

### 3.3.4 Comparison of Applied and Measured Soil Concentrations

#### 3.3.4.1 Uranium

It was assumed when planning the irrigation program that all the uranium would be deposited in the upper 1-ft of soil (ERG and HYDRO, 1999). It was estimated that water containing 0.44 mg/l of uranium applied at 3 ac-ft/year would conservatively increase the concentration of uranium in the upper 1-ft of soil by 0.92 mg/kg per year. The actual average uranium concentrations in the applied water have always been lower than 0.44 mg/l. Actual irrigation application rates have range from significantly below to slightly above 3 ac-ft/yr.

The predictions of uranium accumulation in the soil have been superseded by actual measurements of uranium concentration in the irrigated areas. The measurements indicate that the applied uranium occurs beyond the upper three feet of the soil profile.

It is reasonable to adopt a cumulative mass balance approach to track the fate of the applied uranium since the beginning of the irrigation program for each area. Actual applied uranium concentrations, application rates of irrigation water, and calculated increases in soil are presented in Tables 3-7 and 3-8. The sums of measured concentrations minus background concentrations (gain) are from Table 3-6. Only the upper 7 feet was summed for the Section 34 clay soils to obtain the gain while the entire 17 feet of the Section 28 and 33 center pivot soils were used.

The calculated data in Tables 3-7 and 3-8 are determined as follows:

a = cumulative masses of uranium applied per irrigation area, mg =  $\Sigma_{2000-2010}[(\text{average concentration in water, mg/l}) (\text{volume of water in ac-ft}) (28.3 \text{ l/ft}^3) (43,560 \text{ ft}^2/\text{ac})]$

b = mass of soil per irrigation area, kg =  $(\text{footage of soil used})(\text{no. of acres})(90 \text{ lbs/ft}^3) (454 \text{ g/lb})(43,560 \text{ ft}^2/\text{ac})(10^{-3} \text{ kg/g})$

c = gain in uranium concentration, mg/kg =  $(\text{sum of measured concentrations of uranium minus mean background concentrations})$

d = measured mass of uranium, mg =  $(b)(c)/\text{footage of soil used}$

e = ratio of measured to applied masses of uranium, unitless =  $d/a$

The assumptions are consistent with those reported previously (ERG and HYDRO, 1999). For example, typical soil density is assumed to be 90 pounds per cubic foot ( $\text{lb/ft}^3$ ).

The above-background concentrations (gain) of uranium in each section, in mg/kg are tabulated in Table 3-6 and are: Section 33 Center Pivot (6.08); Section 33 Flood (1.55); Section 34 (4.88); and Section 28 (3.83). Based on this series of calculations, the ratios of measured to applied masses of uranium in the total footage of soil are: Sections 33 Pivot (1.44), 33 Flood (0.76), 34 (1.00), and 28 (1.02).

In Section 33 Pivot and Section 28, 144 and 102 percent of the applied uranium is accounted for, respectively, indicating that all of the applied uranium is likely still in the soil profile. Gains in the upper 17 feet of soil were used in calculating these percentages. The presence of more applied uranium deeper in the soil profile in these fields may be due to the sandy loam soils, which have less adsorptive capacity than clay soils. On the other hand, most of the uranium applied to Section 34 has been retained in the upper seven feet and this is attributed to the presence of clay soils. Only the results in the upper seven feet are thought to indicate some gain in the treated soil in Section 34. The measured concentrations in Section 33 Flood are thought to not produce a reliable retention value.

Accumulating uranium concentrations for each of the upper three layers in each irrigation area are shown in Figures 3-8 (Sections 33 and 34 Flood), 3-12 (Section 28 Center Pivot) and 3-16 (Section 33 Center Pivot). Each figure is subdivided into upper, middle, and lower intervals. The horizontal line on each figure represents the mean background concentration.

**Table 3-7. Uranium Applied in Irrigation Water**

Year	Uranium Concentration (mg/l)a		Acreages				Volume of Irrigation Water Applied (ft)			
	Section 28	Sections 33/34	Section 28	Section 33 Flood	Section 33 Pivot	Section 34	Section 28 Pivot	Section 33 Flood	Section 33 Pivot	Section 34 Flood
2000	NA	0.27	NA	NA	150	120	NA	NA	2.29	3.1
2001	NA	0.26	NA	NA	150	120	NA	NA	2.11	2.85
2002	0.23	0.23	60	NA	150	120	2.2	NA	2.36	3.3
2003	0.24	0.22	60	NA	150	120	2.57	NA	2.62	3.34
2004	0.27	0.26	60	24	150	120	3.04	1.26	2.85	3.23
2005	0.35	0.27	100	24	150	120	2.38	0.84	2.67	3.13
2006	0.35	0.29	100	NA	150	120	2.33	NA	1.94	2.61
2007	0.36	0.28	100	NA	150	120	2.42	NA	2.86	0.98
2008	0.36	0.24	100	24	150	120	2.76	1.93	2.75	2.69
2009	0.39	0.24	100	24	150	120	1.85	6.13	1.43	1.53
2010	NA	0.136	NA	NA	NA	120	NA	NA	NA	1.67

Notes:

NA = not irrigated

**Table 3-8. Cumulative Buildup of Uranium in Soils**

2010	Section			
	28 Pivot	33 Flood	33 Pivot	34 Flood
Applied Mass of Uranium (mg), a	665,802,264	73,633,517	1,130,664,138	1,039,638,519
Sum of Measured Concentrations Minus Background (mg/kg), c	3.82	1.55	6.08	4.88
Mass of Soil (kg), b	3,025,764,720	469,883,462	4,538,647,080	1,495,083,744
Measured Mass of Uranium (mg), d	679,907,131	56,024,567	1,623,233,779	1,042,286,953
Ratio of Measured to Applied Masses, e	1.02	0.76	1.44	1.00

### 3.3.4.2 Selenium

The applied and measured selenium concentrations in the soil were calculated in a manner similar to that for uranium, and are presented in Tables 3-9 and 3-10.

The above-background concentrations of selenium in each section for the soil layers, in mg/kg, are: Section 33 Center Pivot (0.95); Section 33 Flood 0.28); Section 34 (1.01); and Section 28 (0.81). Based on the same series of calculations shown above in Section 3.3.4.1, the ratios of measured to applied masses of selenium in the soil are: Sections 33 Pivot (0.74), 33 Flood (0.71), 34 (0.67), and 28 (0.94).

In the Section 28 Pivot nearly all the applied selenium is accounted for. The 2010 selenium results indicate that some of the applied selenium may have moved beyond the 17 foot interval of soil.

Actual selenium measurements are also shown in Figures 3-10 (Sections 33 and 34 Flood), 3-14 (Section 28 Center Pivot) and 3-18 (Section 33 Center Pivot). Each figure is subdivided into upper, middle, and lower intervals. The horizontal lines on each figure represent the mean background concentration of each layer.

There are indications that selenium, when retained, may partly be in a dissolved phase, rather than being completely absorbed in soils. A review of Figures 3-11 through 3-13 indicates that some retention of selenium appears to be occurring. Only 32, 52 and 48 percent of the chloride concentration applied was measured in the soil in 2009 for Sections 28, 33 and 34, respectively. These percentages are much less than those observed for selenium, showing that a very large percentage of the chloride added to the Section 28, 33 and 34 irrigation areas was not retained in the soil interval. The higher percentage for selenium indicates some retention of this constituent in the soil profile.

**Table 3-9. Selenium Applied in Irrigation Water**

Year	Selenium Concentration (mg/l)a		Acreages				Volume of Irrigation Water Applied (ft)			
	Section 28	Sections 33/34	Section 28	Section 33 Flood	Section 33 Pivot	Section 34	Section 28 Pivot	Section 33 Flood	Section 33 Pivot	Section 34 Flood
2000	NA	0.12	NA	NA	150	120	NA	NA	2.29	3.1
2001	NA	0.1	NA	NA	150	120	NA	NA	2.11	2.85
2002	0.08	0.1	60	NA	150	120	2.2	NA	2.36	3.3
2003	0.08	0.08	60	NA	150	120	2.57	NA	2.62	3.34
2004	0.07	0.09	60	24	150	120	3.04	1.26	2.85	3.23
2005	0.08	0.06	100	24	150	120	2.38	0.84	2.67	3.13
2006	0.08	0.07	100	NA	150	120	2.33	NA	1.94	2.61
2007	0.08	0.06	100	NA	150	120	2.42	NA	2.86	0.98
2008	0.07	0.05	100	24	150	120	2.76	1.93	2.75	2.69
2009	0.07	0.05	100	24	150	120	1.85	6.13	1.43	1.53
2010	NA	0.045	NA	NA	NA	120	NA	NA	NA	1.67

Notes: a. 2003 concentration of selenium is assumed. The value was reported as <0.005 mg/l, which is assumed to be a laboratory artifact.

NA = not irrigated

**Table 3-10. Cumulative Buildup of Selenium in Soils**

2010	Section			
	28 Pivot	33 Flood	33 Pivot	34 Flood
<b>Applied Mass of Selenium (mg), a</b>	154,061,449	16,769,318	344,768,797	323,256,112
<b>Sum of Measured Concentrations Minus Background (mg/kg), c</b>	0.81	0.28	0.95	1.01
<b>Mass of Soil (kg), b</b>	3,025,764,720	555,316,819	4,538,647,080	1,495,083,744
<b>Measured Mass of Selenium (mg), d</b>	144,168,790	11,960,670	253,630,278	215,719,226
<b>Ratio of Measured to Applied Masses, e</b>	0.94	0.71	0.74	0.67

### 3.3.5 Summary of Soil Concentration Comparison

The data collected to date indicate that soil attenuation of uranium is of the same order of magnitude as that predicted by the pre-operational model.

