USIBWC Rio Grande Canalization Project
River Restoration
Depths to Groundwater at Restoration Sites

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4171 N. Mesa
El Paso, Texas 79902

Prepared by:

TRC
Austin, Texas

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1.0 Introduction

Measured water depth data and digital elevation models were used to determine depth to groundwater at 24 USIBWC restoration sites located along the Rio Grande in New Mexico and Texas. There is not enough reliable groundwater depth data to develop contour maps or more detailed groundwater depth distribution maps; therefore, a single average depth and a range of values is presented for each restoration site. All work was performed by Matthew M. Uliana, Ph.D., P.G.

2.0 Data and Methods

TRC measured depths to water at sites 1 – 10 and 17 – 30 during the field soil surveys performed June-July 2010. A summary of all groundwater level data is given in Table 1. Table 1 also includes the ground surface elevation, relative to mean sea level (MSL), of each field survey measuring point based on elevations derived from 1/3 arc-second National Elevation Dataset (NED) grids downloaded from the USGS National Map Seamless Server on 25 August 2010. These elevation grids have a resolution of approximately 30 feet. As discussed below, it is recognized that there is some uncertainty in the accuracy of these elevation data, particularly near the river. But because of the contour interval of the USGS topographic quadrangles (typically 20 feet), there were few, if any, contour lines on most sites. It was felt that these data were the best that could be obtained. The water depth and surface elevation data were used to estimate groundwater elevations for each restoration site.

Table 1 also contains river elevations estimated using the same NED grids. These elevations were subtracted from the groundwater elevations to estimate the difference between the groundwater elevation and the river stage. River stages at the time of the field measurements in comparison to those used in making the NED grids is unknown.

Table 2 contains the number of measurements and the average, minimum, and maximum groundwater depths measured at each site. The average groundwater elevations, and the range of groundwater elevations, are also presented for each site. The NED grids were used to calculate average ground surface elevations and the range of ground surface elevations within each restoration site. The average groundwater elevations were subtracted from the average ground surface elevations to determine an estimated depth to groundwater at each restoration site. The average measured groundwater depth was subtracted from the calculated depth at each site for comparison.

Table 2 also contains the average river elevation for each restoration site as determined from the NED grids. The average river elevations were subtracted from the average groundwater elevations to give an estimated difference between the groundwater elevation at each restoration site and the river stage nearest to each site.

Well records for wells located near the restorations sites were acquired from the following databases:

- Texas Water Development Board (TWDB) Water Well Database; retrieved on July 27, 2010 from http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWDatabaseReports/GWdatabaserpt.htm
- United States Geological Survey (USGS) National Water Information System data for New Mexico and Texas; retrieved on July 29, 2010 from http://waterdata.usgs.gov/nwis/gw
- New Mexico Office of the State Engineer Water Rights Reporting System (NMWRRS) ; retrieved on August 18, 2010 from http://nmwrrs.ose.state.nm.us/nmwrrs/meterReport.html

The well records were filtered to include only records with reliable location coordinates, depth to water, well depth, and measurement dates from wells located within 2,500 ft of each restoration site. For wells with multiple depth to water measurements, all measurements were averaged.

3.0 Data Limitations

Field Groundwater Depth Measurements

The groundwater depth measurements provided by the field survey team, and groundwater depth data acquired from the state and USGS databases, are presented on restoration site maps included here as Figures 1-20. Latitude and longitude coordinates for most of the groundwater depth measurement sites were determined using GPS. GPS coordinates were not determined for measurement locations 2-3, 2-4, 3-1, 7-4, 9-12, 17-2, 17-3, 18-4, 18-5, and 18-6. These measurement sites were arbitrarily assigned locations near the approximate centroid of each restoration site area so that the data could be presented on the restoration site maps.

Site 5 - Yeso West was not correctly surveyed; the survey team accidentally sampled from an area located on the west bank of the Rio Grande opposite site 7 - Crow Canyon B2 (see Figure 5).The location actually surveyed had water depths greater than 60 inches at each survey location. Soils from the spot actually surveyed are similar to those at site 5, and the locations measured are a similar distance from the river and have similar topography to site 5. It is therefore assumed that the locations measured are similar enough to site 5 to be representative of the conditions at site 5, and therefore, those measured depths will be used to determine the groundwater depth at site 5.

NED Grids

The NED grids were used to generate topographic contour maps with a 1-foot contour interval throughout each restoration site. These were overlain on DOQQ aerial photos, and the contours were compared to the river channel and to topographic features visible on the photos. At most sites, the contours follow the river channel and visible topographic features reasonably well, although the elevation accuracy is probably not better than ±1 foot. At sites 18, 19, 24, 25, 27,

28, and 29, the elevation contours cross the river channel in unrealistic ways, and are clearly not representing the river channel with much accuracy.

The groundwater depths calculated using elevations derived from the NED grids are presented and compared to the measured values in Table 2. The actual groundwater depths measured by the field survey team, however, are assumed to be the most reliable data for estimating overall depths at each site.

Presentation of Results

There is not enough measured groundwater depth data to develop contour maps or other representations of spatial distribution of depth within each restoration site. The ground surface elevations derived from the NED grids are not accurate enough to develop reliable elevation maps at the scale of inches. The results of the analysis are therefore presented as an average depth and a range of measured depths at each restoration site.

4.0 Results and Discussion

The number of measurements per site, the average measured groundwater depths, and the range of depths per site are presented in Table 2. The average measured groundwater depths are considered to be the best estimates of groundwater depths at each site and are shown in bold on the table. The measured groundwater depths, the supplementary groundwater depths from the state and USGS databases, and the ground surface contours derived from the NED grids are presented in Figures 1 through 20. Depths to water measured by the project team range from a minimum of 9 inches at site 9 (Rincon Siphon A) to a maximum of over 60 inches at eleven other sites. As expected, supplementary data from state and USGS databases indicates that depth to water generally tends to increase with distance from the river and with increasing well depth. Almost all data from the state and USGS databases are outside of the restoration site boundaries, and are therefore of limited value in supplementing the depth values measured by the field survey team.

The estimated river elevations and groundwater elevations suggest that, with the exception of sites 9 and 20, groundwater elevations are lower than river stage elevations, indicating that the river is losing flow to (recharging) the groundwater throughout the study area. In general, groundwater elevations at the locations observed, which were typically in the middle of the sites, are estimated to be roughly two feet below the river elevations.

TABLES

Table 1. Summary of Groundwater Depths Measured During June-July 2010 Field Survey

Site No.	Site Name	Site ID	Water Depth in	NED Elevation[1] ft	Ground-water Elevation[2] ft	NED River Elevation[3] ft	Ground-water Elev. - River Elev.[4] ft	Ground-water Elev. - River Elev.[4] in
1	Trujillo	1-1	14	4134.4	4133.3	4134.5	-1.2	-14.8
		1-2	30	4136.4	4133.9	4136.8	-2.9	-35.1
		1-3	unk.	4137.9	n/a	4137.1	n/a	n/a
2	Jaralosa	2-1	38	4094.2	4091.0	4091.9	-0.8	-10.0
		2-2	45	4092.8	4089.1	4091.9	-2.8	-33.2
		2-3	43	4092.8	4089.3	4091.9	-2.6	-31.2
		2-4	40	4092.8	4089.5	4091.9	-2.3	-28.2
3	Yeso Arroyo	3-1	>60	4092.8	<4087.8	4091.2	-3.4	-40.3
		3-2	>60	4091.3	<4086.3	4091.2	-4.9	-59.2
		3-3	>60	4091.3	<4086.3	4091.2	-4.9	-59.2
4	Yeso East	4-1	50	4091.4	4087.2	4091.2	-4.0	-47.6
		4-2	42	4091.9	4088.4	4091.2	-2.8	-33.3
		4-3	43	4090.5	4086.9	4091.2	-4.3	-51.7
5	Yeso West[5]	5-1	>60	4081.7	<4076.7	n/a	n/a	n/a
		5-2	>60	4081.7	<4076.7	n/a	n/a	n/a
		5-3	>60	4081.9	<4076.9	n/a	n/a	n/a
6	Crow Canyon A2	6-1	>60	4082.1	<4077.1	4081.7	-4.6	-55.3
		6-2	>60	4082.1	<4077.1	4081.7	-4.6	-55.3
		6-3	54	4082.1	4077.6	4081.7	-4.1	-49.3
		6-4	>60	4082.1	<4077.1	4081.7	-4.6	-55.3
	Crow Canyon A1	6-5	43	4084.5	4081.0	4081.7	-0.7	-8.7
		6-6	42	4084.1	4080.6	4081.7	-1.0	-12.5
		6-7	44	4083.4	4079.7	4081.7	-2.0	-23.5
		6-8	48	4084.6	4080.6	4081.7	-1.1	-13.4
		6-9	46	4082.8	4079.0	4081.7	-2.7	-32.6
7	Crow Canyon B2	7-1	46	4082.0	4078.1	4081.7	-3.5	-42.5
	Crow Canyon B1	7-2	19	4081.7	4080.2	4081.7	-1.5	-18.2
		7-3	24	4081.7	4079.7	4081.7	-1.9	-23.2
		7-4	>60	4081.7	<4076.7	4081.7	-4.9	-59.2
8	Placitas Arroyo	8-1	>60	4053.6	<4048.6	4051.5	-2.9	-34.4
		8-2	>60	4052.6	<4047.6	4051.5	-3.9	-46.6
		8-3	>60	4051.8	<4046.8	4051.5	-4.7	-56.9
		8-4	>60	4051.8	<4046.8	4051.5	-4.7	-56.9
		8-5	>60	4053.5	<4048.5	4051.5	-3.0	-36.0
9	Rincon Siphon A	9-1	47	4045.4	4041.5	4041.3	0.2	1.8
		9-2	47	4042.3	4038.4	4041.3	-3.0	-35.6
		9-3	9	4041.8	4041.0	4041.3	-0.3	-3.9
		9-4	42	4053.1	4049.6	4041.3	8.2	98.9
		9-5	23	4051.1	4049.2	4041.3	7.9	94.7
	Rincon Siphon B	9-6	20	4045.1	4043.5	4041.3	2.1	25.7
		9-7	20	4044.1	4042.4	4041.3	1.1	13.5
		9-8	21	4042.1	4040.4	4041.3	-1.0	-11.6

Table 1. Summary of Groundwater Depths Measured During June-July 2010 Field Survey (cont.)

