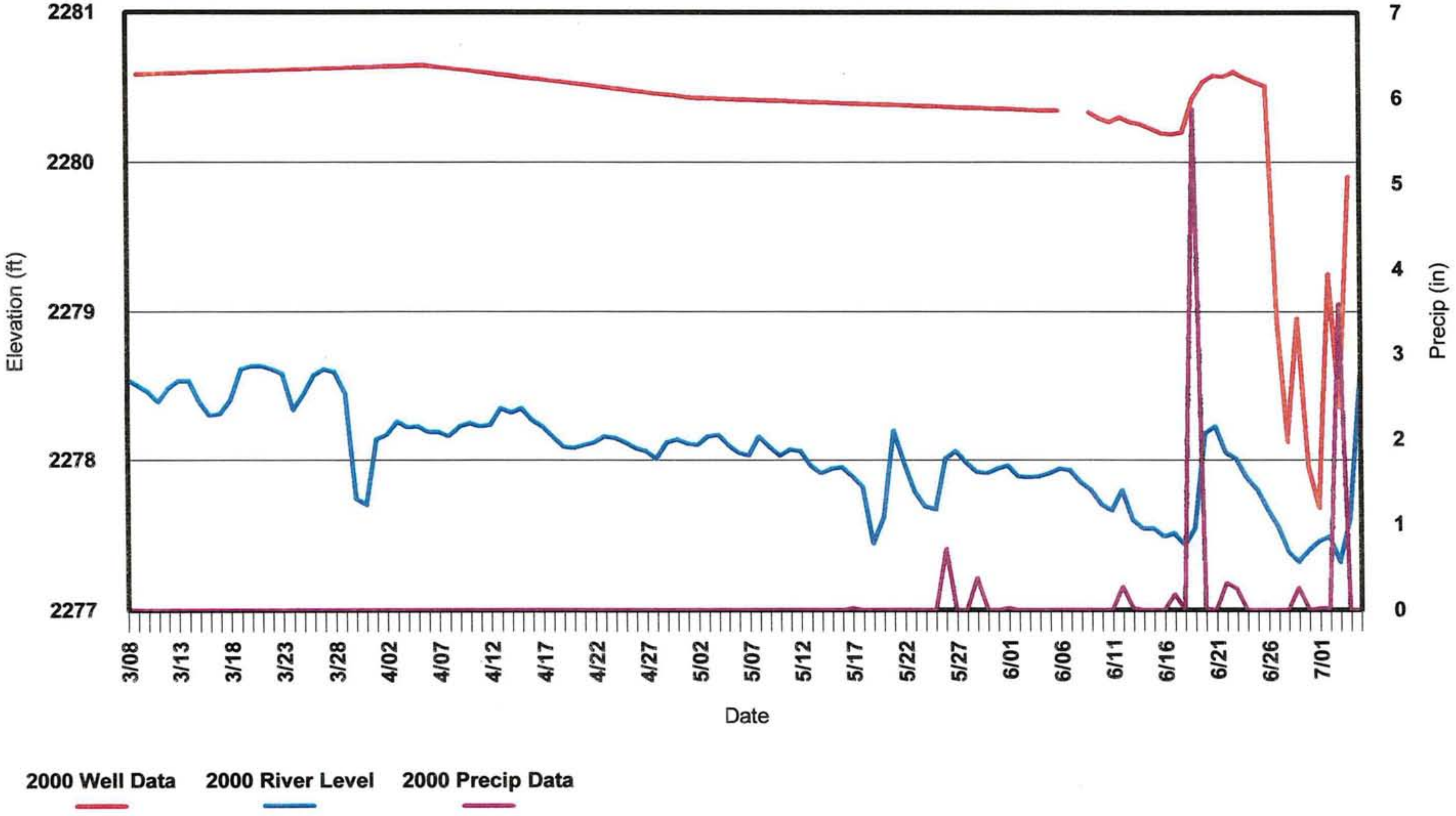
Elm Creek DownstreamTransect - 7,000 Feet from River