The soil properties and method of irrigation differed for the Section 33 and 28 sites and the Section 33 flood and Section 34 flood areas. The irrigation water for the Section 33 and 28 sites was applied using center pivot systems while Section 34 was flood irrigated. An additional 24 acres of flood irrigation area was added in eastern Section 33 at the beginning of the 2004 season. The small incremental changes in concentrations in uranium and selenium along with the natural variability in both the center pivot and flood irrigation areas make it difficult to accurately determine the amount of increase in concentrations in the soil from year to year. The 2001 and 2002 data indicate that the soil concentrations were not continuing to increase with time for either type of irrigation among the three irrigation sites. The 2003 and 2004 data show some increase in Sections 33 and 34 while concentrations slightly increased in 2004 in Section 28. A slight decrease was observed at all three sites in 2005. In 2006, an increase was observed in all sites except Section 28 and 33, where selenium decreased slightly in the two lower intervals. Concentrations generally increased or were fairly steady in 2007, followed by a general decrease in 2008. Uranium concentrations in 2009 increased in the Section 33 and 28 soils. The upper foot uranium concentration in the two center pivot soils decreased in 2010, possibly due to the lack of irrigation in 2010. Future sampling may further diminish the effects of analytical and natural variability and more clearly reveal trends in the accumulation of uranium and selenium.

The 2010 results indicate that uranium is being retained in upper seven feet with a small amount of retention in some intervals down to the top of the basalt in Sections 28 and 33, whereas uranium is only being retained in the upper four feet interval in the Section 34 flood area. The 2010 results also indicate selenium is being retained to similar depths but these results need to be confirmed with future measurements.

In 2010, the measured uranium soil concentrations in the irrigated areas ranged from 0.19 to 4.64 mg/kg. The laboratory reported uranium MDL and PQL in 2003 and 2004 were 0.03 and 0.1



mg/kg, respectively and 0.05 and 0.3 mg/kg in 2005 to 2009. The selenium concentrations in the irrigated areas for 2009 ranged from less than 0.05 to 0.97 mg/kg. The laboratory reported selenium MDL and PQL for the soil analysis was 0.05 and 0.3 mg/kg.

The mass balance approach to tracking uranium and selenium in soil indicates that irrigation can continue without concern for excessive accumulation of these constituents.

### **3.4 Observed Soil Moisture Concentrations**

Lysimeters have been installed in the irrigation field areas to collect soil moisture samples and enable the measurement of the soil moisture constituent concentrations. The lysimeters were installed in augured holes at the desired depths. The porous cups were sand packed with a very fine flour sand to enhance their ability to pull moisture into the cup. A vacuum is placed on the lysimeter, which causes the soil moisture water to enter the cup. The soil moisture samples are then collected by purging the lysimeter cup. Lysimeters have been placed in each of the irrigation areas. Table 3-11 presents the completion information for the eight lysimeters in Section 33. Table 3-12 presents the lithology of the alluvium at each lysimeter. The sand pack interval is given in the fourth column of Table 3-11 while the depth to the top of the basalt is noted in the third column. A bentonite seal was placed above the sand pack that exists around the lysimeter to prevent soil moisture from readily moving down the annulus. Tables 3-13 and 3-14 present the soil moisture concentration data collected from the lysimeters.

#### **3.4.1 Section 34**

Four lysimeters have been placed in the clay soils in Section 34 and 33 flood areas. Lysimeters LY34-1, LY34-2 and LY34-3 are in the Section 34 flood while LY34-4 is in the Section 33 flood area. Figure 3-1 shows the location of these lysimeters. Three lysimeters were installed in the Section 34 area and were completed at intervals 8-10 feet below the land surface. The completion interval for the 34-4 lysimeter was 10-11 feet (see Table 3-11 for completion details). The Section 34 lysimeters were installed in October 2009. LY-34-1 produced a sample in October and December of 2009 and then continual from February of 2010. Lysimeters LY34-2 and LY34-3 have produced samples for each month. LY34-4 produced a sample for each month until February of 2010 and then again in August and September of 2010.

The soil moisture concentration time plot for lysimeter LY34-1 is presented in Figures 3-20 and 3-21. These plots show that the TDS, sulfate, uranium and selenium have been typically 3500, 1500, 0.33 and 0.06 mg/l respectively in 2010. The higher values in October and November of 2010 need additional samples before they are given much significant. Figure 3-22 presents TDS, sulfate and chloride concentrations for lysimeter LY34-2. These concentrations generally show an increasing trend with time and a TDS and a sulfate of 4400 and 1900 mg/l are thought to best represent the 2010 values. The uranium, selenium and molybdenum concentrations for lysimeter LY34-2 are presented in Figure 3-23 which shows an increasing trend for uranium and selenium but a decreasing trend for molybdenum. This data indicates that a uranium and selenium of 0.22 and 0.06 are representative of the 2010 values for LY34-2. The results from lysimeters LY34-3 are fairly similar (see Figures 3-24 and 3-25). The TDS, sulfate, chloride, uranium and selenium concentrations of 2800, 1200, 0.3 and 0.08 mg/l are representative of the

2010 values for LY34-3. Figures 3-25 and 3-26 present the concentration plots for lysimeter LY34-4 which is located in the Section 33 Flood Area. This data shows increasing trends for TDS, sulfate, chloride and selenium concentrations and relatively steady concentrations for uranium and molybdenum except for a higher molybdenum in September of 2010.

**Table 3-11. Irrigation Field Lysimeter Completion Information**

LYSIMETER NUMBER	LYSIMETER INTERVAL (FT-LSD)	DEPTH TO TOP OF BASALT (FT-LSD)	INTERVAL OF SAND PACK (FT-LSD)	INTERVAL OF BENTONITE SEAL (FT-LSD)
SECTION 33				
LY1	16-17	17	15-17	0-15
LY2	15-16	16	14-16	0-14
LY3	6-7	7	5-7	0-5
LY3M	30-31	7	29-31	0-29
LY4	14-15	15	13-15	0-13
LY4MU	24-25	14	24-25	0-24
LY4ML	44-45	14	44-45	25-44
LY5	3-4	4	3-4	0-3
SECTION 28				
LY28-1	15-16	16	14-16	0-14
LY28-1M	20-21	16	19-21	0-19
LY28-2	6-7	7	5-7	0-5
LY28-2M	20-21	14	19-21	0-19
LY28-3	9-10	10	8-10	0-8
SECTION 34 AND 33 FLOOD				
LY34-1	8-9	DNE	7-9	0-7
LY34-2	10-11	DNE	9-11	0-9
LY34-3	10-11	DNE	9-11	0-9
LY34-4	10-11	26	8-10	0-8
NOTE: DNE= DOES NOT EXIST AT THIS LOCATION				

**Table 3-12. Lithology of the Alluvium at the Lysimeters**

<b>SECTION 33 SOUTH PIVOT</b>			
<b>LY33-1</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-1	SAND/SILT/CLAY	WET	BROWN
1-2.5	SAND/SILT	WET	BROWN
2.5-4	SAND/CLAY	VERY MOIST	RED
4-5	SAND/CLAY	VERY MOIST	RED
5-7	SAND/CLAY	VERY MOIST	RED
7-9	SAND/CLAY	VERY MOIST	RED
9-11	SAND/CLAY	VERY MOIST	RED
11-12	SAND/CLAY	VERY MOIST	RED
12-12.8	SAND/CLAY	VERY MOIST	RED
12.8-13.8	CLAY	VERY MOIST	BROWN
13.8	BASALT		
<b>SECTION 33 SOUTH PIVOT</b>			
<b>LY33-2</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-2	VERY FINE SAND/SILT/CLAY	MOIST	RED
2-4	VERY FINE SAND/SILT/CLAY	MOIST	RED
4-5.5	VERY FINE SAND	MOIST	RED
5.5-6	VERY FINE SAND	MOIST	RED
6-8	VERY FINE SAND	MOIST	RED
8-10	VERY FINE SAND	MOIST	RED
10-12	VERY FINE SAND	MOIST	RED
12-14	CLAY	MOIST	RED
14-16	CLAY	MOIST	RED
16-16.5	CLAY	MOIST	RED
16.5	BASALT		
<b>SECTION 33 SOUTH PIVOT</b>			
<b>LY33-3/M</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-1	SAND/SILT	DRY	RED
1-1.5	V.F. SAND	MOIST	RED
1.5-2	V.F. SAND	MOIST	RED
2-4	V.F. SAND	MOIST	RED
4-6	V.F. SAND	MOIST	RED
6-6.6	V.F. SAND	MOIST	RED
6.6-35	BASALT		