Site No.	Site Name	Site ID	Water Depth in	NED Elevation[1] ft	Ground-water Elevation ft	NED River Elevation[2] ft	Ground-water Elev. - River Elev.[3] ft	Ground-water Elev. - River Elev.[3] in
9	Rincon Siphon B (continued)	9-9	37	4053.0	4049.9	4041.3	8.6	103.2
		9-10	21	4043.9	4042.2	4041.3	0.8	10.1
		9-11	20	4055.9	4054.2	4041.3	12.9	154.8
		9-12	22	4055.9	4054.1	4041.3	12.7	152.8
10	Angostura Arroyo	10-1	>60	4032.3	<4027.3	4032.1	-4.9	-58.4
		10-2	>60	4032.2	<4027.2	4032.1	-4.9	-59.2
		10-3	>60	4032.1	<4027.1	4032.1	-5.0	-60.0
		10-4	>60	4032.6	<4027.6	4032.1	-4.5	-54.1
		10-5	>60	4033.1	<4028.1	4032.1	-4.1	-49.0
17	Shalem Colony	17-1	47	3912.0	3908.0	3911.7	-3.7	-44.2
		17-2	48	3912.0	3908.0	3911.7	-3.8	-45.2
		17-3	>60	3912.0	<3907.0	3911.7	-4.8	-57.2
18	Leasburg Extension Lateral WW 8	18-1	42	3900.2	3896.7	3897.3	-0.6	-7.7
		18-2	42	3899.2	3895.7	3897.3	-1.6	-19.6
		18-3	27	3899.2	3896.9	3897.3	-0.4	-4.6
		18-4	27	3899.2	3896.9	3897.3	-0.4	-4.6
		18-5	27	3899.2	3896.9	3897.3	-0.4	-4.6
		18-6	27	3899.2	3896.9	3897.3	-0.4	-4.6
19	Clark Lateral	19-1	49	3881.7	3877.7	3881.2	-3.6	-42.7
		19-2	>60	3881.7	<3876.7	3881.2	-4.5	-53.7
		19-3	52	3881.7	3877.4	3881.2	-3.8	-45.7
		19-4	?	3881.7	n/a	3881.2	n/a	n/a
20	Mesilla Valley Bosque St. Park	20-1	33	3876.9	3874.1	3872.0	2.1	24.9
		20-2	42	3877.2	3873.7	3872.0	1.6	19.4
		20-3	30	3877.1	3874.6	3872.0	2.6	31.0
		20-4	25	3877.2	3875.1	3872.0	3.0	36.4
		20-5	20	3872.3	3870.6	3872.0	-1.4	-17.2
		20-6	46	3873.5	3869.7	3871.7	-2.0	-24.0
		20-7	37	3872.0	3868.9	3871.7	-2.8	-33.9
		20-8	32	3872.2	3869.6	3871.7	-2.1	-25.7
21	Mesilla East	21-1	42	3871.9	3868.4	3871.7	-3.3	-39.2
		21-2	42	3872.0	3868.5	3871.7	-3.2	-38.9
		21-3	42	3872.0	3868.5	3871.7	-3.2	-38.9
22	Berino West	22-1	47	3812.6	3808.7	3811.3	-2.6	-31.6
		22-2	45	3812.2	3808.4	3811.3	-2.9	-34.8
		22-3	23	3811.8	3809.9	3811.0	-1.1	-13.2
		22-4	50	3811.2	3807.0	3811.0	-4.0	-47.6
23	Berino East	23-1	42	3806.9	3803.4	3806.7	-3.3	-40.0
		23-2	42	3806.9	3803.4	3806.7	-3.3	-40.0
		23-3	44	3809.8	3806.1	3806.7	-0.6	-7.4

Table 1. Summary of Groundwater Depths Measured During June-July 2010 Field Survey (cont.)

Site No.	Site Name	Site ID	Water Depth in	NED Elevation[1] ft	Ground-water Elevation ft	NED River Elevation[2] ft	Ground-water Elev. - River Elev.[3] ft	Ground-water Elev. - River Elev.[3] in
24	Vinton A	24-1	24	3785.9	3783.9	3786.7	-2.9	-34.2
		24-2	17	3786.5	3785.1	3786.7	-1.6	-19.8
		24-3	17	3787.2	3785.8	3786.7	-1.0	-11.5
		24-4	20	3787.4	3785.8	3786.7	-1.0	-11.7
		24-5	24	3787.1	3785.1	3786.7	-1.7	-20.1
		24-6	24	3784.4	3782.4	3786.7	-4.3	-51.6
25	Vinton B	25-1	28	3783.9	3781.6	3781.8	-0.2	-2.8
		25-2	32	3782.6	3779.9	3781.8	-1.9	-22.9
		25-3	29	3781.7	3779.3	3781.8	-2.5	-30.2
26	Valley Creek	26-1	30	3755.1	3752.6	3755.9	-3.3	-39.4
		26-2	30	3756.6	3754.1	3755.9	-1.8	-21.7
		26-3	40	3756.6	3753.2	3755.9	-2.6	-31.7
27	Nemexas Siphon	27-1	31	3748.2	3745.7	3750.0	-4.3	-51.9
		27-2	28	3748.2	3745.9	3750.0	-4.1	-48.9
		27-3	28	3746.9	3744.6	3750.0	-5.4	-64.6
		27-4	42	3747.3	3743.8	3750.0	-6.2	-74.3
		27-5	30	3747.3	3744.8	3750.0	-5.2	-62.3
		27-6	>60	3758.0	<3753.0	3750.0	3.0	35.7
		27-7	19	3758.1	3756.5	3750.0	6.5	78.2
		27-8	30	3749.3	3746.8	3750.0	-3.2	-37.9
28	Country Club East	28-1	54	3742.1	3737.6	3746.7	-9.1	-109.5
		28-2	60	3742.0	3737.0	3746.7	-9.7	-116.7
		28-3	32	3758.0	3755.4	3746.7	8.7	103.8
		28-4	42	3757.8	3754.3	3746.7	7.6	91.5
		28-5	36	3742.7	3739.7	3746.7	-7.0	-83.6
29	Sunland Park	29-1	40	3736.9	3733.6	3733.9	-0.3	-4.2
		29-2	>60	3736.4	<3731.4	3733.9	-2.5	-30.5
		29-3	50	3736.1	3731.9	3733.9	-2.0	-24.0
		29-4	40	3736.2	3732.8	3733.9	-1.1	-12.8
		29-5	39	3736.1	3732.8	3733.9	-1.1	-13.0
30	Anapra Bridge	30-1	47	3731.1	3727.2	3730.6	-3.5	-41.5
		30-2	61	3731.2	3726.1	3730.6	-4.5	-54.3
		30-3	34	3731.1	3728.3	3730.6	-2.3	-28.1
		30-4	46	3731.1	3727.3	3730.6	-3.3	-40.1

Notes:
1 "NED Elevation" is the elevation of the ground surface at the measuring point estimated from the 1/3 arc-second NED grid
2 "Groundwater Elevation" is the NED elevation minus the measured water depth
3 "NED River Elevation" is the elevation at the river channel estimated from the 1/3 arc-second NED grid
4 "GW Elev. - River Elev." is the calculated groundwater elevation minus the estimated river stage. Negative numbers indicate that the groundwater is below the river stage.
5 The Yeso West soil survey was taken in the wrong location. See the report text for details.

Table 2. Comparison of Measured Groundwater Depths to Calculated Groundwater Depths

Site ID #	Site Name	Measured Groundwater Depth (inches)			Groundwater Elevation[2] (ft MSL)		Ground Surface Elevation[3] (ft MSL)		Calculated GW Depth[4] (inches)	Calc. - Meas. GW Depth[5] (inches)	NED River Elevation[6] (ft MSL)	GW Elev. - River Elev.[7] (inches)	
		Avg.[1]	Range	Count	Avg.	Range	Avg.	Range			Avg.	Avg.	Range
1	Trujillo	**22.0**	16	2	4,133.6	0.6	4,136.0	4.5	29.1	7.1	4,136.1	-25	20
2	Jaralosa	**41.5**	7	4	4,089.7	1.9	4,093.4	3.9	44.1	2.6	4,091.9	-26	23
3	Yeso Arroyo	**>60**	n/a	2	4,086.8	1.6	4,091.3	2.1	54.3	-5.7	4,091.2	-53	19
4	Yeso East	**45.0**	8	3	4,087.5	1.5	4,091.7	2.0	50.0	5.0	4,091.2	-44	18
5	Yeso West[8]	**>60**	n/a	3[8]	4,076.8	0.1	4,090.4	1.8	n/a	n/a	n/a	n/a	n/a
6	Crow Canyon A1	**58.5**	>6	5	4,080.2	2.0	4,083.9	3.4	44.3	-14.2	4,081.7	-54	6
6	Crow Canyon A2	**44.6**	6	4	4,077.2	0.5	4,082.0	2.0	58.0	13.4	4,081.7	-18	24
7	Crow Canyon B1	**46.0**	0	1	4,078.9	3.4	4,081.8	0.5	35.1	-10.9	4,081.7	-42	0
7	Crow Canton B2	**34.3**	>41	3	4,078.1	0.0	4,081.8	0.0	43.4	9.1	4,081.7	-34	41
8	Placitas Arroyo	**>60**	n/a	4	4,047.7	1.9	4,052.0	2.9	52.5	-7.5	4,051.5	-46	22
9	Rincon Siphon A	**33.6**	38	4	4,043.9	11.2	4,046.1	11.4	25.6	-8.0	4,041.3	31	135
9	Rincon Siphon B	**23.0**	17	6	4,046.7	13.9	4,049.9	17.3	38.3	15.3	4,041.3	64	166
10	Angostura Arroyo	**>60**	n/a	5	4,027.5	0.9	4,032.6	5.2	61.2	1.2	4,032.1	-59	2
17	Shalem Colony	**51.7**	>13	2	3,907.7	1.1	3,912.5	4.3	58.6	6.9	3,911.7	-49	13
18	Leasburg Extension...	**32.0**	15	3	3,896.7	1.3	3,899.4	2.6	32.5	0.5	3,897.3	-8	15
19	Clark Lateral	**53.7**	>11	2	3,877.3	0.9	3,881.8	0.0	53.7	0.0	3,881.2	-47	11
20	Mesilla Valley Bosque...	**33.1**	26	8	3,872.0	6.2	3,874.1	6.6	24.4	-8.7	3,871.9	1	70
21	Mesilla East	**42.0**	0	3	3,868.5	0.0	3,872.0	0.0	42.0	0.0	3,871.7	-39	0
22	Berino West	**41.3**	27	4	3,808.5	2.9	3,810.7	5.6	25.8	-15.4	3,811.2	-32	34
23	Berino East	**42.7**	2	3	3,804.3	2.7	3,806.9	0.0	31.0	-11.7	3,806.7	-29	33
24	Vinton A	**21.0**	7	5	3,784.7	3.3	3,786.0	4.1	16.2	-4.8	3,786.7	-25	40
25	Vinton B	**29.7**	4	3	3,780.3	2.3	3,782.3	2.4	24.4	-5.3	3,781.8	-19	27
26	Valley Creek	**33.3**	10	3	3,753.3	1.5	3,756.5	3.3	38.2	4.9	3,755.9	-31	18
27	Nemexas Siphon	**33.5**	>41	8	3,747.6	12.7	3,748.9	16.6	15.5	-18.0	3,750.0	-28	153
28	Country Club East	**44.8**	28	5	3,744.8	18.4	3,756.0	18.4	134.9	90.1	3,746.7	-23	221
29	Sunland Park	**45.8**	>21	3	3,732.5	2.2	3,736.1	4.7	43.0	-2.8	3,733.9	-17	26
30	Anapra Bridge	**47.0**	27	4	3,727.2	2.2	3,731.2	1.0	47.2	0.2	3,730.6	-41	26

Notes:
1 Average depths were calculated with a depth of 60 inches substituted for all depths reported as >60 inches.
2 "Groundwater Elevation" is the average of the elevations, in feet above mean sea level, at each site as presented in column 6 of Table 1.
3 "Ground Surface Elevation" is the average of all elevations, in feet above mean sea level, from the 1/3 arc-second NED grid within the boundaries of each restoration site. The resolution for the elevations grids is approximately 30 feet.
4 "Calculated GW Depth" is the average ground surface elevation minus the average groundwater elevation for each site.
5 "Calc. – Meas. GW Depth" is the difference between the average measured depth and the average calculated depth. Negative values mean that the measured value is deeper than the calculated value.
6 "NED River Elevation" is the average of the river elevation values as presented in column 7 of Table 1.
7 "GW Elev. - River Elev." is the calculated groundwater elevation minus the estimated river stage. Negative numbers indicate that the groundwater is below the river stage.
8 The Yeso West soil survey and groundwater depth measurements were taken in the wrong location. See the report text for details.