Difference from Mean



Well #8-19-3BAA

Elm Creek DownstreamTransect - 3,300 Feet from River

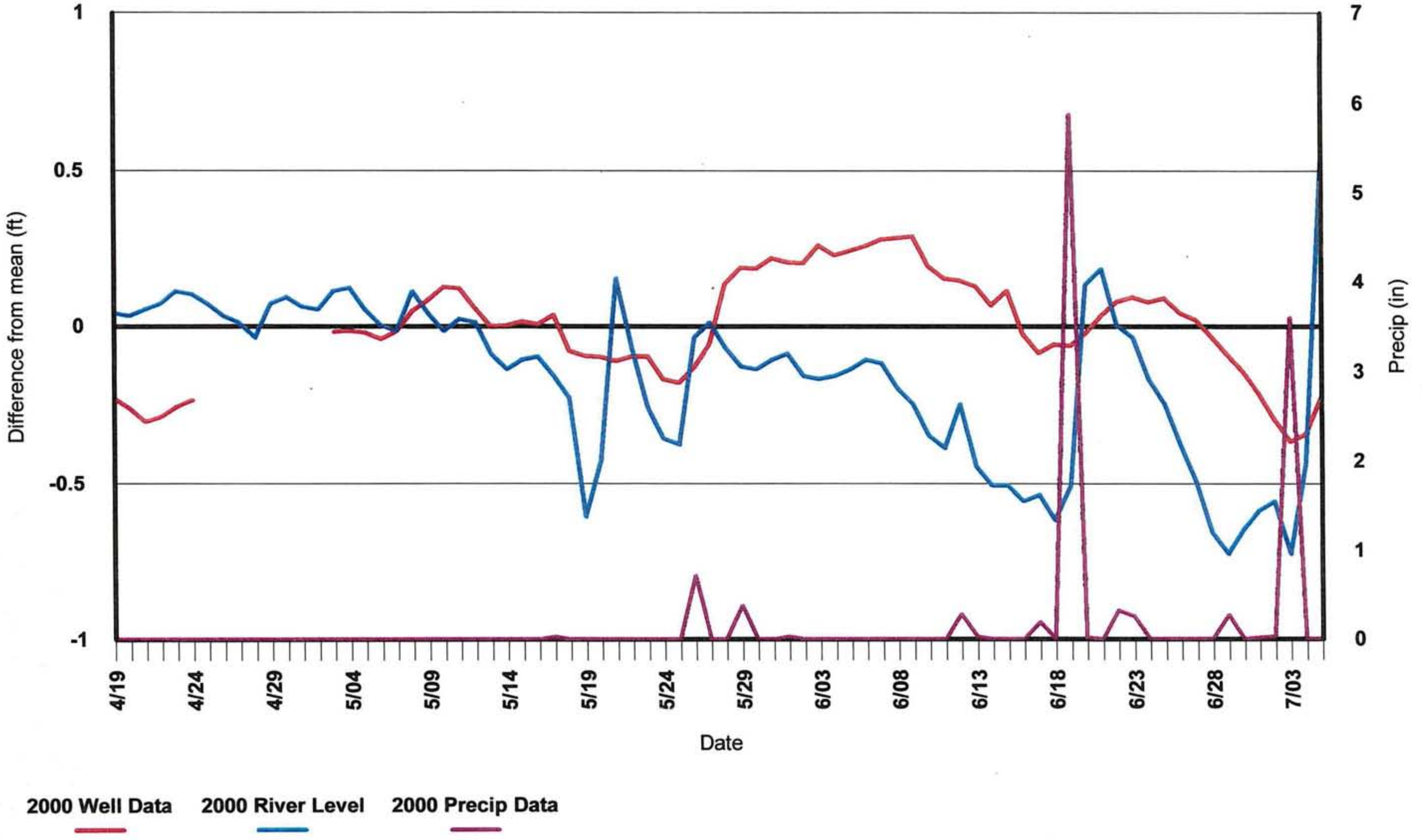


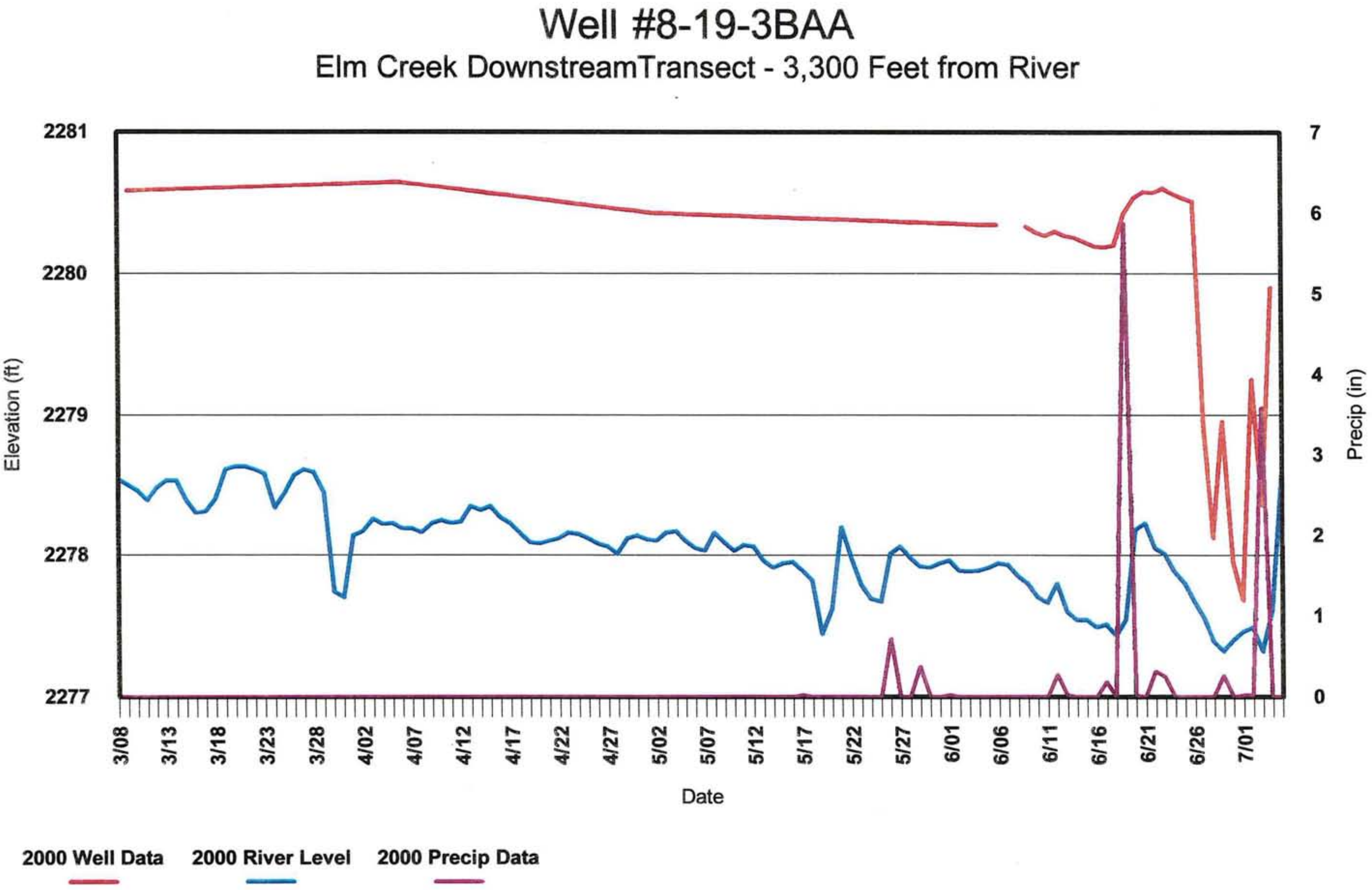
Manual Reading on 7/5/00 = Elevation 2280.18