**Table 3-12. Lithology of the Alluvium at the Lysimeters (continued)**

<b>SECTION 33 SOUTH PIVOT</b>			
<b>LY33-4/M</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-2	V.F. SAND	DRY	RED
2-4	V.F. SAND	DRY	RED
4-6	V.F. SAND	DRY	RED
6-8	V.F. SAND	DRY	RED
8-10	V.F. SAND	DRY	RED
10-12	V.F. SAND	DRY	RED
12-14	V.F. SAND	DRY	RED
14-25	BASALT	MOIST	
25-50	BASALT		
<b>SECTION 33 SOUTH PIVOT</b>			
<b>LY33-5</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-1	CLAY	DRY	RED
1-2	CLAY	DAMP	RED
2-3	CLAY	DAMP	RED
3-3.5	CLAY	DAMP	RED
3.5	BASALT		

**Table 3-12. Lithology of the Alluvium at the Lysimeters (continued)**

<b>SECTION 33/34 FLOOD</b>			
<b>LY34-1</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-1	CLAY/SAND	DAMP	BROWN
1-2	CLAY	DAMP	BROWN
2-3	CLAY/SAND	DAMP	BROWN
3-4	SAND	DAMP	BLACK
4-5	SAND/LITTLE CLAY	MOIST	GREY
5-6	SAND	MOIST	GREY
6-7	SAND/GRAVEL	MOIST	GREY
7-8	CLAY/SAND	MOIST	TAN/GREY
8-9	CLAY/SAND	MOIST	TAN/ORANGE
9-10	SAND	MOIST	TAN/ORANGE
<b>SECTION 33/34 FLOOD</b>			
<b>LY34-2</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-1	CLAY	MOIST	BROWN
1-2	CLAY	MOIST	BROWN
2-3	CLAY/LITTLE SAND	SOME MOISTURE	BROWN
3-4	CLAY/SAND	DRY	LIGHT BROWN
4-5	SAND	DRY	GREY/TAN
5-6	SAND	DRY	GREY
6-7	F. SAND/LITTLE CLAY	SOME MOISTURE	GREY/ORANGE
7-8	F. SAND/LITTLE CLAY	SOME MOISTURE	GREY/ORANGE
8-9	F. SAND/LITTLE CLAY	MOIST	BROWN/ORANGE
9-10	CLAY/FINE SAND	MOIST	BROWN/ORANGE
10-11	CLAY/FINE SAND	MOIST	BROWN
11-12	SAND/LITTLE CLAY	MOIST	BROWN/TAN
<b>SECTION 33/34 FLOOD</b>			
<b>LY34-3</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-1	CLAY	DAMP	BROWN
1-2	CLAY	DAMP	BROWN
2-3	CLAY/SAND	DAMP	DARK BROWN
3-4	FINE SAND	MOIST	BROWN/BLACK
4-5	SAND	DAMP	BROWN/TAN
5-6	SAND	DAMP	TAN
6-7	SAND/CLAY	MOIST	TAN/ORANGE
7-8	CLAY/SAND	MOIST	GREY/ORANGE
8-9	CLAY/SAND	MOIST	BROWN/ORANGE
9-10	CLAY/SAND	MOIST	BROWN/RED
10-11	SAND/GRAVEL	MOIST	TAN/ORANGE

**Table 3-12. Lithology of the Alluvium at the Lysimeters (continued)**

SECTION 33/34 FLOOD			
LY34-4			
SAMPLE DEPTH	SOIL TYPE	MOISTURE CONT.	COLOR
0-1	CLAY	DRY	BROWN
1-2	CLAY	DRY	BROWN
2-3	CLAY	DRY	BROWN
3-4	CLAY/SAND	DRY	BROWN/GREY
4-5	SAND/CLAY	DRY	LIGHT GREY
5-6	SAND/CLAY	DRY	LIGHT GREY
6-7	SAND	DRY	LIGHT GREY
7-8	SAND	DRY	LIGHT GREY
8-9	CLAY/SAND	SOME MOISTURE	BROWN/LIGHT GREY
9-10	CLAY/SAND	MOIST	BROWN/LIGHT GREY
10-11	CLAY/SAND	MOIST	BROWN/LIGHT GREY
11-12	SAND/CLAY/COARSE	SOME MOISTURE	BROWN/LIGHT GREY
12-13	SAND/CLAY/COARSE	SOME MOISTURE	BROWN

**Table 3-12. Lithology of the Alluvium at the Lysimeters (continued)**

<b>SECTION 28 NORTH PIVOT</b>			
<b>LY28-1</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-1	SAND	MOIST	LIGHT BROWN
1-2	SAND	MOIST	LIGHT BROWN
2-3	SAND	MOIST	LIGHT BROWN
3-4	SAND	DAMP	LIGHT BROWN
4-5	SAND	DAMP	LIGHT BROWN
5-6	SAND/LITTLE CLAY	DAMP	LIGHT BROWN /ORANGE
6-7	SAND/LITTLE CLAY	MOIST	BROWN
7-8	SAND/LITTLE CLAY	MOIST	BROWN
8-9	SAND/CLAY	MOIST	BROWN
9-10	SAND/CLAY	MOIST	TAN
10-11	CLAY/SAND	MOIST	TAN
11-12	CLAY/LITTLE SAND	DAMP	BROWN/ORANGE
12-13	CLAY/LITTLE SAND	DAMP	BROWN/RED
13-14	CLAY/LITTLE SAND	DAMP	BROWN/TAN
14-15	CLAY	DAMP	TAN
15-15.6	CLAY	DAMP	TAN
15.6	BASALT		
<b>SECTION 28 NORTH PIVOT</b>			
<b>LY28-2</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-1	SAND	MOIST	BROWN
1-2	SAND/CLAY	MOIST	BROWN
2-3	SAND/CLAY	DAMP	LIGHT BROWN
3-4	SAND/CLAY	DAMP	BROWN /ORANGE
4-5	SAND	DAMP	BROWN/RED
5-6	SAND/CLAY	DAMP	BROWN/GREY
6-7	CLAY	DAMP	BROWN /ORANGE
7-7.3	CLAY	DAMP	BROWN /ORANGE
7.3	BASALT		
<b>SECTION 28 NORTH PIVOT</b>			
<b>LY28-3</b>			
<b>SAMPLE DEPTH</b>	<b>SOIL TYPE</b>	<b>MOISTURE CONT.</b>	<b>COLOR</b>
0-1	F. SAND	MOIST	LIGHT BROWN
1-2	SAND	MOIST	BROWN
2-3	SAND/CLAY	MOIST	BROWN
3-4	SAND/CLAY	DAMP	BROWN
4-5	SAND/CLAY	DAMP	LIGHT BROWN
5-6	SAND/CLAY	DAMP	BROWN/RED
6-7	CLAY/SAND	DAMP	BROWN/TAN
7-8	CLAY	DAMP	BROWN/TAN
8-8.6	CLAY	DAMP	BROWN
8.6	BASALT		

TABLE 3-13. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

Ca THROUGH ION_BAL													
Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (µmhos/cm)	Ion_B (ratio)
LY1	7/22/2009	ENER	---	---	---	---	---	---	121	337	1240	---	---
	8/13/2009	ENER	---	---	---	---	---	---	152	543	1530	---	---
	9/23/2009	ENER	201	118	2.90	61.3	529	<1.000	168	489	1500	*2010	0.951
	10/16/2009	ENER	---	---	---	---	---	---	179	508	1550	*2082	---
	11/13/2009	ENER	189	154	2.80	61.5	488	<5.00	218	590	1560	*2270	0.934
	12/18/2009	ENER	230	141	2.60	60.1	467	<5.00	235	647	1640	*2338	0.922
	12/30/2009	ENER	285	127	2.40	61.2	430	<5.00	248	719	1770	*2075	0.940
	1/31/2010	ENER	---	---	---	---	---	---	266	770	1940	*2490	---
	2/22/2010	ENER	---	---	---	---	---	---	275	814	1850	*2560	---
	3/25/2010	ENER	---	---	---	---	---	---	289	840	2100	*2650	---
	4/29/2010	ENER	---	---	---	---	---	---	313	927	2180	*2750	---
	5/31/2010	ENER	---	---	---	---	---	---	321	1020	2360	*2870	---
	6/30/2010	ENER	---	---	---	---	---	---	350	1200	2670	*3136	---
	7/27/2010	ENER	---	---	---	---	---	---	372	1370	2870	*3310	---
LY2	6/24/2009	ENER	---	---	---	---	---	---	225	654	1720	*2308	---
LY4	1/7/2009	ENER	---	---	---	---	---	---	330	1870	4120	---	---
	2/18/2009	ENER	702	138	5.20	412	783	<1.000	353	2050	4150	---	0.934
	3/20/2009	ENER	---	---	---	---	---	---	326	1940	4220	---	---
	4/18/2009	ENER	---	---	---	---	---	---	336	1990	3870	*4522	---
	5/15/2009	ENER	---	---	---	---	---	---	328	1950	3990	---	---
	6/10/2009	ENER	---	---	---	---	---	---	336	1880	3870	*4370	---
	6/24/2009	ENER	---	---	---	---	---	---	324	1920	4180	*4503	---
	7/22/2009	ENER	---	---	---	---	---	---	315	1990	4220	---	---
	8/13/2009	ENER	---	---	---	---	---	---	354	2170	4380	---	---
	9/23/2009	ENER	728	142	3.50	392	842	<1.000	339	2250	4530	*4870	0.928
	10/16/2009	ENER	---	---	---	---	---	---	340	2270	4240	*5040	---
	11/13/2009	ENER	652	147	3.80	430	634	<5.00	338	2220	4170	*5100	0.957
	12/18/2009	ENER	757	149	4.00	425	712	<5.00	343	2260	4170	*5096	1.00
	12/30/2009	ENER	699	153	4.00	488	837	<5.00	342	2260	4250	*3091	0.962