FIGURES

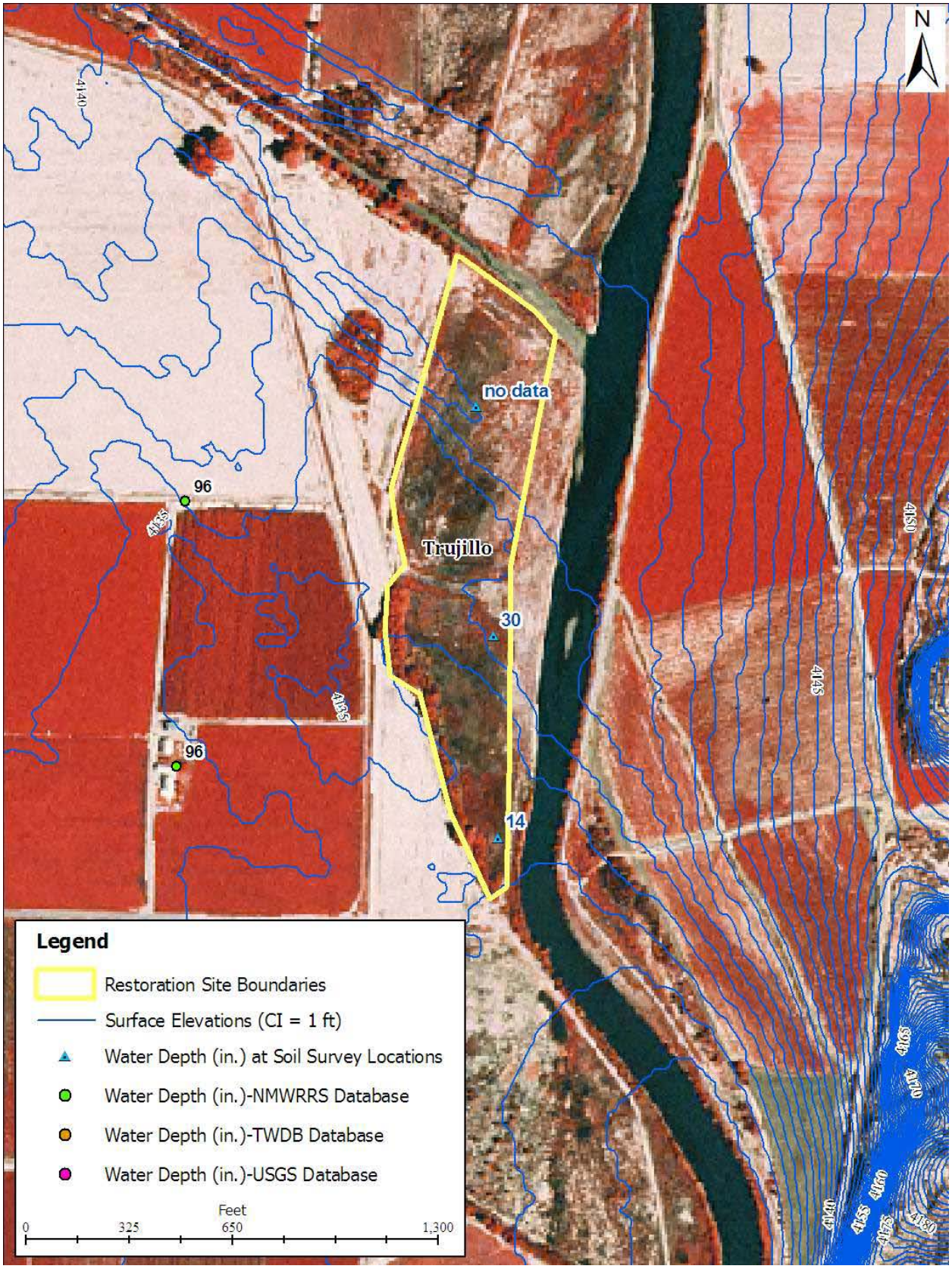

Figure 1. Site 1 - Trujillo

Figure 2. Site 2 – Jaralosa

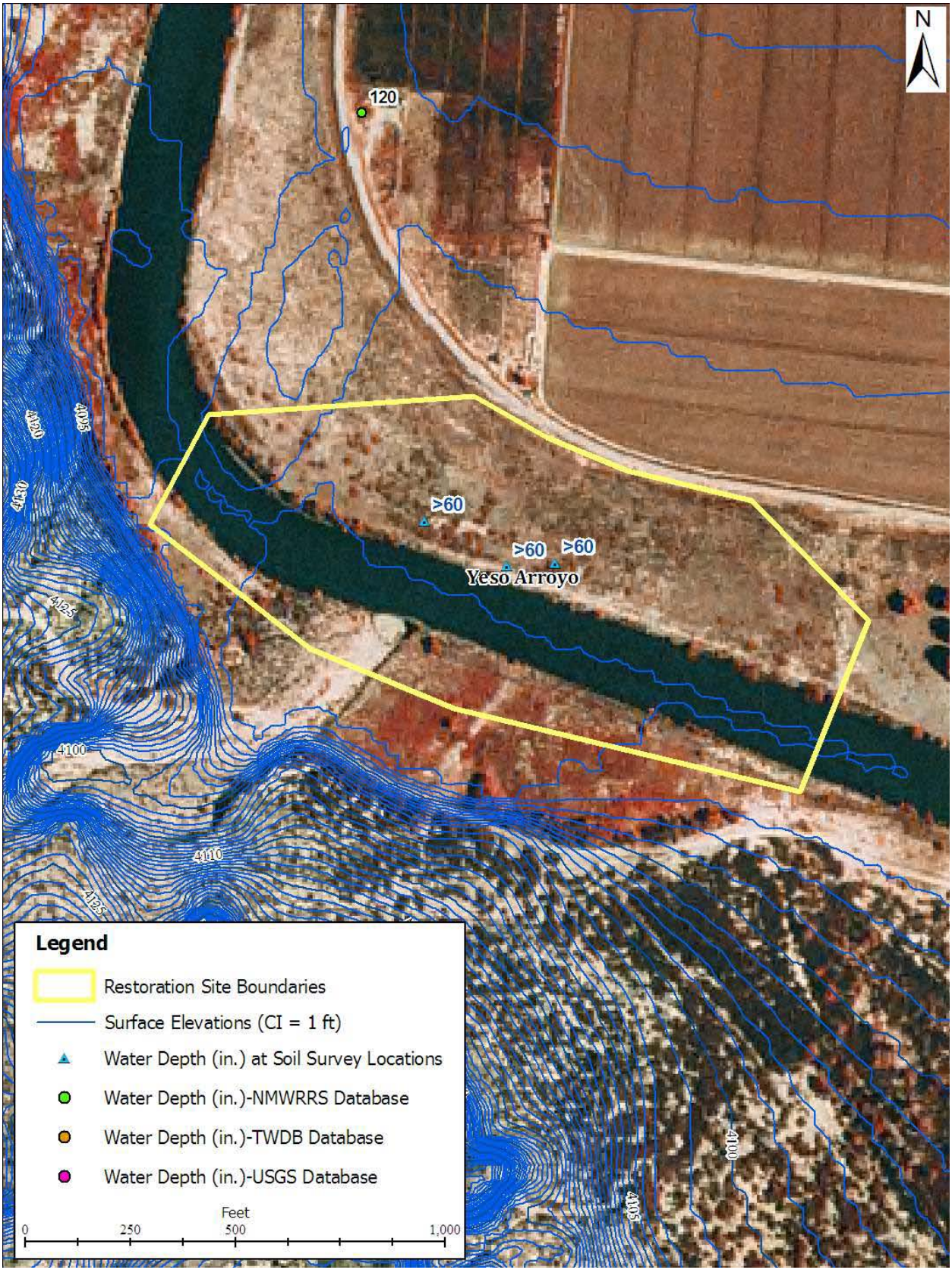

Figure 3. Site 3 – Yeso Arroyo

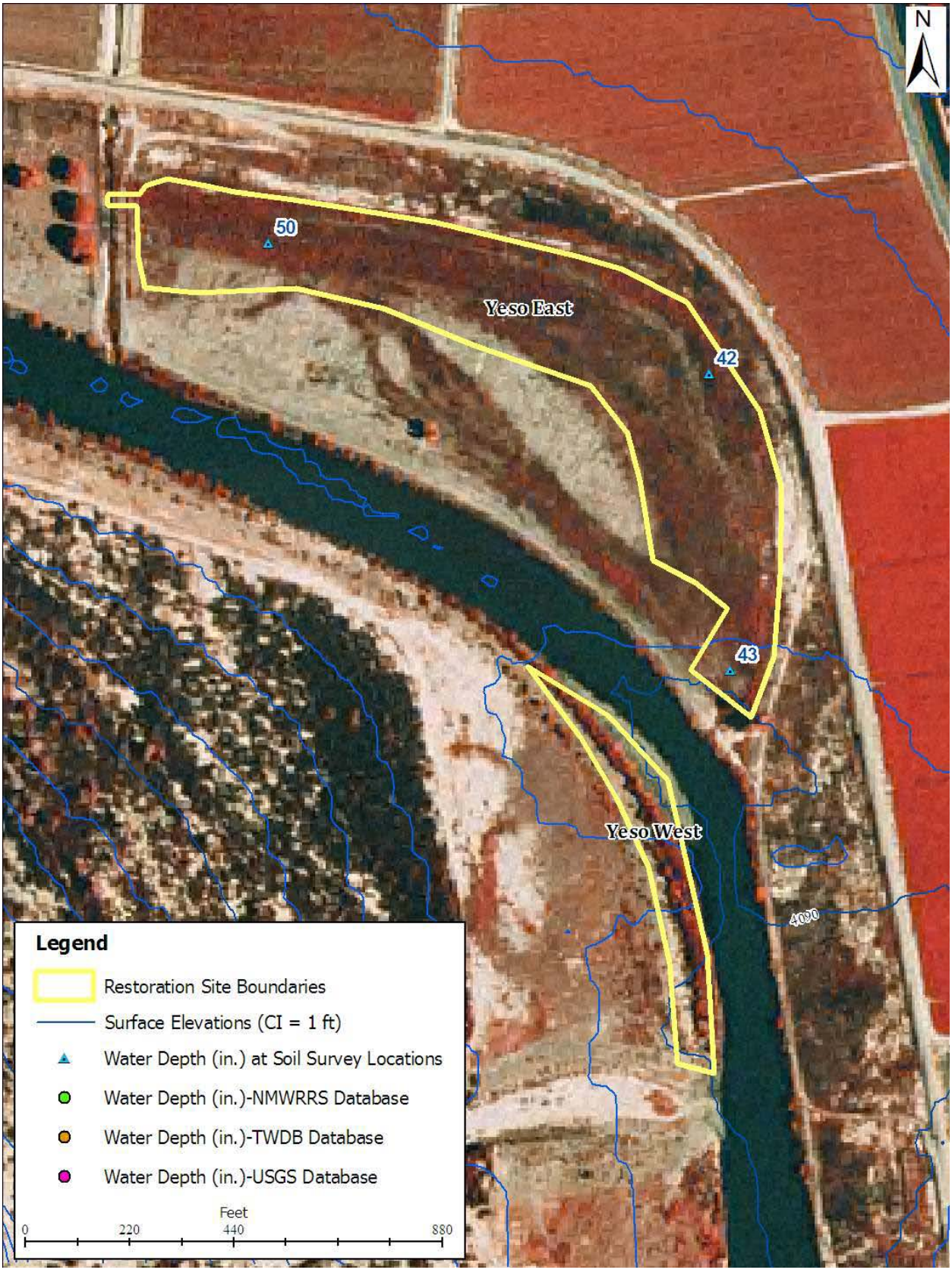

Figure 4. Sites 4 and 5 – Yeso East and West