Well #9-19-34BAA

Elm Creek DownstreamTransect - 7,000 Feet from River

Difference from Mean



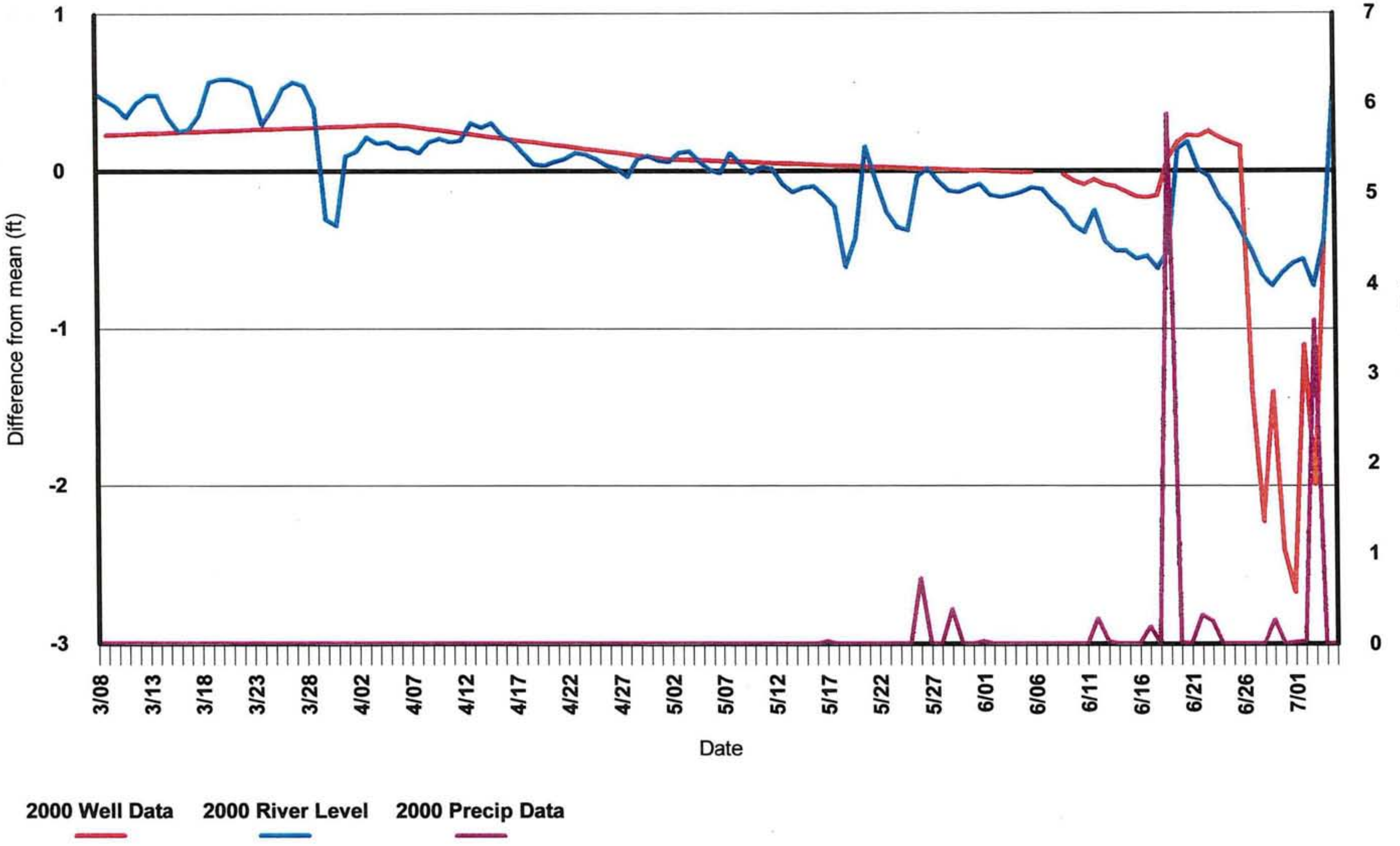


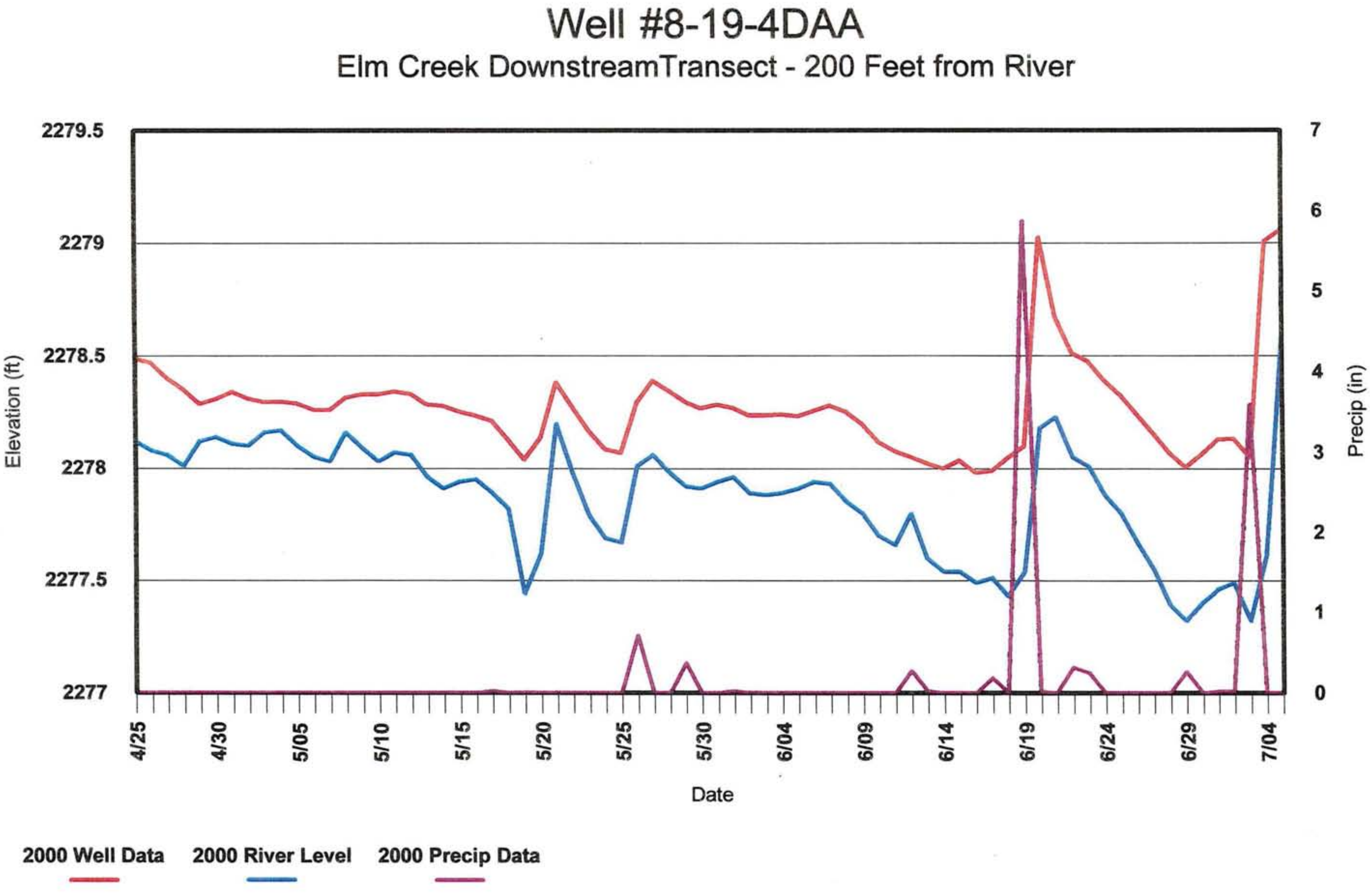
Manual Reading on 7/5/00 = Elevation 2280.18