\* Signifies Specific Conductivity from HMC



TABLE 3-13. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

Ca THROUGH ION_BAL													
Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (µmhos/cm)	Ion_B (ratio)
LY4	1/31/2010	ENER	---	---	---	---	---	---	343	2210	4470	*5030	---
	2/22/2010	ENER	---	---	---	---	---	---	331	2160	4140	*5020	---
	3/25/2010	ENER	---	---	---	---	---	---	339	2170	4520	*5020	---
	4/29/2010	ENER	---	---	---	---	---	---	357	2280	4400	*5040	---
	5/31/2010	ENER	---	---	---	---	---	---	349	2300	4410	*5100	---
	6/30/2010	ENER	---	---	---	---	---	---	357	2320	4570	*5100	---
	7/27/2010	ENER	---	---	---	---	---	---	357	2270	4500	*4900	---
	8/31/2010	ENER	---	---	---	---	---	---	363	2190	4160	*4900	---
	9/30/2010	ENER	---	---	---	---	---	---	366	2170	3970	*4850	---
	10/31/2010	ENER	---	---	---	---	---	---	381	2180	4110	*4670	---
	11/30/2010	ENER	---	---	---	---	---	---	383	2100	4150	*4660	---
LY4-ML	4/18/2009	ENER	---	---	---	---	---	---	142	409	---	---	---
	6/24/2009	ENER	---	---	---	---	---	---	684	5510	12000	---	---
	7/22/2009	ENER	---	---	---	---	---	---	650	5460	11600	---	---
	8/13/2009	ENER	---	---	---	---	---	---	663	5050	10400	---	---
	9/23/2009	ENER	180	29.6	6.00	2180	1140	<1.000	629	3460	7340	*9310	0.981
	10/16/2009	ENER	---	---	---	---	---	---	568	2570	5940	*7904	---
	11/13/2009	ENER	166	98.2	11.0	2820	1570	72.0	591	3930	7830	*7250	1.10
	12/18/2009	ENER	113	25.5	5.00	1520	1190	<5.00	562	1760	4520	*6490	1.03
	4/29/2010	ENER	---	---	---	---	---	---	571	1070	3700	*5330	---
	5/31/2010	ENER	---	---	---	---	---	---	567	917	3080	---	---
	6/30/2010	ENER	---	---	---	---	---	---	531	907	3130	---	---
	7/27/2010	ENER	---	---	---	---	---	---	574	866	3190	*4860	---
	8/31/2010	ENER	---	---	---	---	---	---	588	851	3080	*4820	---
	9/30/2010	ENER	---	---	---	---	---	---	580	805	2980	*4760	---
10/31/2010	ENER	---	---	---	---	---	---	575	777	2970	*4660	---	
11/30/2010	ENER	---	---	---	---	---	---	566	751	3180	*4670	---	
LY4-MU	7/22/2009	ENER	---	---	---	---	---	---	660	3240	8210	---	---
	8/13/2009	ENER	---	---	---	---	---	---	903	6990	13900	---	---

\* Signifies Specific Conductivity from HMC

TABLE 3-13. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

Ca THROUGH ION BAL

Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO <sub>3</sub> (mg/l)	CO <sub>3</sub> (mg/l)	Cl (mg/l)	SO <sub>4</sub> (mg/l)	TDS (mg/l)	Cond(calc.) (µmhos/cm)	Ion_B (ratio)
LY4-MU	9/23/2009	ENER	263	90.0	14.0	3510	1580	<1.000	712	6130	11700	*13860	1.000
	10/16/2009	ENER	—	—	—	—	—	—	592	4850	9780	*12060	—
	11/13/2009	ENER	100.0	31.7	5.00	1790	1030	<5.00	584	2210	5160	*10600	1.08
	1/31/2010	ENER	—	—	—	—	—	—	600	2010	5730	*7950	—
	2/22/2010	ENER	—	—	—	—	—	—	631	1280	4630	*6740	—
	3/25/2010	ENER	—	—	—	—	—	—	634	920	4500	*6390	—
	4/29/2010	ENER	—	—	—	—	—	—	674	742	4210	*6200	—
	5/31/2010	ENER	—	—	—	—	—	—	697	694	4090	*6160	—
	6/30/2010	ENER	—	—	—	—	—	—	711	675	4220	*6150	—
	7/27/2010	ENER	—	—	—	—	—	—	717	657	4190	*6050	—
	8/31/2010	ENER	—	—	—	—	—	—	722	662	4140	*6140	—
	9/30/2010	ENER	—	—	—	—	—	—	717	679	4210	*6190	—
LY28-1	10/31/2010	ENER	—	—	—	—	—	—	724	718	4080	*6170	—
	11/30/2010	ENER	—	—	—	—	—	—	724	760	4350	*6280	—
	10/16/2009	ENER	—	—	—	—	—	—	101	358	852	*1286	—
	11/13/2009	ENER	187	74.2	3.80	331	232	<5.00	174	1040	1850	*2650	0.980
	12/18/2009	ENER	308	61.7	3.40	345	399	<5.00	184	1240	2320	*3130	0.942
	12/30/2009	ENER	298	61.4	3.20	354	378	<5.00	180	1220	2460	*3163	0.961
	1/31/2010	ENER	—	—	—	—	—	—	187	1350	2550	*3250	—
	2/23/2010	ENER	—	—	—	—	—	—	186	1350	2450	*3250	—
	3/25/2010	ENER	—	—	—	—	—	—	183	1300	2660	*3240	—
	4/29/2010	ENER	—	—	—	—	—	—	180	1340	2580	*3250	—
	5/31/2010	ENER	—	—	—	—	—	—	191	1350	2550	*3270	—
	6/30/2010	ENER	—	—	—	—	—	—	197	1380	2650	*3280	—
	7/27/2010	ENER	—	—	—	—	—	—	201	1410	2670	*3250	—
	8/31/2010	ENER	—	—	—	—	—	—	200	1360	2610	*3270	—
	9/30/2010	ENER	—	—	—	—	—	—	192	1350	2700	*3310	—
	10/31/2010	ENER	—	—	—	—	—	—	190	1330	2600	*3290	—
	11/30/2010	ENER	—	—	—	—	—	—	191	1310	2660	*3300	—

\* Signifies Specific Conductivity from HMC

TABLE 3-13. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

Ca THROUGH ION_BAL													
Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (µmhos/cm)	Ion_B (ratio)
LY28-1M	10/16/2009	ENER	---	---	---	---	---	---	114	84.0	440	*698	---
LY28-2	10/16/2009	ENER	---	---	---	---	---	---	335	218	954	*1580	---
LY28-2M	10/16/2009	ENER	---	---	---	---	---	---	158	255	773	*1178	---
	11/13/2009	ENER	147	60.5	7.80	106	414	6.00	128	304	937	*1560	1.01
	12/18/2009	ENER	150	54.5	6.90	83.8	447	< 5.00	123	247	980	*1482	0.980
	12/30/2009	ENER	143	51.5	7.30	80.2	438	< 5.00	120	202	939	*1544	1.01
	1/31/2010	ENER	---	---	---	---	---	---	115	158	901	*1320	---
	2/22/2010	ENER	---	---	---	---	---	---	113	132	756	*1280	---
	3/25/2010	ENER	---	---	---	---	---	---	107	111	658	*1260	---
	4/29/2010	ENER	---	---	---	---	---	---	120	106	778	*1250	---
	5/31/2010	ENER	---	---	---	---	---	---	110	95.0	787	*1300	---
	6/30/2010	ENER	---	---	---	---	---	---	112	93.0	847	*1290	---
	7/27/2010	ENER	---	---	---	---	---	---	109	89.0	842	*1230	---
	8/31/2010	ENER	---	---	---	---	---	---	112	88.0	841	*1260	---
	9/30/2010	ENER	---	---	---	---	---	---	108	83.0	896	*1230	---
	10/31/2010	ENER	---	---	---	---	---	---	110	84.0	891	*1200	---
	11/30/2010	ENER	---	---	---	---	---	---	108	83.0	856	*1220	---
LY28-3	10/16/2009	ENER	---	---	---	---	---	---	190	781	1710	*2476	---
	11/13/2009	ENER	308	96.9	10.00	983	421	< 5.00	290	2300	4110	*5560	1.05
	12/18/2009	ENER	392	126	11.0	1200	399	< 5.00	318	3030	5220	*6638	1.05
	12/30/2009	ENER	426	126	11.0	1260	394	< 5.00	339	3260	5720	*6961	1.03
	1/31/2010	ENER	---	---	---	---	---	---	339	3380	5770	*7250	---
	2/22/2010	ENER	---	---	---	---	---	---	344	3520	5880	*7360	---
	3/25/2010	ENER	---	---	---	---	---	---	347	3360	6360	*7320	---
	4/29/2010	ENER	---	---	---	---	---	---	350	3590	6340	*7470	---
	5/31/2010	ENER	---	---	---	---	---	---	410	3730	6600	*7920	---
	6/30/2010	ENER	---	---	---	---	---	---	471	3850	7210	*8340	---
	7/27/2010	ENER	---	---	---	---	---	---	597	3690	7160	*8200	---