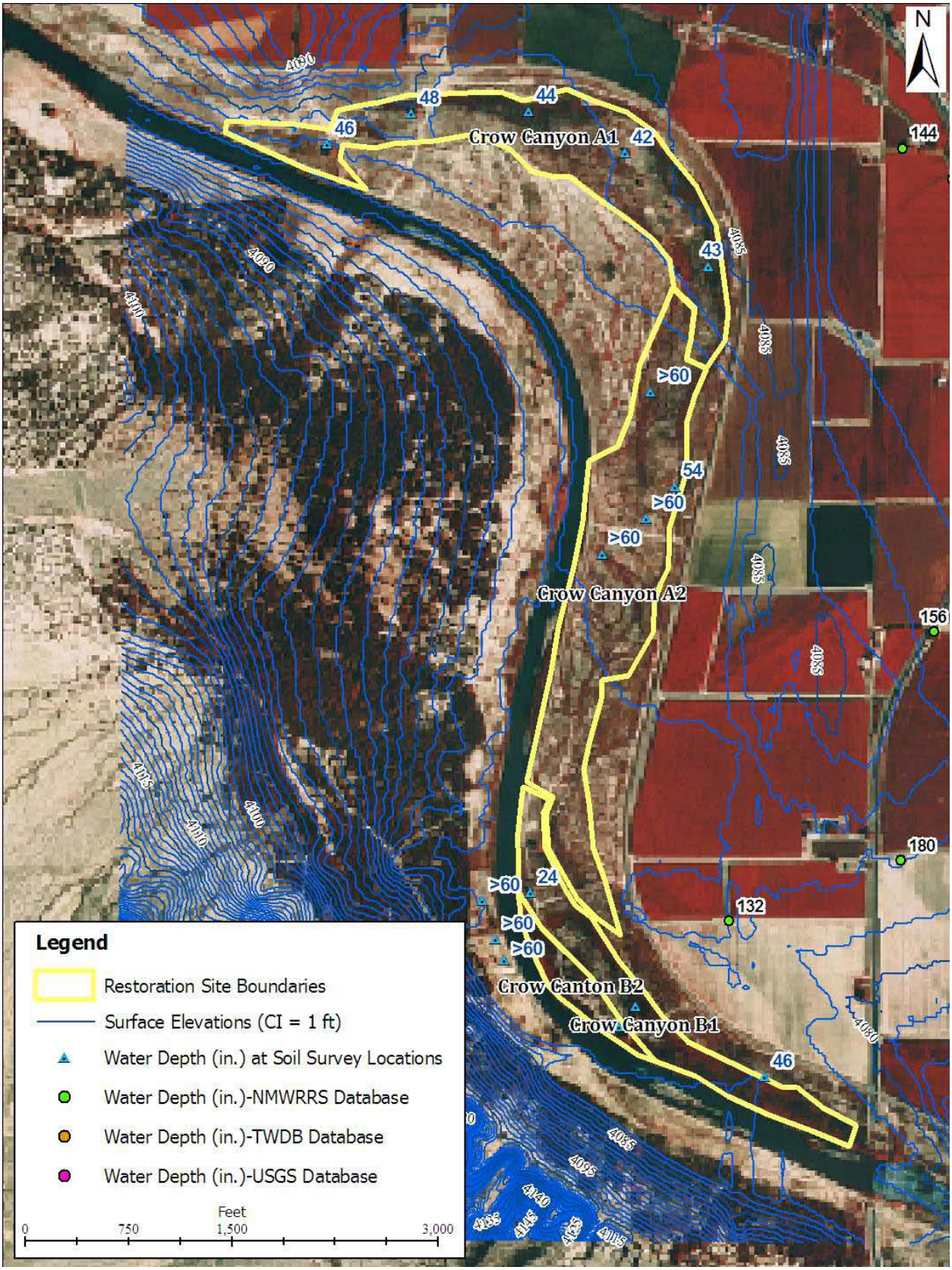

Figure 5. Sites 6 and 7 – Crow Canyon A and B

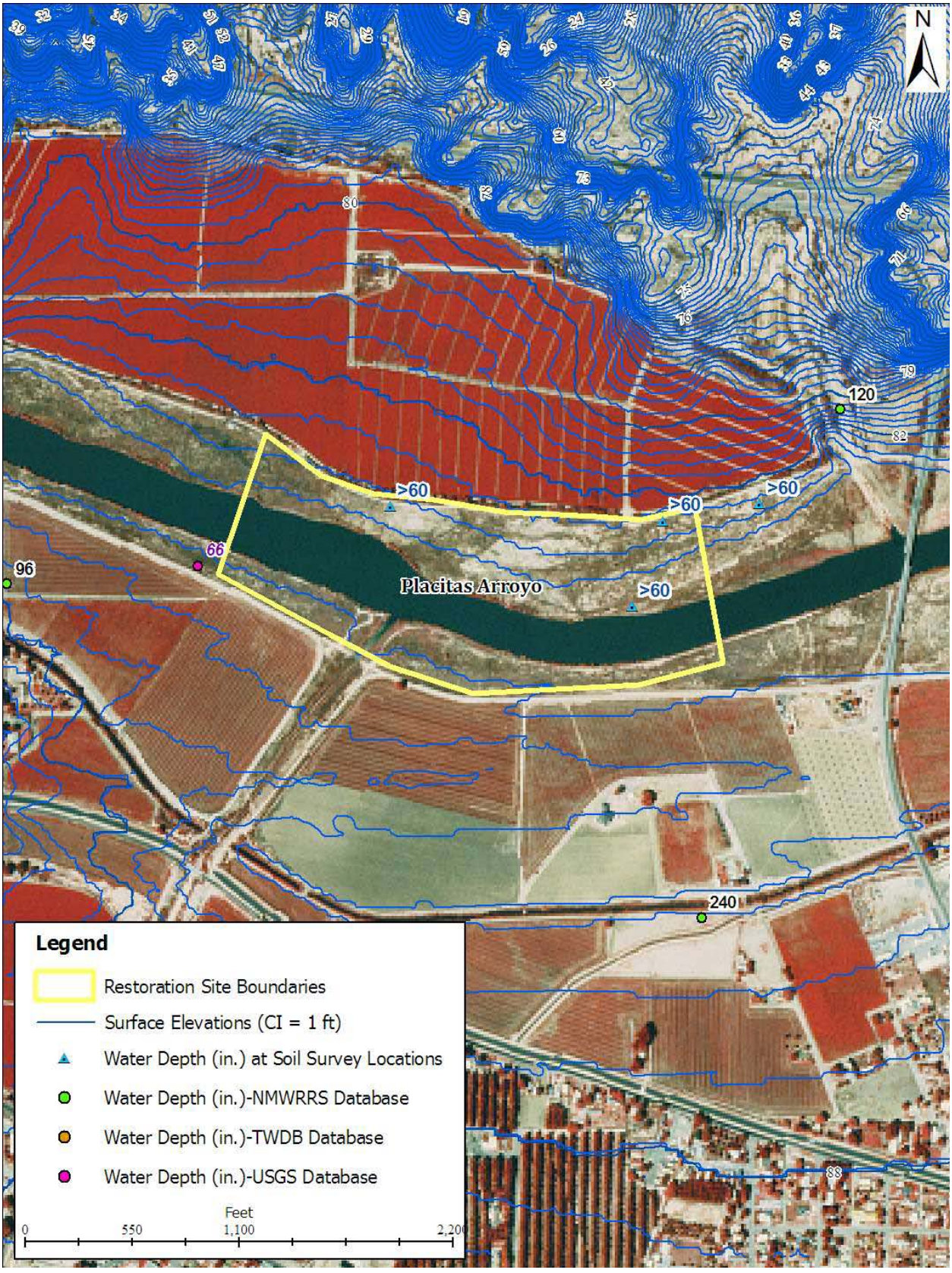

Figure 6. Site 8 – Placitas Arroyo

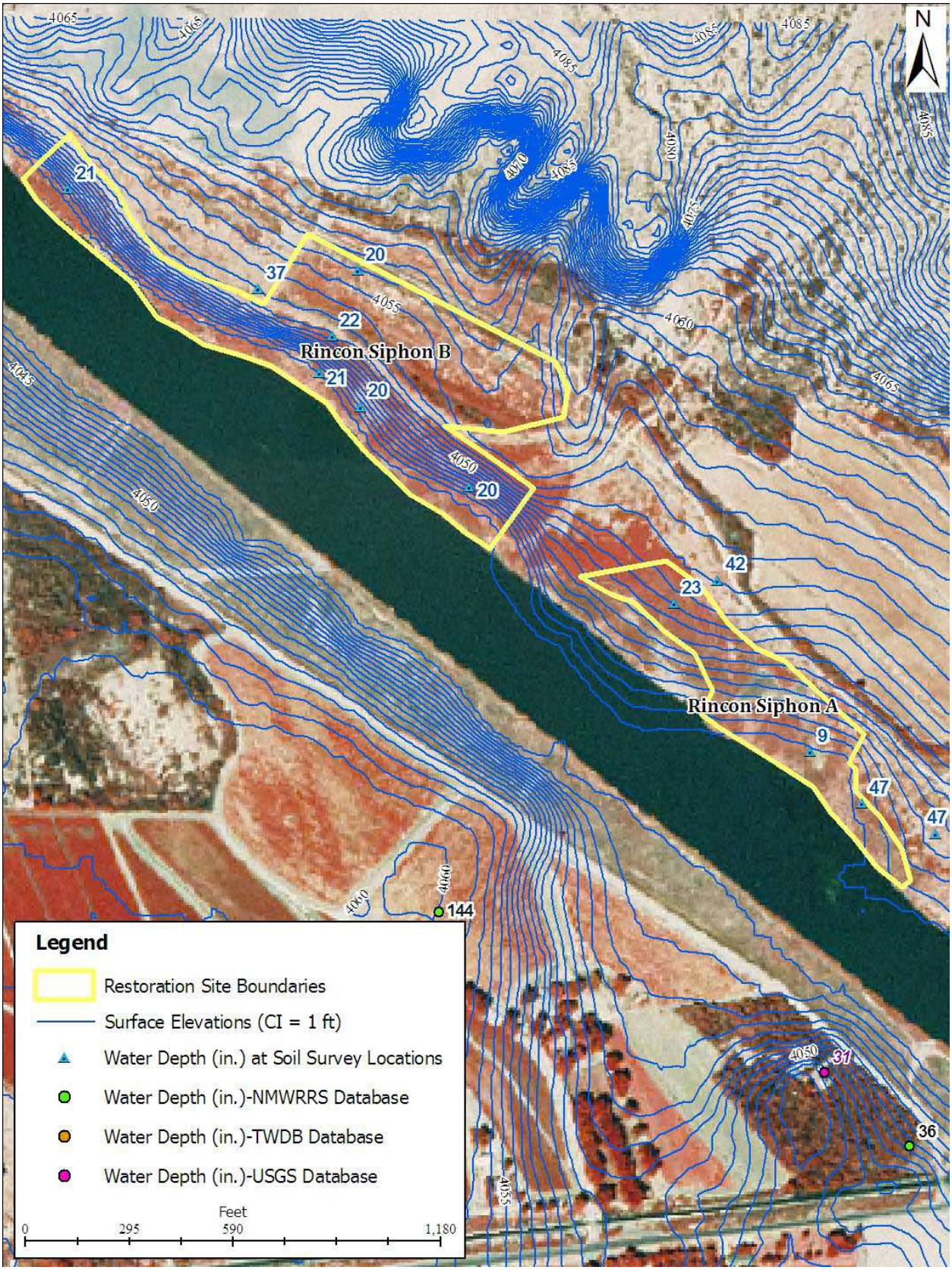

Figure 7. Site 9 – Rincon Siphon