Well #8-19-3BAA

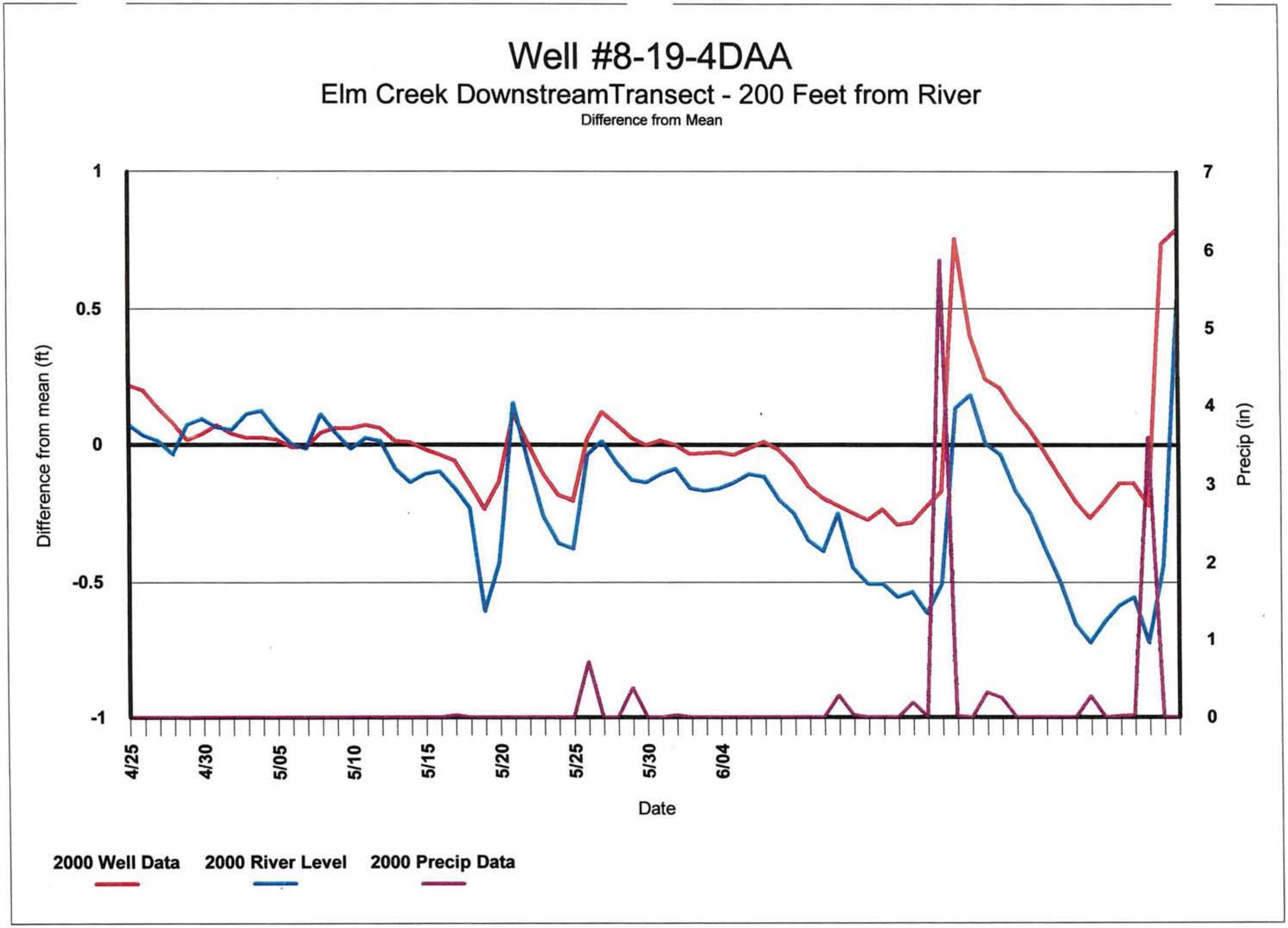
Elm Creek DownstreamTransect - 3,300 Feet from River