\* Signifies Specific Conductivity from HMC

TABLE 3-13. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

Ca THROUGH ION\_BAL

Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (µmhos/cm)	Ion_B (ratio)
LY28-3	8/31/2010	HMC	---	---	---	---	---	---	788	3420	6660	---	---
LY34-1	10/16/2009	ENER	---	---	---	---	---	---	124	239	1060	*1620	---
	12/30/2009	ENER	292	77.1	2.50	543	667	< 5.00	310	1180	2630	*3763	1.01
	2/22/2010	ENER	---	---	---	---	---	---	321	1230	2760	*3940	---
	3/25/2010	ENER	---	---	---	---	---	---	328	1240	3120	*4030	---
	4/29/2010	ENER	---	---	---	---	---	---	359	1350	3130	*4090	---
	5/31/2010	ENER	---	---	---	---	---	---	353	1340	3050	*4140	---
	6/30/2010	ENER	---	---	---	---	---	---	362	1370	3250	*4190	---
	7/27/2010	ENER	---	---	---	---	---	---	362	1380	3220	*3920	---
	8/31/2010	ENER	---	---	---	---	---	---	362	1410	3490	*4190	---
	9/30/2010	ENER	---	---	---	---	---	---	375	1450	3530	*4490	---
	10/31/2010	ENER	---	---	---	---	---	---	514	1910	5220	*5390	---
	11/30/2010	ENER	---	---	---	---	---	---	501	1890	4230	*5360	---
LY34-2	10/16/2009	ENER	---	---	---	---	---	---	96.0	214	590	*1000	---
	11/13/2009	ENER	175	69.4	12.3	354	457	< 5.00	315	676	1850	*2850	0.985
	12/18/2009	ENER	231	84.8	10.8	387	372	< 5.00	397	888	1220	*3413	1.00
	12/30/2009	ENER	192	85.6	11.8	436	567	< 5.00	377	799	2250	*3339	0.977
	1/31/2010	ENER	---	---	---	---	---	---	467	1020	2500	*3920	---
	2/22/2010	ENER	---	---	---	---	---	---	514	1190	2960	*4160	---
	3/25/2010	ENER	---	---	---	---	---	---	515	1250	3460	*4710	---
	4/29/2010	ENER	---	---	---	---	---	---	653	1600	3720	---	---
	5/31/2010	ENER	---	---	---	---	---	---	659	1710	3660	---	---
	6/30/2010	ENER	---	---	---	---	---	---	723	1850	4180	---	---
	7/27/2010	ENER	---	---	---	---	---	---	710	1910	4450	*5660	---
	8/31/2010	ENER	---	---	---	---	---	---	686	1550	3470	---	---
	9/30/2010	ENER	---	---	---	---	---	---	651	1350	3640	*4680	---
	10/31/2010	ENER	---	---	---	---	---	---	689	1880	3090	*5650	---
	11/30/2010	ENER	---	---	---	---	---	---	632	2220	4930	*8060	---

\*Signifies Specific Conductivity from HMC

TABLE 3-13. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

Sample Point Name	Date	Lab	Ca THROUGH ION BAL										TDS (mg/l)	Cond(calc.) (µmhos/cm)	Ion_B (ratio)
			Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)					
LY34-3	10/16/2009	ENER	—	—	—	—	—	—	96.0	102			637	* 920	—
	11/13/2009	ENER	90.9	44.0	4.30	229	488	6.00	128	277			956	* 1660	1.04
	12/18/2009	ENER	178	78.0	3.90	338	648	< 5.00	184	768			1900	* 2760	0.943
	12/30/2009	ENER	234	105	4.70	456	680	< 5.00	211	904			2170	* 3030	1.12
	1/31/2010	ENER	—	—	—	—	—	—	231	983			2410	* 3246	—
	2/22/2010	ENER	—	—	—	—	—	—	244	1030			2370	* 3350	—
	3/25/2010	ENER	—	—	—	—	—	—	250	1020			2630	* 3460	—
	4/29/2010	ENER	—	—	—	—	—	—	279	1100			2580	* 3520	—
	5/31/2010	ENER	—	—	—	—	—	—	287	1120			2580	* 3610	—
	6/30/2010	ENER	—	—	—	—	—	—	293	1120			2790	* 3680	—
	7/27/2010	ENER	—	—	—	—	—	—	321	1220			2780	* 3700	—
	8/31/2010	ENER	—	—	—	—	—	—	302	1130			2780	* 3780	—
	9/30/2010	ENER	—	—	—	—	—	—	322	1210			2990	* 3850	—
LY34-4	10/31/2010	ENER	—	—	—	—	—	—	315	1150			2330	* 3850	—
	11/30/2010	ENER	—	—	—	—	—	—	323	1160			3030	* 3920	—
	10/16/2009	ENER	—	—	—	—	—	—	74.0	322			854	* 1245	—
	11/13/2009	ENER	58.4	18.3	4.20	289	335	6.00	106	384			977	* 1660	1.03
	12/18/2009	ENER	80.3	20.7	3.70	347	329	13.0	130	501			1260	* 1896	1.05
	12/30/2009	ENER	110	22.6	3.40	331	295	8.00	146	608			1470	* 2038	0.998
	1/31/2010	ENER	—	—	—	—	—	—	163	763			1620	* 2540	—
	7/27/2010	HMC	—	—	—	—	—	—	—	—			—	4850	—
	8/31/2010	ENER	—	—	—	—	—	—	259	1350			2960	* 3930	—
	9/30/2010	ENER	—	—	—	—	—	—	269	1480			3450	—	—

\* Signifies Specific Conductivity from HMC

TABLE 3-14. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

pH THROUGH Th-230											
Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	V (mg/l)	Th230 (pCi/l)
LY1	7/22/2009	ENER	---	0.0420	0.0400	0.0300	1.14	---	---	---	---
	8/13/2009	ENER	---	0.0878	< 0.0300	0.0500	1.10	---	---	---	---
	9/23/2009	ENER	7.77	0.0519	0.0300	0.0350	1.90	---	---	---	---
	10/16/2009	ENER	---	0.0540	< 0.0300	0.0400	1.70	---	---	---	---
	11/13/2009	ENER	8.17	0.0487	< 0.0300	0.0390	2.80	---	---	---	---
	12/18/2009	ENER	7.81	0.0656	< 0.0300	0.0470	2.20	---	---	---	---
	12/30/2009	ENER	7.80	0.0585	< 0.0300	0.0790	1.80	---	---	---	---
	1/31/2010	ENER	---	0.0506	< 0.0300	0.0720	1.60	---	---	---	---
	2/22/2010	ENER	---	0.0506	< 0.0300	0.0820	1.50	---	---	---	---
	3/25/2010	ENER	---	0.0471	< 0.0300	0.105	1.40	---	---	---	---
	4/29/2010	ENER	---	0.0471	< 0.0300	0.0860	1.30	---	---	---	---
	5/31/2010	ENER	---	0.0527	0.0300	0.116	1.20	---	---	---	---
	6/30/2010	ENER	---	0.0574	< 0.0300	0.115	1.30	---	---	---	---
	7/27/2010	ENER	---	0.0532	< 0.0300	0.127	1.30	---	---	---	---
LY2	6/24/2009	ENER	---	0.0406	0.0400	0.0140	3.31	---	---	---	---
LY4	1/7/2009	ENER	---	0.0813	< 0.0300	0.0410	0.870	---	---	---	---
	2/18/2009	ENER	7.44	0.0655	< 0.0300	0.0410	1.40	---	---	---	---
	3/20/2009	ENER	---	0.0732	< 0.0300	0.0430	1.72	---	---	---	---
	4/18/2009	ENER	---	0.0589	< 0.0300	0.0350	0.800	---	---	---	---
	5/15/2009	ENER	---	0.0611	< 0.0300	0.0380	1.46	---	---	---	---
	6/10/2009	ENER	---	0.0630	< 0.0300	0.0550	0.800	---	---	---	---
	6/24/2009	ENER	---	0.0621	< 0.0300	0.0500	0.560	---	---	---	---
	7/22/2009	ENER	---	0.0636	< 0.0300	0.0430	0.460	---	---	---	---
	8/13/2009	ENER	---	0.0718	< 0.0300	0.0400	0.600	---	---	---	---
	9/23/2009	ENER	7.29	0.0664	< 0.0300	0.0340	0.500	---	---	---	---
	10/16/2009	ENER	---	0.0701	< 0.0300	0.0310	0.500	---	---	---	---
	11/13/2009	ENER	7.84	0.0652	< 0.0300	0.0330	0.600	---	---	---	---
	12/18/2009	ENER	7.58	0.0651	< 0.0300	0.0310	0.500	---	---	---	---
	12/30/2009	ENER	7.60	0.0643	< 0.0300	0.0340	0.600	---	---	---	---