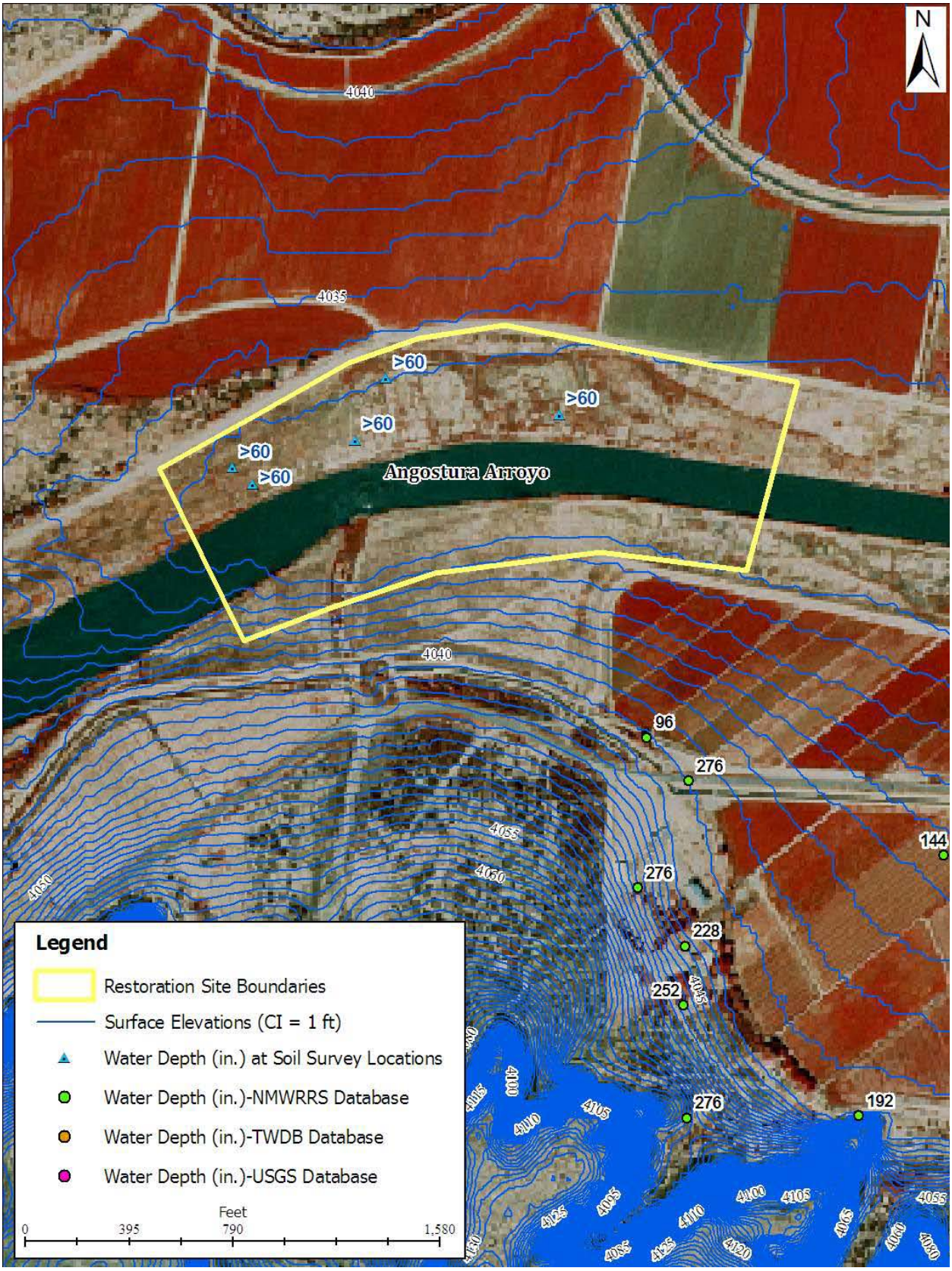

Figure 8. Site 10 – Angostura Arroyo

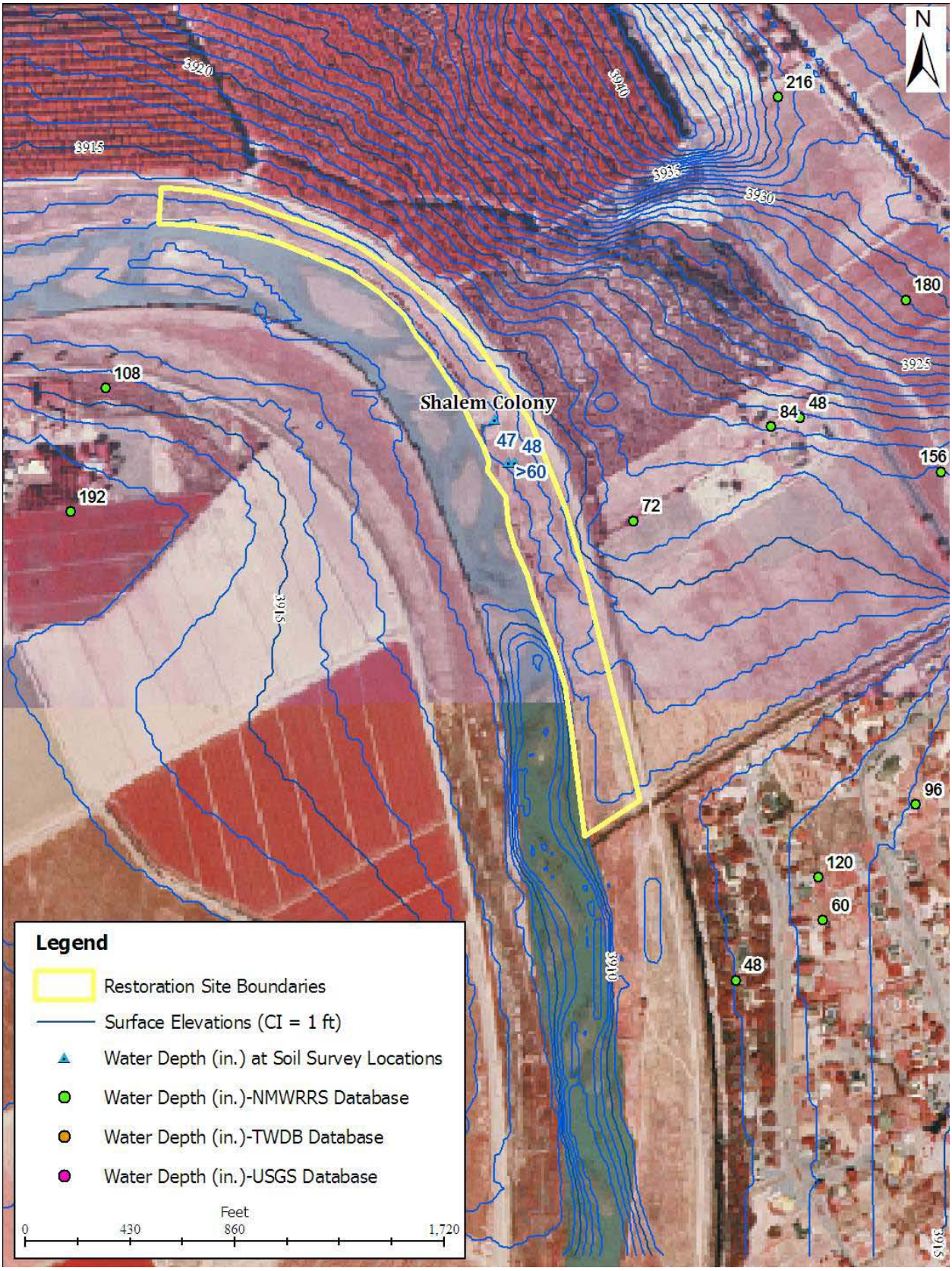

Figure 9. Site 17 – Shalem Colony

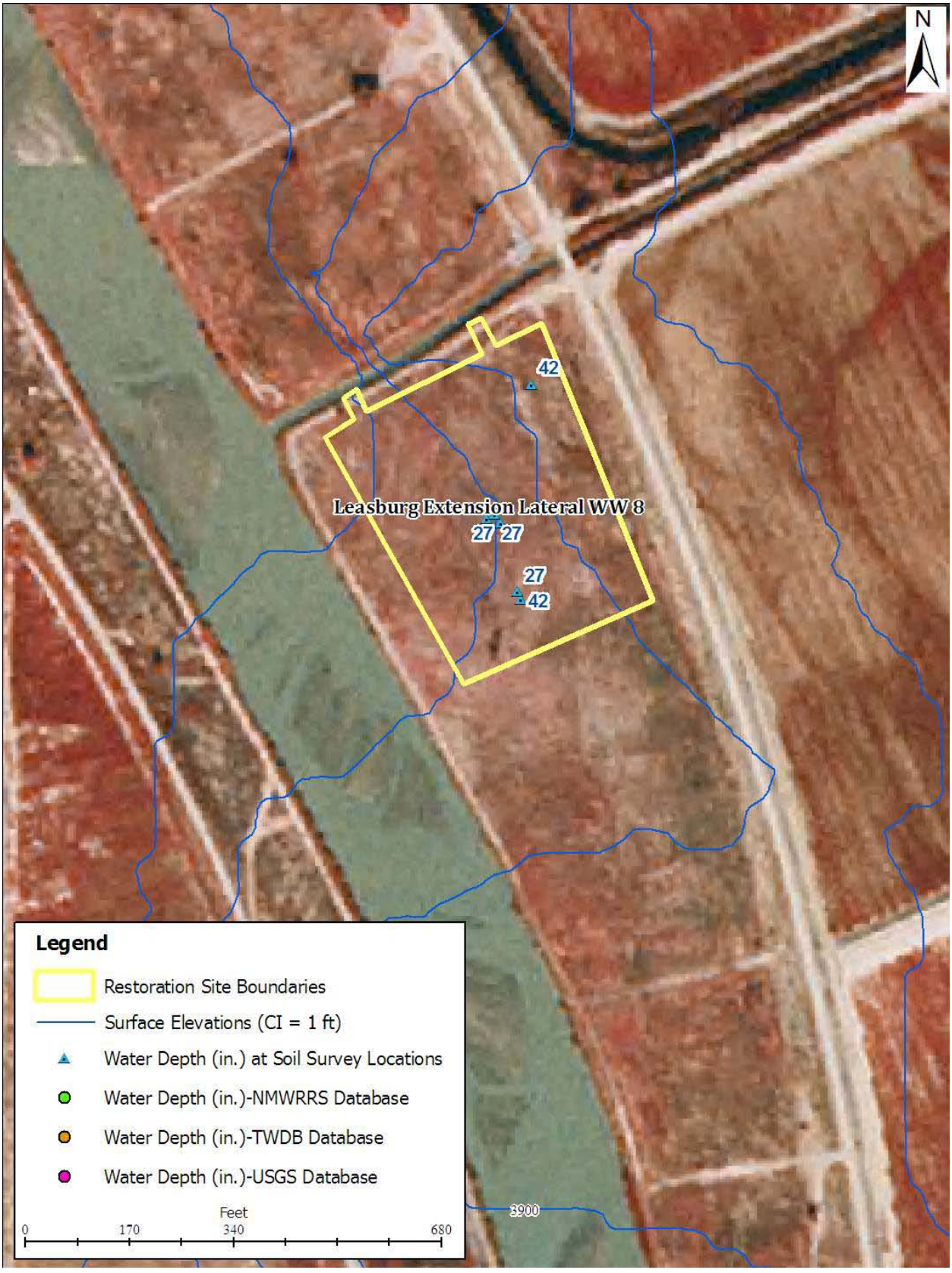

Figure 10. Site 18 – Leasburg Extension Lateral Wasteway 8