Difference from Mean





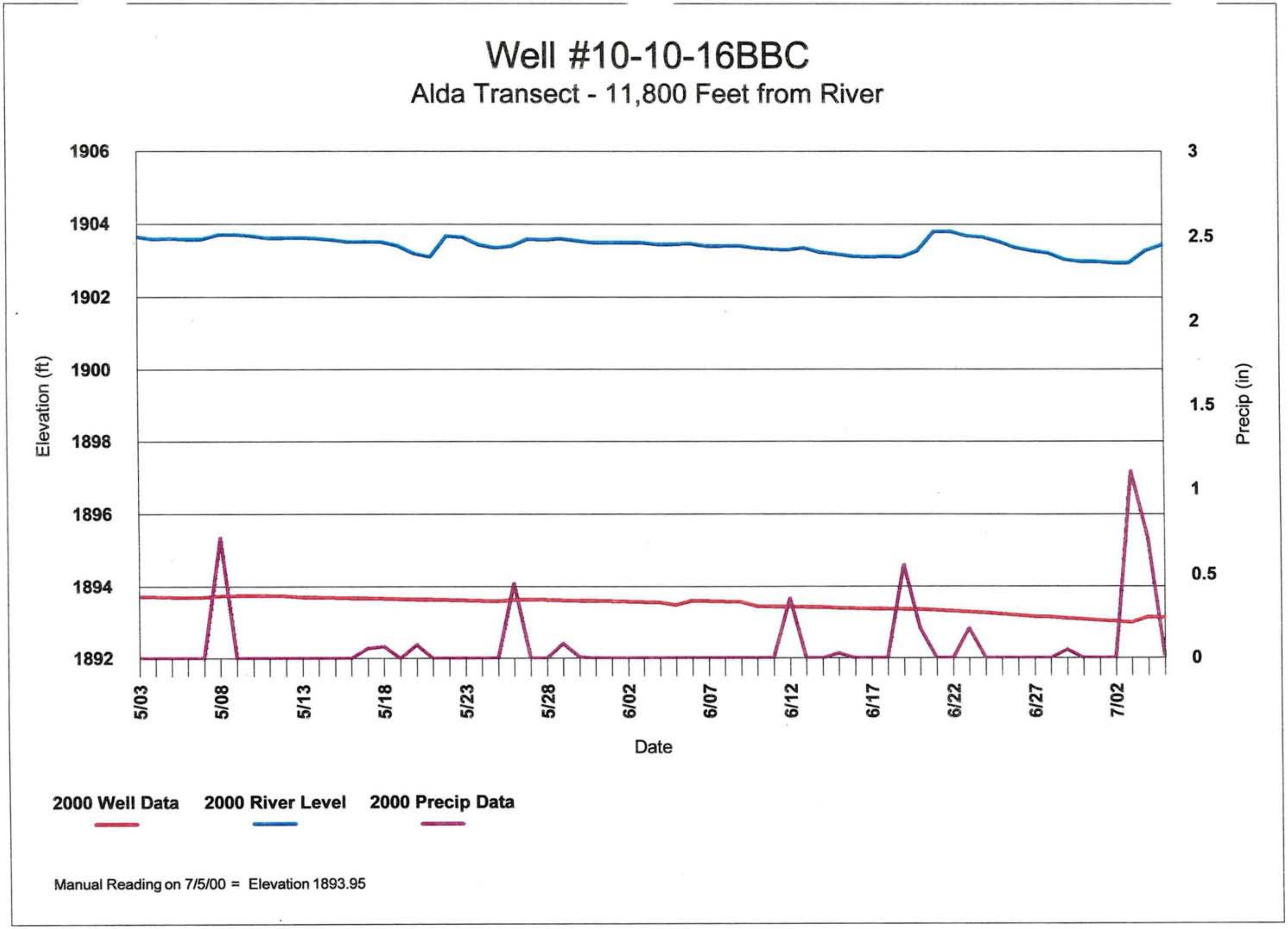
Manual Reading on 7/5/00 = Elevation 2279.0