TABLE 3-14. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

pH THROUGH Th-230											
Sample Point Name	Date	Lab	pH (std. units)	Urat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	V (mg/l)	Th230 (pCi/l)
LY4	1/31/2010	ENER	---	0.0702	< 0.0300	0.0380	0.500	---	---	---	---
	2/22/2010	ENER	---	0.0732	< 0.0300	0.0350	0.500	---	---	---	---
	3/25/2010	ENER	---	0.0720	< 0.0300	0.0360	0.500	---	---	---	---
	4/29/2010	ENER	---	0.0899	< 0.0300	0.0380	0.600	---	---	---	---
	5/31/2010	ENER	---	0.0833	< 0.0300	0.0540	0.600	---	---	---	---
	6/30/2010	ENER	---	0.0766	< 0.0300	0.0420	0.600	---	---	---	---
	7/27/2010	ENER	---	0.0707	< 0.0300	0.0420	0.700	---	---	---	---
	8/31/2010	ENER	---	0.0708	< 0.0300	0.0420	0.800	---	---	---	---
	9/30/2010	ENER	---	0.0682	< 0.0300	0.0450	1.10	---	---	---	---
	10/31/2010	ENER	---	0.0672	< 0.0300	0.0440	---	---	---	---	---
	11/30/2010	ENER	---	0.0610	< 0.0300	0.0520	---	---	---	---	---
LY4-ML	4/18/2009	ENER	---	0.0188	0.120	0.0050	0.200	---	---	---	---
	6/24/2009	ENER	---	0.358	0.110	< 0.0050	10.00	---	---	---	---
	7/22/2009	ENER	---	0.552	0.0900	0.0100	0.0200	---	---	---	---
	8/13/2009	ENER	---	0.421	0.0600	< 0.0050	< 0.100	---	---	---	---
	8/23/2009	ENER	7.76	0.268	0.0400	0.0100	< 0.100	---	---	---	---
	10/16/2009	ENER	---	0.244	0.0400	0.0060	< 0.100	---	---	---	---
	11/13/2009	ENER	8.35	0.508	0.0900	0.0110	< 0.100	---	---	---	---
	12/18/2009	ENER	7.55	0.214	< 0.0300	0.0050	< 0.100	---	---	---	---
	4/29/2010	ENER	---	0.292	0.0500	0.0110	< 0.100	---	---	---	---
	5/31/2010	ENER	---	0.463	0.0900	0.0150	< 0.100	---	---	---	---
	6/30/2010	ENER	---	0.482	0.110	0.0120	< 0.100	---	---	---	---
	7/27/2010	ENER	---	0.375	0.0900	0.0170	< 0.100	---	---	---	---
	8/31/2010	ENER	---	0.366	0.0900	0.0150	< 0.100	---	---	---	---
	9/30/2010	ENER	---	0.394	0.100	0.0130	< 0.100	---	---	---	---
	10/31/2010	ENER	---	0.394	0.100	0.0140	---	---	---	---	---
	11/30/2010	ENER	---	0.453	0.140	0.0180	---	---	---	---	---
LY4-MU	7/22/2009	ENER	---	0.261	0.140	0.0100	0.0200	---	---	---	---
	8/13/2009	ENER	---	0.586	0.160	0.0060	< 0.100	---	---	---	---

TABLE 3-14. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

Sample Point Name	Date	Lab	pH THROUGH Th-230							
			pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Th230 (pCi/l)
LY4-MU	9/23/2009	ENER	7.68	0.583	0.120	0.0090	< 0.100	—	—	—
	10/16/2009	ENER	—	0.557	0.100	0.0090	< 0.100	—	—	—
	11/13/2009	ENER	8.04	0.212	0.0300	0.0090	< 0.100	—	—	—
	1/31/2010	ENER	—	0.504	0.0500	0.0100	< 0.100	—	—	—
	2/22/2010	ENER	—	0.516	0.0600	0.0100	0.800	—	—	—
	3/25/2010	ENER	—	0.574	0.0500	0.0100	1.80	—	—	—
	4/29/2010	ENER	—	0.546	0.0400	0.0120	2.30	—	—	—
	5/31/2010	ENER	—	0.626	0.0400	0.0130	3.20	—	—	—
	6/30/2010	ENER	—	0.617	0.0400	0.0090	3.50	—	—	—
	7/27/2010	ENER	—	0.600	0.0400	0.0110	3.50	—	—	—
	8/31/2010	ENER	—	0.0395	0.350	0.0460	4.10	—	—	—
	9/30/2010	ENER	—	0.691	0.0500	0.0060	3.80	—	—	—
	10/31/2010	ENER	—	0.633	0.0400	0.0060	—	—	—	—
	11/30/2010	ENER	—	0.628	0.0400	0.0100	—	—	—	—
LY28-1	10/16/2009	ENER	—	0.0224	0.0500	0.0100	2.60	—	—	—
	11/13/2009	ENER	8.19	0.0489	< 0.0300	0.0250	4.40	—	—	—
	12/18/2009	ENER	7.77	0.131	< 0.0300	0.0310	0.900	—	—	—
	12/30/2009	ENER	7.83	0.161	< 0.0300	0.0420	6.60	—	—	—
	1/31/2010	ENER	—	0.149	< 0.0300	0.0370	6.70	—	—	—
	2/22/2010	ENER	—	0.161	< 0.0300	0.0380	6.10	—	—	—
	3/25/2010	ENER	—	0.161	< 0.0300	0.0400	7.90	—	—	—
	4/29/2010	ENER	—	0.150	< 0.0300	0.0360	7.50	—	—	—
	5/31/2010	ENER	—	0.194	0.0300	0.0490	7.60	—	—	—
	6/30/2010	ENER	—	0.183	< 0.0300	0.0410	7.20	—	—	—
	7/27/2010	ENER	—	0.171	< 0.0300	0.0440	8.00	—	—	—
	8/31/2010	ENER	—	0.187	< 0.0300	0.0470	7.50	—	—	—
	9/30/2010	ENER	—	0.194	< 0.0300	0.0450	7.30	—	—	—
	10/31/2010	ENER	—	0.191	0.0800	0.0810	—	—	—	—
	11/30/2010	ENER	—	0.168	< 0.0300	0.0470	—	—	—	—



TABLE 3-14. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

pH THROUGH Th-230											
Sample Point Name	Date	Lab	pH (std. units)	Urat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	V (mg/l)	Th230 (pCi/l)
LY28-1M	10/16/2009	ENER	---	0.0009	0.160	0.0070	1.40	---	---	---	---
LY28-2	10/16/2009	ENER	---	0.0031	0.0500	0.0140	1.10	---	---	---	---
LY28-2M	10/16/2009	ENER	---	0.0044	0.160	0.0110	1.80	---	---	---	---
	11/13/2009	ENER	8.15	0.0327	0.120	< 0.0050	2.30	---	---	---	---
	12/18/2009	ENER	7.73	0.0567	0.100	< 0.0050	5.90	---	---	---	---
	12/30/2009	ENER	7.87	0.0641	0.0900	< 0.0050	6.30	---	---	---	---
	1/31/2010	ENER	---	0.0489	0.0900	< 0.0050	6.40	---	---	---	---
	2/22/2010	ENER	---	0.0558	0.0900	0.0060	7.10	---	---	---	---
	3/25/2010	ENER	---	0.0581	0.100	0.0070	7.40	---	---	---	---
	4/29/2010	ENER	---	0.0552	0.0800	0.0060	7.60	---	---	---	---
	5/31/2010	ENER	---	0.0619	0.110	0.0090	8.70	---	---	---	---
	6/30/2010	ENER	---	0.0117	< 0.0300	< 0.0050	9.00	---	---	---	---
	7/27/2010	ENER	---	0.0502	0.0900	0.0080	10.00	---	---	---	---
	8/31/2010	ENER	---	0.0504	0.0800	0.0080	9.70	---	---	---	---
	9/30/2010	ENER	---	0.0534	0.100	0.0080	9.70	---	---	---	---
	10/31/2010	ENER	---	0.0475	0.140	0.0090	---	---	---	---	---
	11/30/2010	ENER	---	0.0396	0.100	0.0090	---	---	---	---	---
LY28-3	10/16/2009	ENER	---	0.0875	0.100	0.0230	21.0	---	---	---	---
	11/13/2009	ENER	8.11	0.487	0.100	0.0500	43.5	---	---	---	---
	12/18/2009	ENER	7.87	0.553	< 0.0300	0.0420	53.7	---	---	---	---
	12/30/2009	ENER	7.90	0.628	< 0.0300	0.0480	55.3	---	---	---	---
	1/31/2010	ENER	---	0.694	< 0.0300	0.0490	60.0	---	---	---	---
	2/22/2010	ENER	---	0.758	< 0.0300	0.0520	63.7	---	---	---	---
	3/25/2010	ENER	---	0.707	< 0.0300	0.0450	58.9	---	---	---	---
	4/29/2010	ENER	---	0.710	0.0500	0.0580	52.0	---	---	---	---
	5/31/2010	ENER	---	0.971	0.110	0.0940	54.0	---	---	---	---
	6/30/2010	ENER	---	0.973	0.0400	0.0910	62.0	---	---	---	---
	7/27/2010	ENER	---	0.781	< 0.0300	0.105	72.0	---	---	---	---