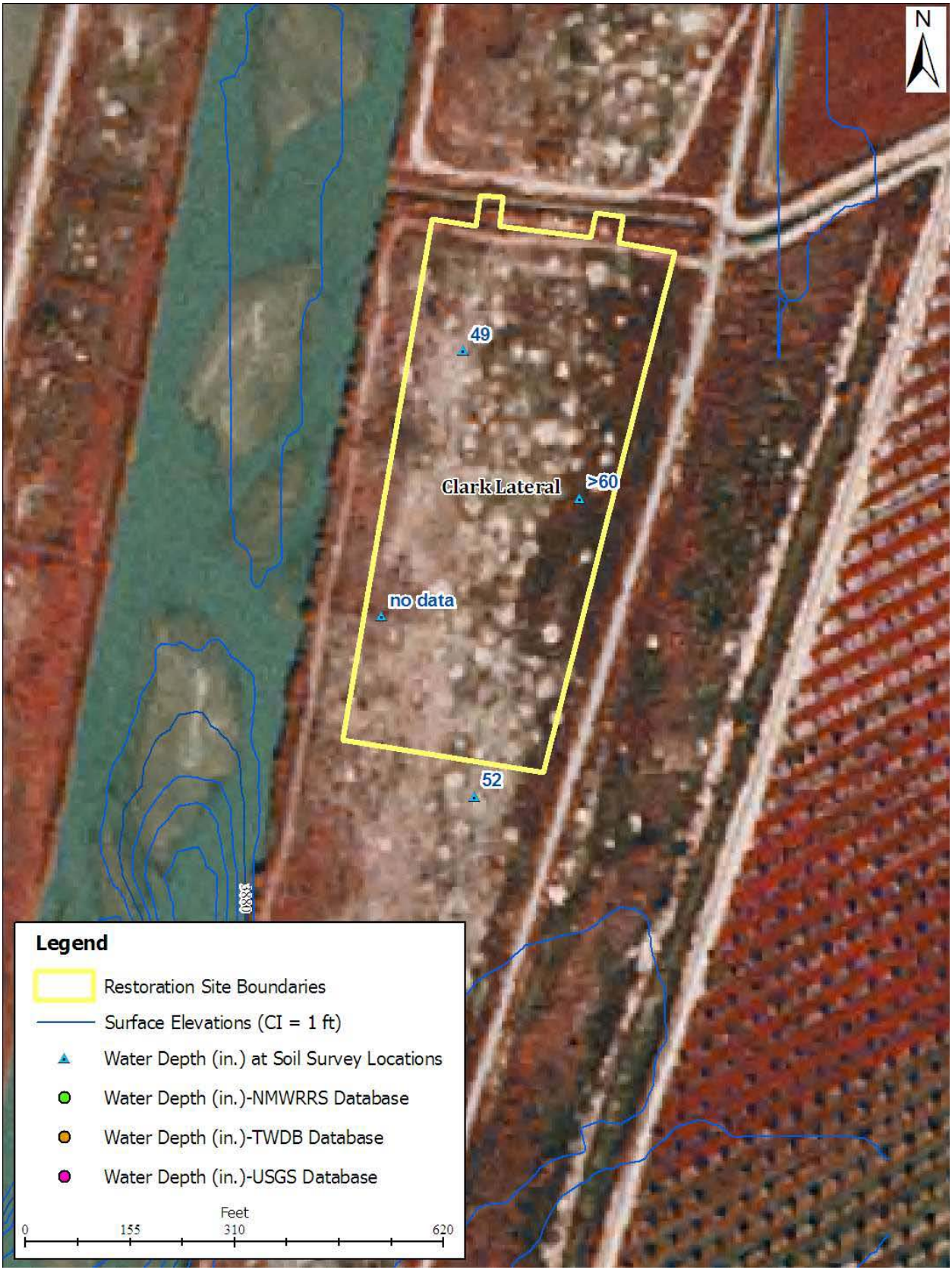

Figure 11. Site 19 – Clark Lateral

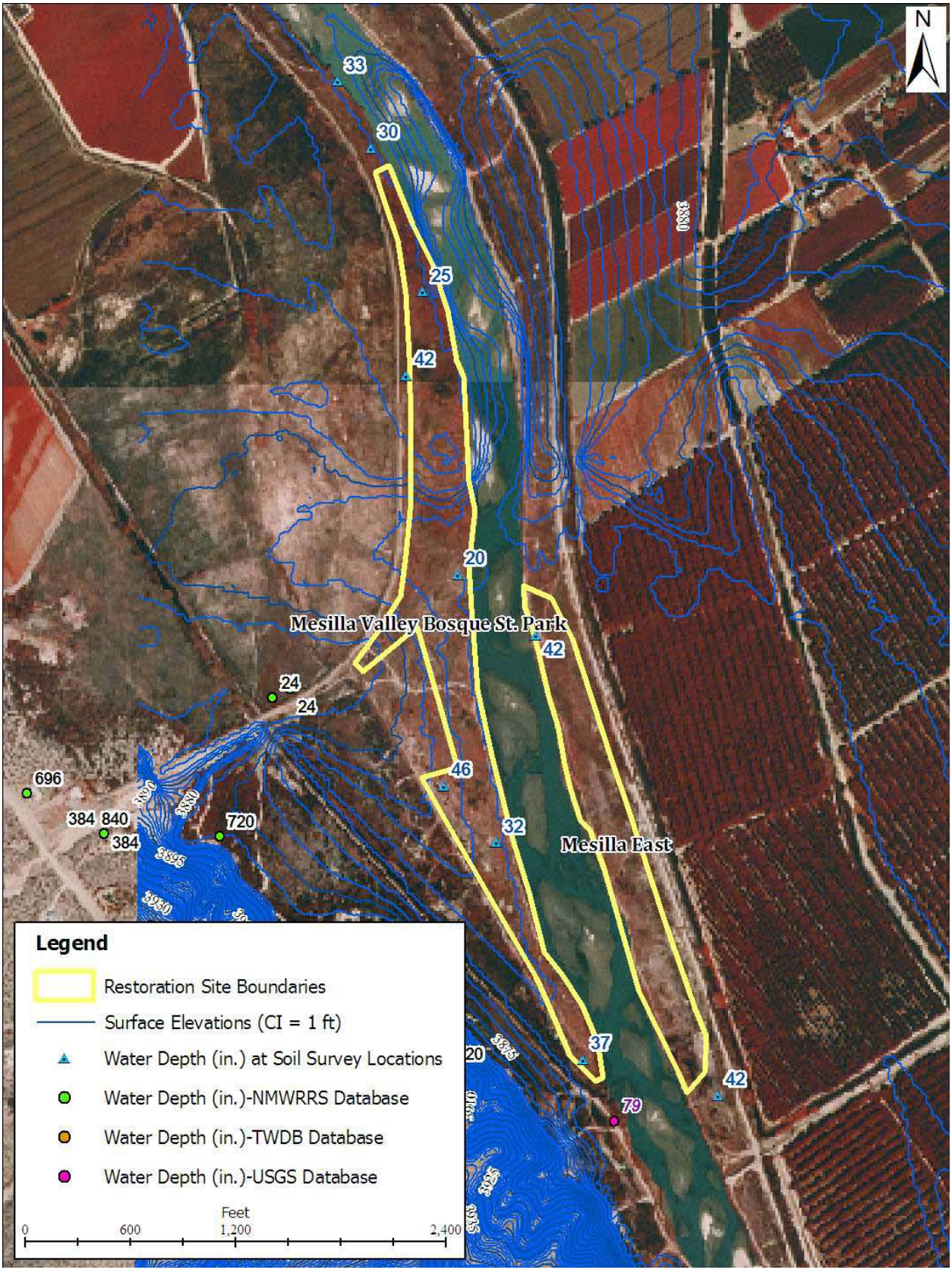

Figure 12. Sites 20 and 21 – Mesilla Valley Bosque State Park and Mesilla East

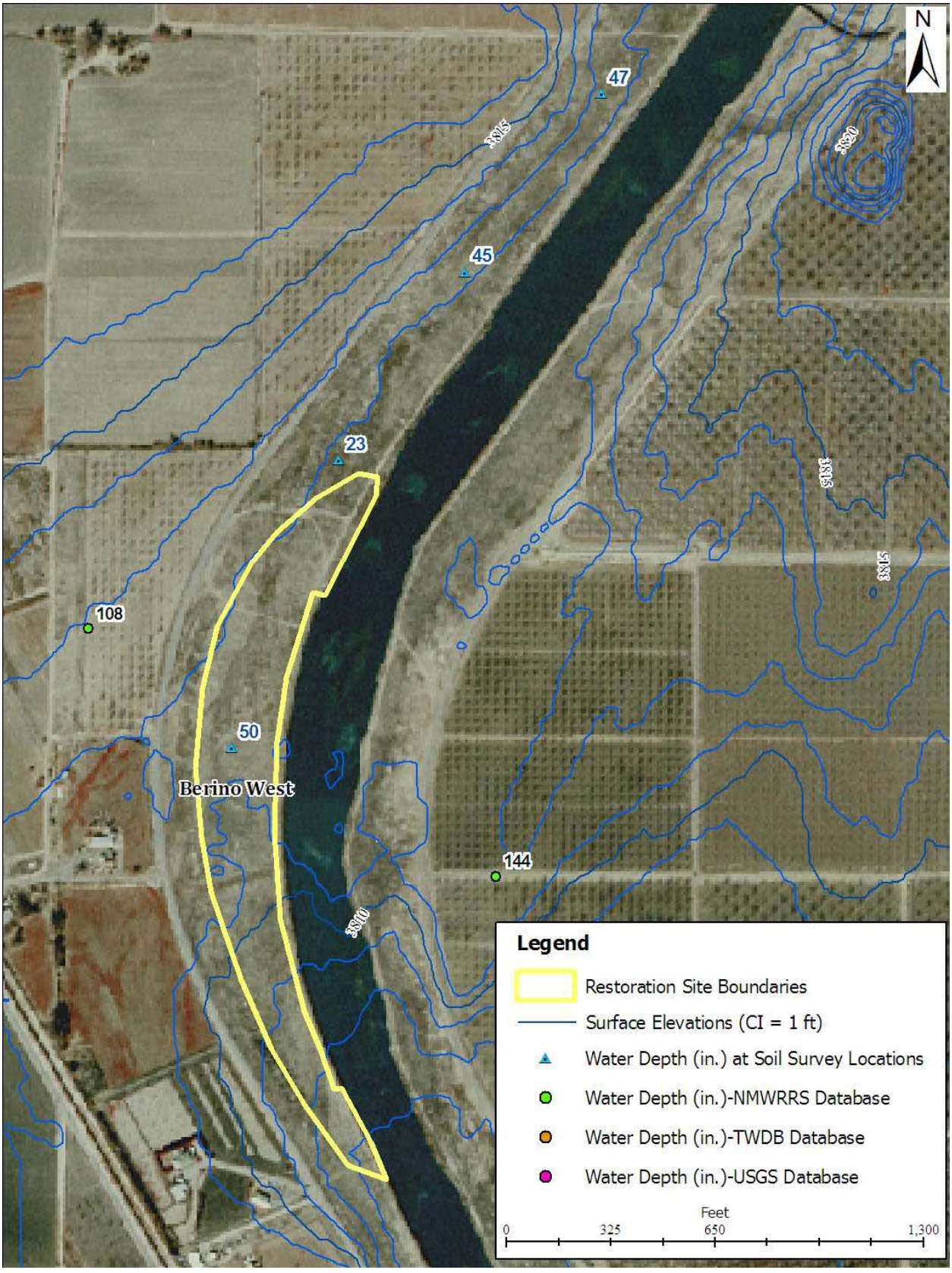

Figure 13. Site 22 – Berino West