Well #8-19-4DAA

Elm Creek DownstreamTransect - 200 Feet from River

Difference from Mean

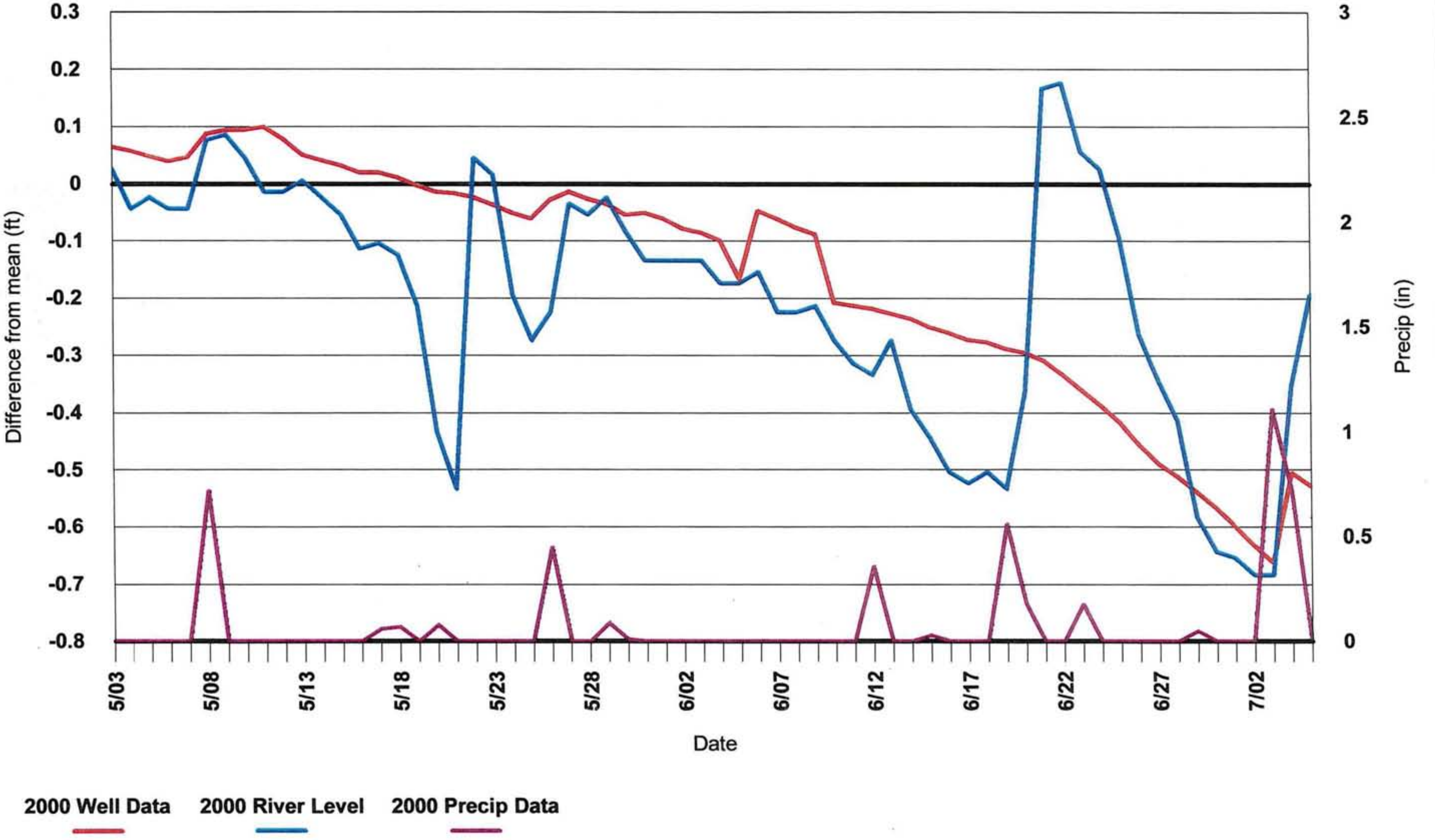


Manual Reading on 7/5/00 = Elevation 1893.95

Well #10-10-16BBC

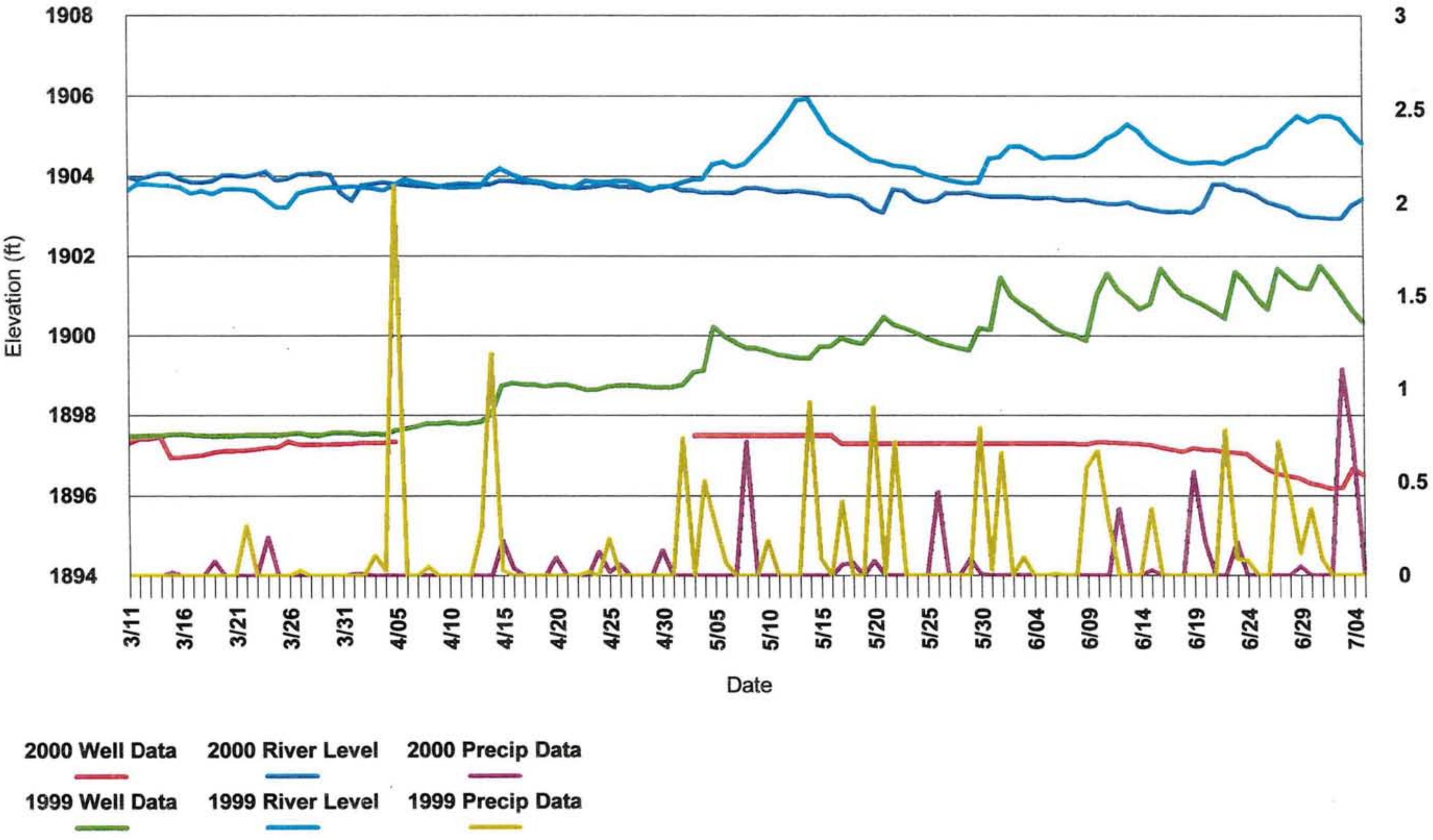