TABLE 3-14. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

pH THROUGH Th-230											
Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	V (mg/l)	Th230 (pCi/l)
LY28-3	8/31/2010	HMC	---	0.809	< 0.0300	0.167	74.0	---	---	---	---
LY34-1	10/16/2009	ENER	---	0.0837	0.0800	0.0090	2.80	---	---	---	---
	12/30/2009	ENER	7.80	0.375	< 0.0300	0.0540	10.1	---	---	---	---
	2/22/2010	ENER	---	0.368	0.0400	0.0470	11.7	---	---	---	---
	3/25/2010	ENER	---	0.312	< 0.0300	0.0450	13.7	---	---	---	---
	4/29/2010	ENER	---	0.279	< 0.0300	0.0460	14.5	---	---	---	---
	5/31/2010	ENER	---	0.324	0.0500	0.0610	15.2	---	---	---	---
	6/30/2010	ENER	---	0.332	0.0400	0.0470	14.8	---	---	---	---
	7/27/2010	ENER	---	0.272	0.0400	0.0450	15.0	---	---	---	---
	8/31/2010	ENER	---	0.231	< 0.0300	0.0490	15.9	---	---	---	---
	9/30/2010	ENER	---	0.317	< 0.0300	0.0610	30.0	---	---	---	---
	10/31/2010	ENER	---	0.310	< 0.0300	0.0680	---	---	---	---	---
	11/30/2010	ENER	---	0.339	< 0.0300	0.310	---	---	---	---	---
LY34-2	10/16/2009	ENER	---	0.0067	0.140	0.0060	< 0.100	---	---	---	---
	11/13/2009	ENER	8.34	0.0695	0.110	0.0150	2.40	---	---	---	---
	12/18/2009	ENER	7.94	0.0871	0.0800	0.0190	7.50	---	---	---	---
	12/30/2009	ENER	7.98	0.0876	0.100	0.0210	8.30	---	---	---	---
	1/31/2010	ENER	---	0.0962	0.0800	0.0300	12.5	---	---	---	---
	2/22/2010	ENER	---	0.118	0.0900	0.0330	4.40	---	---	---	---
	3/25/2010	ENER	---	0.126	0.0800	0.0350	14.0	---	---	---	---
	4/29/2010	ENER	---	0.142	0.0800	0.0440	12.0	---	---	---	---
	5/31/2010	ENER	---	0.192	0.110	0.0550	11.4	---	---	---	---
	6/30/2010	ENER	---	0.222	0.120	0.0600	12.8	---	---	---	---
	7/27/2010	ENER	---	0.202	0.100	0.0590	12.1	---	---	---	---
	8/31/2010	ENER	---	0.104	0.0500	0.0420	8.00	---	---	---	---
	9/30/2010	ENER	---	0.0932	0.0400	0.0370	6.20	---	---	---	---
	10/31/2010	ENER	---	0.195	0.0600	0.0600	---	---	---	---	---
	11/30/2010	ENER	---	0.402	0.0700	0.279	---	---	---	---	---

TABLE 3-14. WATER QUALITY ANALYSIS FOR LYSIMETER (cont.)

pH THROUGH Th-230										
Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Th230 (pCi/l)
LY34-3	10/16/2009	ENER	---	0.0051	0.130	0.0070	1.50	---	---	---
	11/13/2009	ENER	8.24	0.0749	0.210	0.0250	3.60	---	---	---
	12/18/2009	ENER	7.91	0.239	0.0800	0.0420	7.10	---	---	---
	12/30/2009	ENER	7.92	0.349	0.0600	0.0740	7.60	---	---	---
	1/31/2010	ENER	---	0.269	0.0700	0.0600	9.20	---	---	---
	2/22/2010	ENER	---	0.292	0.0700	0.0630	0.500	---	---	---
	3/25/2010	ENER	---	0.282	0.0700	0.0640	10.5	---	---	---
	4/29/2010	ENER	---	0.243	0.0600	0.0620	9.60	---	---	---
	5/31/2010	ENER	---	0.291	0.0900	0.0880	9.60	---	---	---
	6/30/2010	ENER	---	0.266	0.0600	0.0700	8.80	---	---	---
	7/27/2010	ENER	---	0.254	0.0600	0.0710	6.20	---	---	---
	8/31/2010	ENER	---	0.250	0.0500	0.0800	6.70	---	---	---
	9/30/2010	ENER	---	0.287	0.0600	0.0730	5.00	---	---	---
	10/31/2010	ENER	---	0.275	0.120	0.103	---	---	---	---
	11/30/2010	ENER	---	0.279	0.0500	0.0720	---	---	---	---
LY34-4	10/16/2009	ENER	---	0.0261	0.260	0.0050	1.40	---	---	---
	11/13/2009	ENER	8.38	0.0613	0.310	0.0110	4.20	---	---	---
	12/18/2009	ENER	8.34	0.0714	0.260	0.0130	12.4	---	---	---
	12/30/2009	ENER	8.36	0.0671	0.230	0.0180	15.8	---	---	---
	1/31/2010	ENER	---	0.0574	0.270	0.0220	22.9	---	---	---
	8/31/2010	ENER	---	0.0397	0.320	0.0480	49.0	---	---	---
	9/30/2010	ENER	---	0.0749	0.460	0.0510	53.0	---	---	---

### 3.4.2 Section 28

Lysimeters were installed at three locations in the Section 28 Center Pivot area. Table 3-11 shows that five lysimeters were installed at these three locations. In addition to the alluvial lysimeters at the LY28-1 and LY28-2 locations, there is also a basalt lysimeter. The completion details of these lysimeters are presented in Table 3-11.

Tables 3-13 and 3-14 presents the water quality results obtained from the LY28 series of lysimeters. Only one sample was obtained from the basalt lysimeter LY28-1M. Monthly samples have been obtained from lysimeter LY28-1. Only an initial sample was collected from LY28-2 which indicates that there is not adequate soil moisture at this location to consistently produce a sample. Monthly samples have been obtained from the basalt lysimeter at LY28-2M and monthly samples were collected from lysimeter LY28-3 through August of 2010 prior to it becoming non-functional.

The time concentration plots for lysimeter LY28-1 are presented in Figure 3-28 and 3-29. The TDS, sulfate and chloride concentrations each are gradually increasing with time and values of 2700, 1300 and 120 mg/l are typical of 2010 values for this lysimeter. The uranium and selenium concentrations show a similar pattern with a small increase in concentration with time with typical 2010 values of 0.2 and 0.05 mg/l. The molybdenum concentrations have been low in lysimeter LY28-1. The monitoring data for lysimeter LY28-2M is presented in Figures 3-30 and 3-31. Chloride and sulfate concentrations in this lysimeter are decreasing with time while the TDS concentration has shown a gradual increase in the last half of 2010. The uranium concentrations generally have shown a gradual decrease in concentration in the last half of 2010 while the selenium concentrations have stayed very small. An overall steady molybdenum concentration has been observed in this basalt lysimeter location if the first two values are not used. The low major constituent concentrations indicate that all of the concentrations occurring in LY28-2M may be natural.

The soil moisture sample concentrations for lysimeter LY28-3 show an increasing trend for the major constituents of TDS, sulfate and chloride (see Figure 3-32). An increasing trend is also observed for uranium in this soil moisture (see Figure 3-33). This data indicates that less soil moisture has moved past this lysimeter in 2010 than previously.

### 3.4.3 Section 33

A total of eight lysimeters have been installed in Section 33 Center Pivot irrigation area. These lysimeters have been installed at five different locations. Figure 3-5 shows the five lysimeter locations. Lysimeters were placed in the alluvial material above the basalt except at the locations LY-3 and LY-4. A hole was drilled to a depth of 31 feet at LY-3M and the lysimeter placed in the bottom of this hole with the top of the lysimeter being located 23 feet below the top of the basalt. Two lysimeters were installed in a drill hole at the LY-4M site. These lysimeters were installed ten and thirty feet below the top of the basalt at this location.

Vacuum was applied to each of the lysimeters during each sampling event. Some of the lysimeters have not produced soil moisture samples while some have produced a sample each

time a vacuum has been applied. Tables 3-13 and 3-14 present the water quality analysis of the soil moisture for the lysimeters. Lysimeter LY-1 was installed in July, 2009 and monthly samples have been obtained for this lysimeter each time the vacuum has been applied through July 2010. LY-2 was installed in June of 2009 and only a sample shortly after installation was obtained from this lysimeter. This inability to extract a sample with this lysimeter likely indicates adequate soil moisture is not available at this location. Lysimeters LY-3 and LY-3M were installed in June 2009 and neither of these lysimeters have ever produced a soil moisture sample. LY-4 was installed in December of 2008 and samples from this lysimeter have been obtained each time the vacuum was applied to the lysimeter. Lysimeter LY-4ML was installed in June of 2009 and monthly samples were collected from this lysimeter through December 2009. LY-4ML did not produce a sample in January, February and March of 2010. Lysimeter LY-4MU was installed in July of 2009 and samples from this lysimeter have been collected each month except December 2009.

Lysimeter LY-1, which is installed 16 feet below the land surface, has been monitored monthly and has consistently produced a sample. Figure 3-34 shows the TDS, sulfate and chloride concentrations for samples from LY-1. These concentrations have generally been gradually increasing during the last half of 2009 and 2010, possibly arising from a decrease in the rate of flow. Figure 3-35 presents the uranium, selenium and molybdenum concentrations for LY-1, which shows an overall low concentrations in each of these constituents with an increase in selenium concentrations in 2010.

Figure 3-36 presents the TDS, sulfate, chloride concentrations for lysimeter LY-4. The TDS and sulfate scales are shown on the left of the graph and the chloride scale is presented on the right. The chloride concentrations are presented with the green triangles. The first 2 to 3 samples from this lysimeter likely show some effect from the water that was used to install the fine flour sand pack around this lysimeter. Subsequent sample results indicate a very gradual increasing trend in concentrations. Figure 3-37 presents the uranium, selenium and molybdenum concentrations for LY-4 lysimeter. These three constituents show in general a fairly steady concentration with time. A typical uranium concentration of 0.08 is significantly less than the concentration of 0.24 mg/l that was present in irrigation water applied in 2009. The representative selenium concentration of 0.05 mg/l in the lysimeter is slightly less than the selenium concentration of the irrigation water. No measurable molybdenum concentrations above the detection limit of 0.03 mg/l is indicated at this lysimeter. This data indicates that a similar amount of soil moisture has been moving past this lysimeter in the two years.