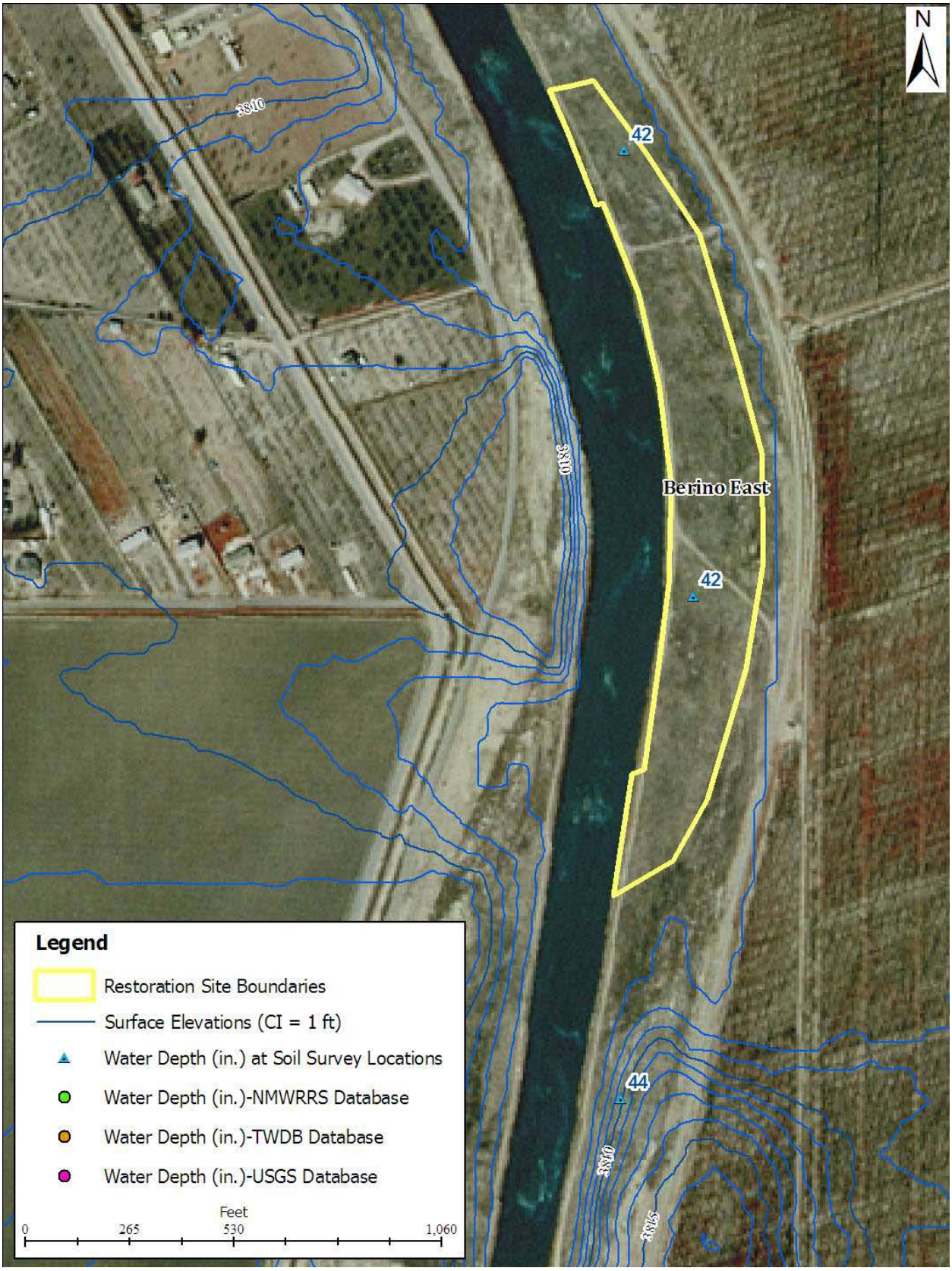

Figure 14. Site 23 – Berino East

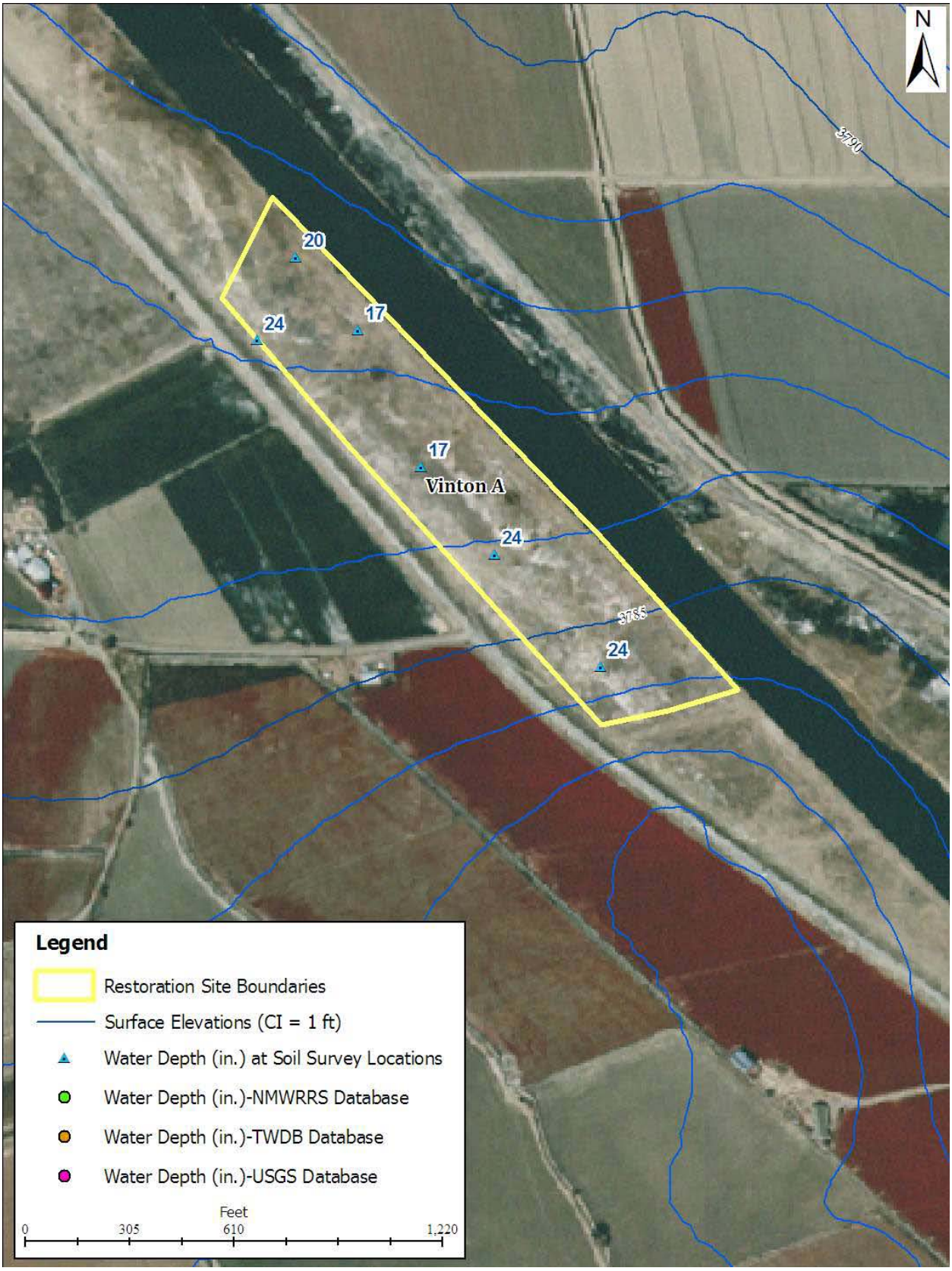

Figure 15. Site 24 – Vinton A

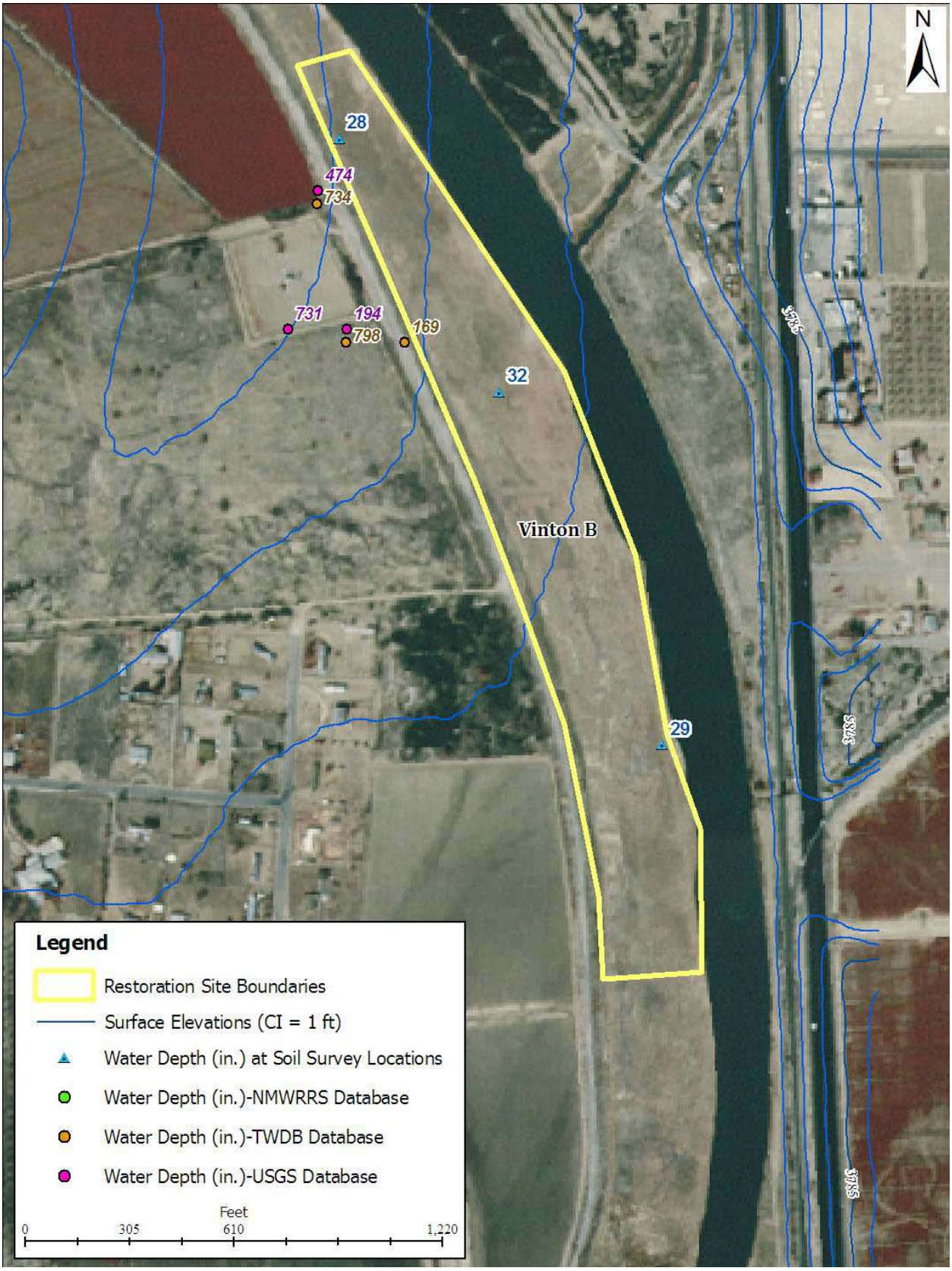

Figure 16. Site 25 – Vinton B

Figure 17. Site 26 – Valley Creek