Alda Transect - 11,800 Feet from River

Difference from Mean

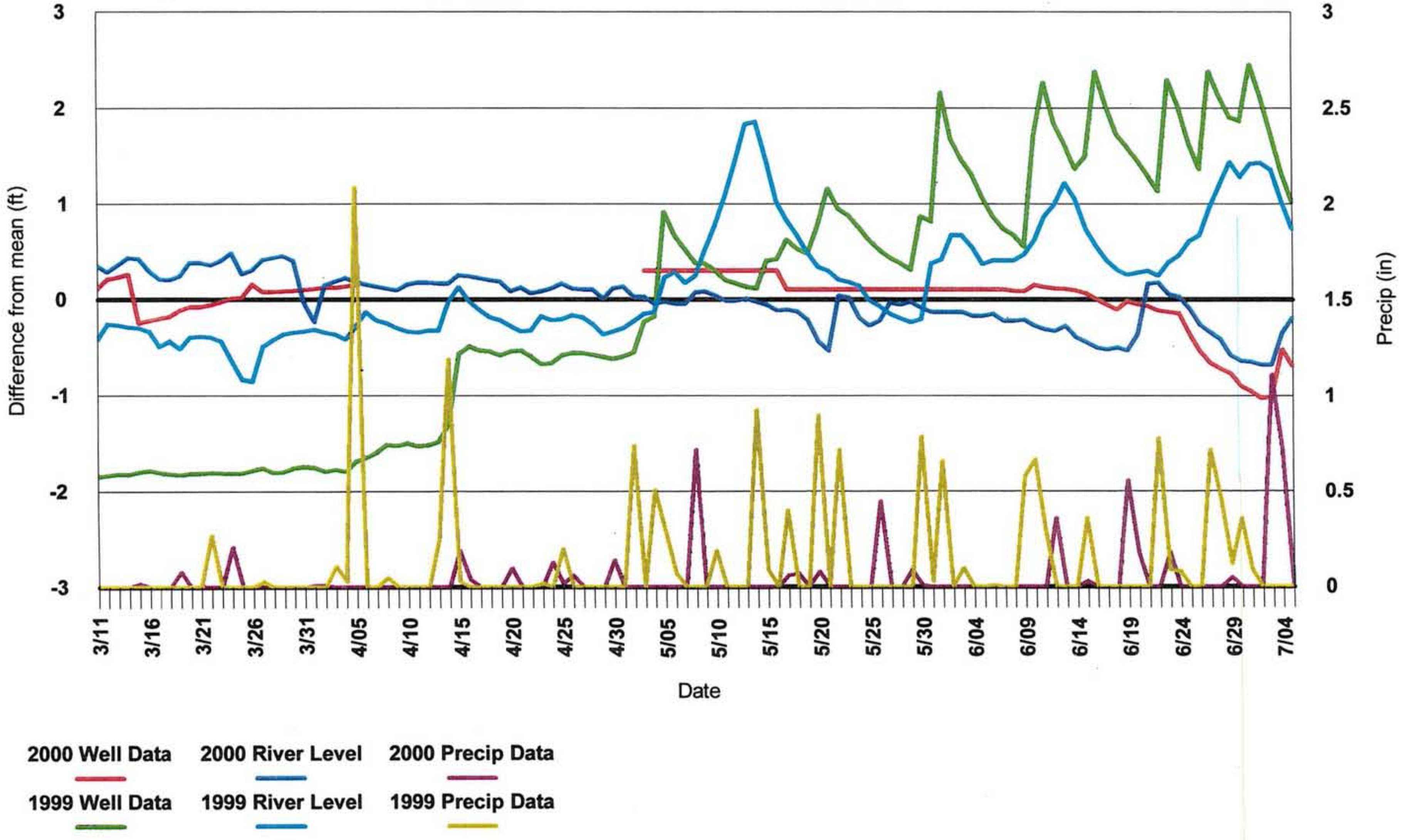


Well #10-10-20AAA

Alda Transect - 8,000 Feet from River



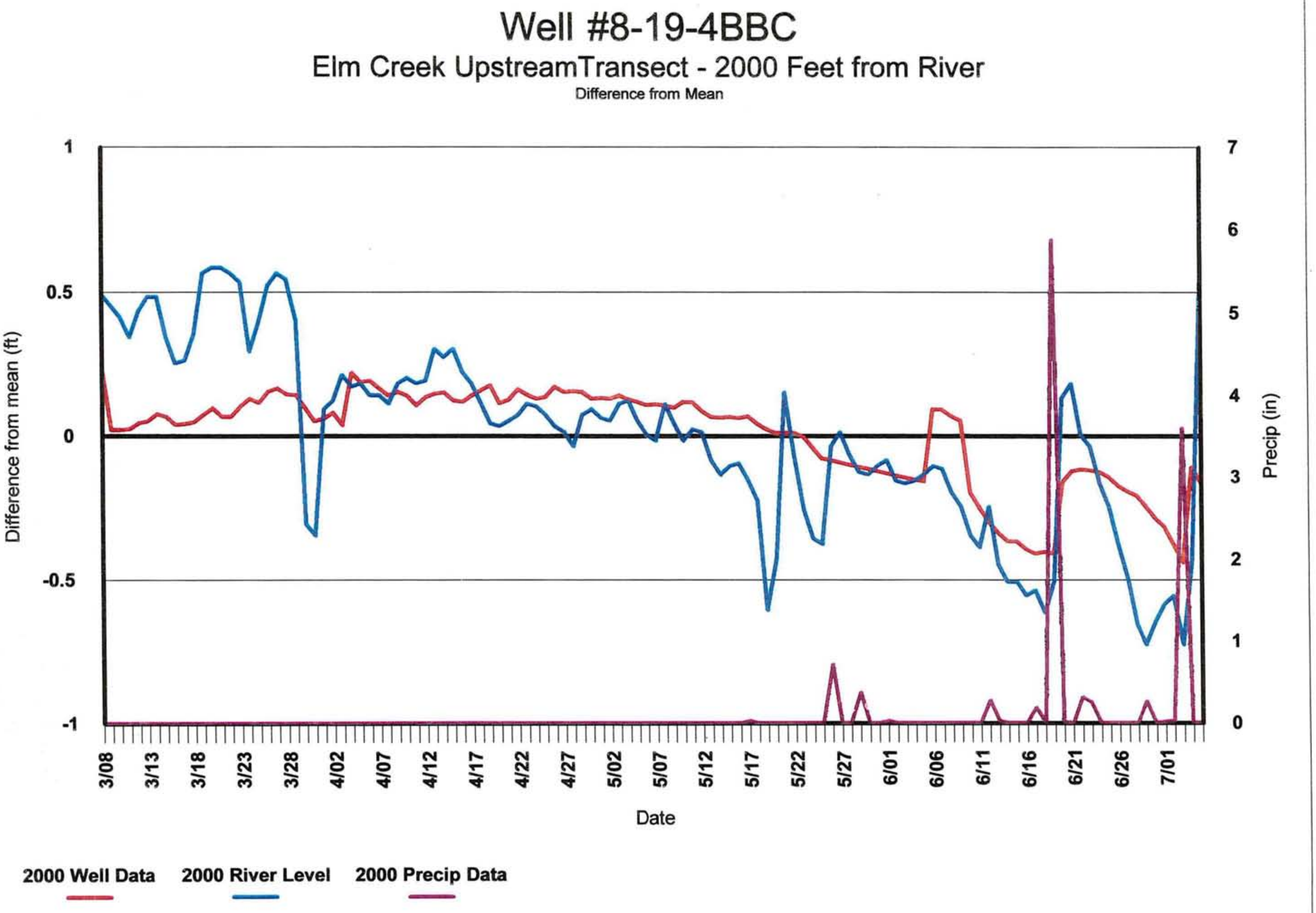
Manual Reading on 7/5/00 = Elevation 1896.4