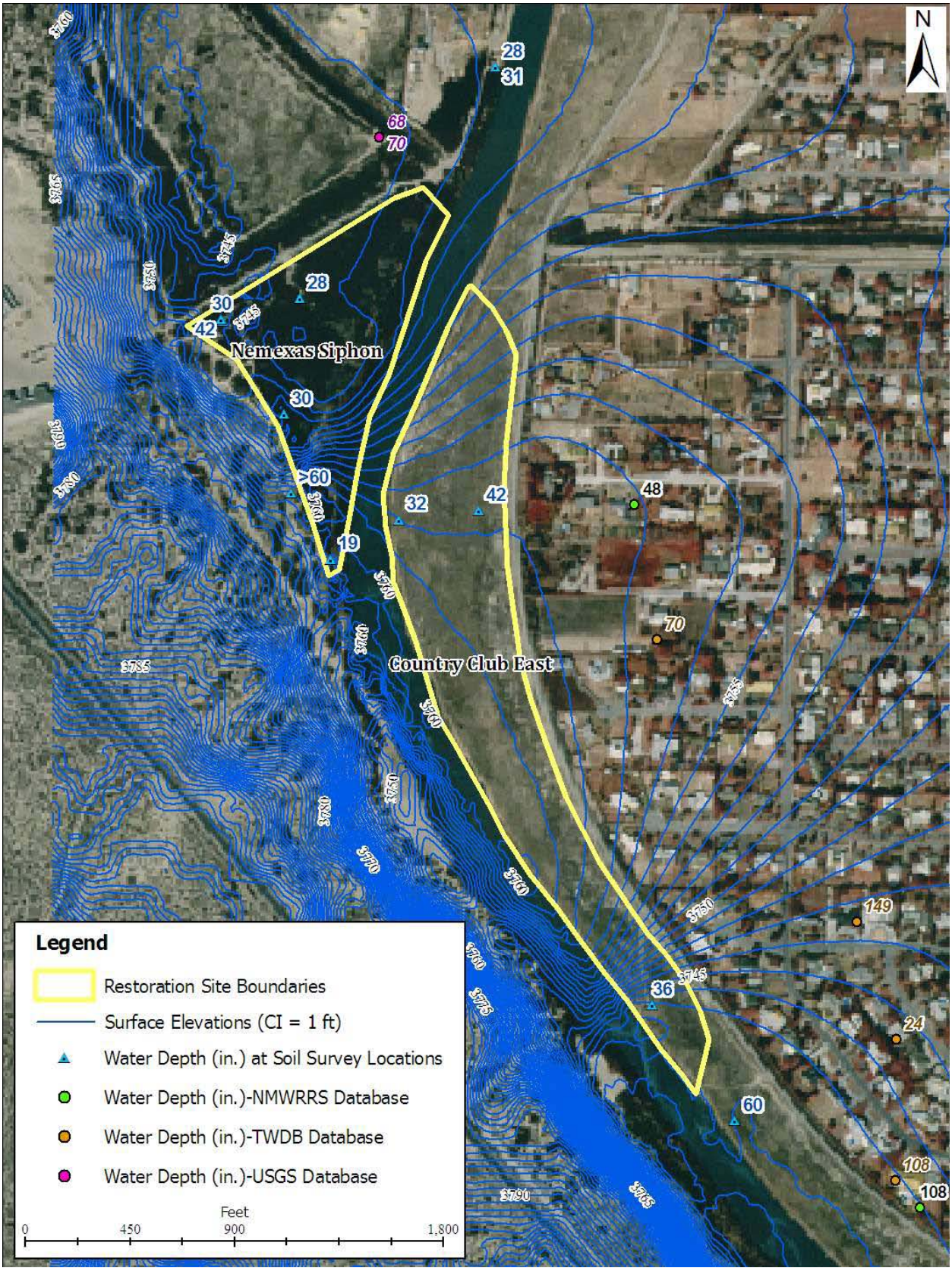

Figure 18. Sites 27 and 28 – Nemexas Siphon and Country Club East

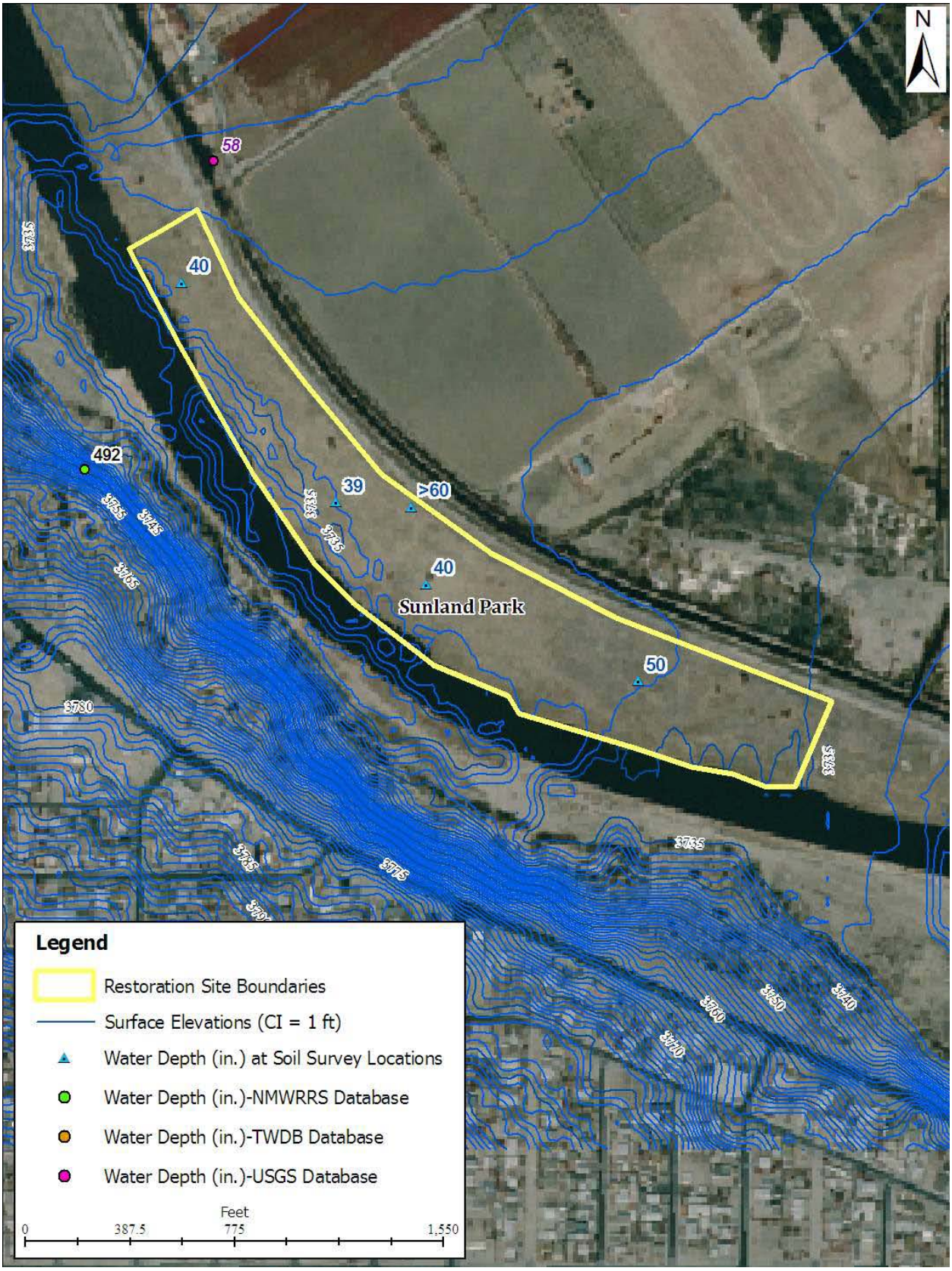

Figure 19. Site 29 – Sunland Park

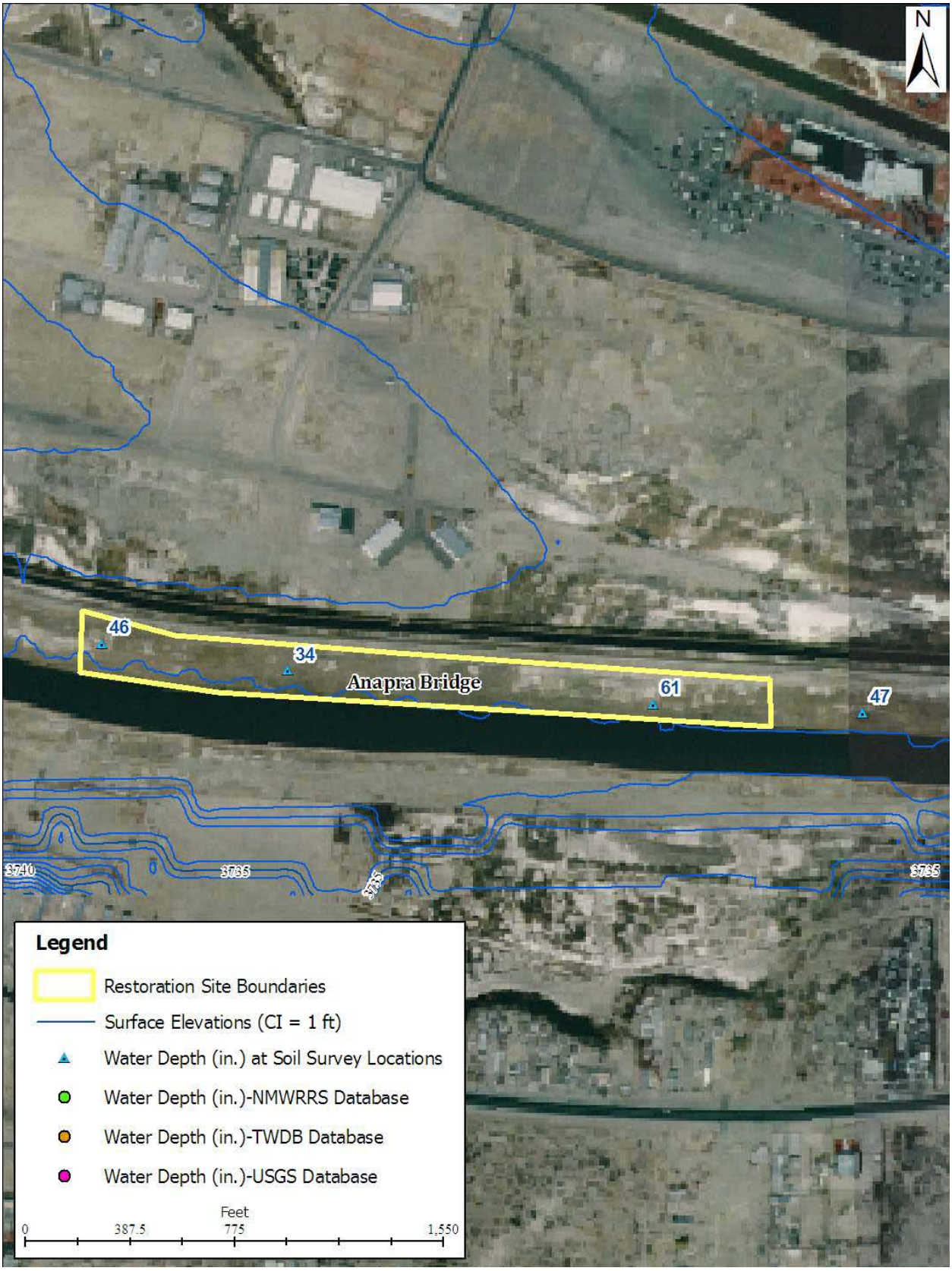

Figure 20. Site 30 – Anapra Bridge