Well #10-10-20AAA

Alda Transect - 8,000 Feet from River

Difference from Mean



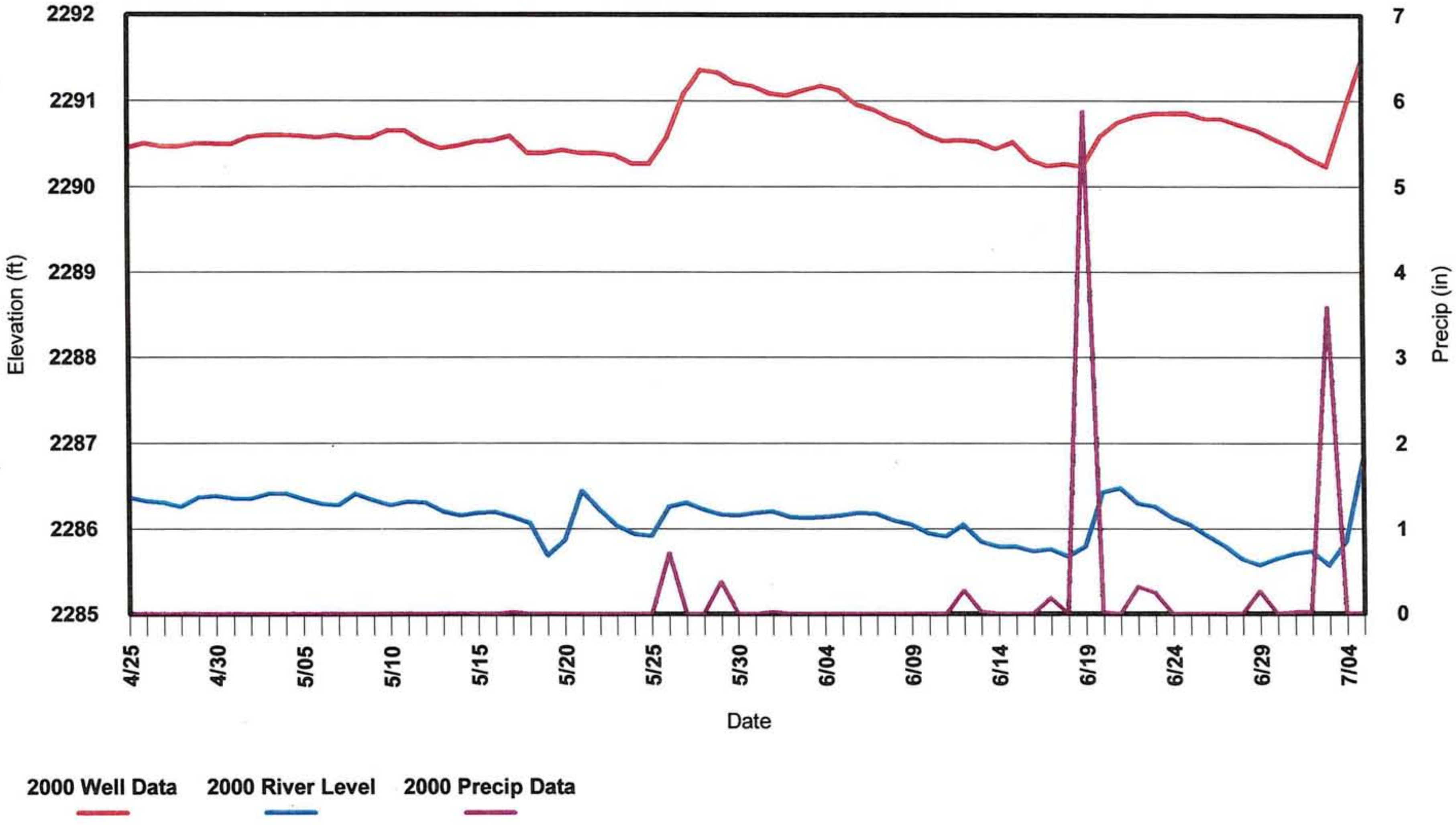
Well #8-19-4BBC

Elm Creek UpstreamTransect - 2000 Feet from River

Difference from Mean

Well #9-19-33ABB

Elm Creek UpstreamTransect - 8,200 Feet from River



Manual Reading on 6/6/00 = Elevation 2291.3

Well #9-19-21CDA

Elm Creek UpstreamTransect - 14,600 Feet from River

Difference from Mean