The TDS, sulfate and chloride concentrations for the lysimeter that was placed ten feet below the top of the basalt (LY-4MU) is presented in Figure 3-38. The constituent concentrations in the soil moisture gradually declined to early 2010, when the TDS and sulfate concentrations became fairly steady and the chloride concentrations gradually increased. The first sample from this lysimeter may have been biased by water used in installation, and results should not be given any significance. This data shows a much higher TDS, sulfate and chloride concentrations existing in the soil moisture until the last part of 2009. The concentrations then declined to levels that are fairly similar to the levels in lysimeter LY-4 which is located at a shallower depth at the base of the alluvial material above the basalt. Figure 3-39 presents the uranium concentrations for LY-4MU. This data shows that a gradual increasing trend in uranium concentrations was observed in the soil moisture samples from LY-4MU during 2010. The November 2009 value from LY-

4MU and LY-4ML should not be given much significance because it appears that these two samples may have been switched in November 2009. This plot indicates that the uranium concentrations are not decreasing at the same rate as the major constituents and its concentrations indicate that the soil moisture passing LY-4MU is getting some uranium that previously migrated to this interval of the basalt. The selenium concentration in Figure 3-39 have been steady while the molybdenum concentration decreased to a low value in late 2009.

Figure 3-40 and 3-41 present the concentration plots for the lower lysimeter LY-4ML. These plots show that in general the concentrations are decreasing with time. Again, the November 2009 value should be viewed with skepticism because the samples from LY-4ML and LY-4MU are thought to have been switch based on the concentration results. The TDS, sulfate and chloride concentrations are each generally declining with time. This indicates that the rate of soil moisture water entering this area is increasing. The load (concentrations times flow rate) of major constituents is expected to be fairly constant through the soil profile. The concentrations in the soil moisture would be expected to increase when the rate of water passing through an interval decreases as a result of the crop using more water. The alfalfa that existed in this field prior to 2008 likely used more water than the present vegetation that consists primarily of grass, and therefore, the concentrations are probably declining due to a larger rate of water moving in the soil profile.

### 3.5 Predicted Soil Moisture Concentrations

The 2000-2015 irrigation monitoring report also presents information that indicates ground-water uranium concentrations are not increasing in the irrigation areas. The partially saturated numerical model LEACHP model was used to predict the movement of constituents in soil moisture below the irrigation areas with time. This section presents the predicted soil moisture concentrations for each of the irrigated areas.

Homestake proposes to reduce the irrigation water quality limits with time as the alternate treatment processes are employed to reduce the concentrations. Table 3-15 below shows the proposed schedule to reduce the maximum concentrations for uranium, selenium, TDS and sulfate in irrigation water applied to these fields. Uranium concentrations in the irrigation water are proposed to be decreased from 0.16 mg/L in 2011 to 0.03 in 2015. The selenium concentrations are proposed to be reduced from 0.1 to 0.05 by 2014. A maximum TDS and sulfate concentration of 2000 and 900 mg/l is proposed for the irrigation water.

**Table 3-15. Proposed Irrigation Supply Upper Limits for Uranium, Selenium, TDS and Sulfate and Anticipated Irrigation Amount**

Year	Maximum Concentration Applied, mg/l				Anticipated Irrigation (Ft of Water)		
	U	Se	TDS	SO4	Sec 33 and 34 Flood	Sec 28 Pivot	Sec 33 Pivot
2011	0.16	0.1	2000	900	2.4	2.3	0.4
2012	0.16	0.1	2000	900	2.4	2.3	0.4
2013	0.12	0.08	2000	900	1.04	0.5	0
2014	0.05	0.05	2000	900	1.04	0.5	0
2015	0.03	0.05	2000	900	1.04	0.5	0
2016	0.03	0.05	2000	900	1.04	0.5	0
2017	0.03	0.05	2000	900	1.04	0.5	0

Some San Andres water will have to be used in early years until the alternate restoration reduces alluvial water constituent concentrations to a level which meets the irrigation concentration limits. The *insitu* restoration concentrations will be reduced in the western portion of the plume initially, and therefore this area of the restoration area will initially supply more water to the irrigation supply program.

Table 3-15 also presents the anticipated feet of irrigation water applied each year. Irrigation rates of 2.4 feet/year and 2.3 feet/year are planned to be applied to the Section 34 and Section 28 irrigation areas, respectively in 2011 and 2012. A limited amount of irrigation is proposed to be applied to the Section 33 center pivot to establish permanent grass. The amount of irrigation will decrease significantly after the full implementation of the alternative restoration program. These irrigation rates may vary due to the combination of restoration programs actually used. The continuing use of the irrigation program after the alternative restoration program is implemented will aid in controlling the restoration zone on its downgradient side.

### 3.5.1 Section 34

Figure 3-42 presents the predicted soil solution TDS concentrations for the flood irrigation for 2010. The observed lysimeter soil moisture TDS concentrations are also shown on this figure for lysimeters LY34-1, LY34-2 and LY34-3 for 2010. This shows that model prediction of concentrations for 2010 (blue line) are higher than those observed in the lysimeter. The predictions show that the soil solution concentrations have not increased below 25 feet in the soil profile. This figure also presents the predicted soil moisture concentrations for TDS for the flood area for 2030, 2050 and 2100 after operation of the irrigation program through 2017. This figure shows that the maximum concentration in the upper soil profile will increase but very little change in the soil profile is projected for depths greater than 20 feet. The very small change in the soil moisture concentration between 2030, 2050 and 2100 are due to the very limited driving force without irrigation. This prediction shows that the TDS concentrations from the flood irrigation essentially should never reach the water table. The long-term drainage of soil moisture from the bottom of the soil profile into the ground water is predicted to be roughly 3 mm/year or 0.73 gpm for the 120 acre flood area. Table C-1 in Appendix C presents the inputs and results from the LEACHP soil moisture model for the flood irrigation. The column labeled interval rain in Table C-1 includes both rainfall and irrigations depths.

The predicted soil solution sulfate concentrations for the flood irrigation for 2010 are presented in Figure 3-43. The observed lysimeter soil moisture sulfate concentrations are also shown on this figure for lysimeters LY34-1, LY34-2 and LY34-3 for 2010. This shows that model predictions (blue line) are greater than those observed in the lysimeter. The predictions show that the soil solution concentrations have not increased below 25 feet in the soil profile. This figure also presents the predicted soil moisture concentrations for sulfate for the flood area for 2030, 2050 and 2100 after operation of the irrigation program through 2017. This figure shows that the maximum concentration in the upper soil profile will increase but very little change in the soil profile is projected for depths greater than 20 feet. The very small change in constituent concentrations in soil moisture concentration between 2030, 2050 and 2100 is due to the very limited driving force without irrigation. This prediction shows that the sulfate concentrations from the flood irrigation essentially should never reach the water table. The long term drainage

of soil moisture from the bottom of the soil profile into the ground water is predicted to be roughly 3 mm/year or 0.73 gpm for the 120 acre flood area.

The predicted soil solution chloride concentrations for Section 34 flood irrigation for 2010 are presented in Figure 3-43A. The observed lysimeters soil moisture chloride concentrations are also shown on this figure for lysimeters LY34-1, LY34-2, and LY34-3 for 2010. This model shows that the predictions (blue line) are greater than the observed concentrations in the lysimeters for two of the lysimeters but fits the LY34-2 lysimeter very well. This prediction shows that the chloride soil solution concentrations should not increase below 25ft in the soil profile. This figure also presents the predicted soil moisture concentrations for chloride for the Section 34 flood area for 2030, 2050, and 2100 after operation of irrigation program through 2017. The prediction shows that the chloride concentrations in the upper portion of the soil profile will decrease with time and some increase will occur in the soil profile before the upper few feet. This prediction shows that the chloride concentrations from the flood irrigation essentially should never reach the water table in the Section 34 flood area for 2010 and the other three simulations. This shows that our predictions are slightly higher from the numerical model.

The predictions for the uranium soil solution uranium concentrations in the flood area are presented in the Figure 4-16. The blue line shows the predicted concentrations after the 2010 irrigation season in the soil moisture for uranium and the figure also shows the uranium concentrations in the three lysimeters in the flood area. The prediction is slightly higher than the observed concentrations in the three lysimeters. The figure also shows the predicted concentrations for 2030 and 2050 which indicate essentially no increase in uranium concentrations below a depth of 15ft. Uranium concentrations in the soil moisture should never reach the water table in flood area.

Selenium transport in the soil was also modeled for the flood irrigation area and the results are presented in Figure 3-45. This figure also shows the 2010 observed selenium concentrations in the 3 lysimeters in the flood area. The prediction for 2010 is slightly greater than the observed selenium concentrations and indicates that no change in the soil moisture concentrations have occurred below 15 feet. The 2030, 2050 and 2100 soil moisture movements show only a very small change in the selenium concentrations in the future and that the downward movement rate of this soil moisture is very slow. This predicts that selenium from the irrigation will not reach the water table in the foreseeable future.

### **3.5.2 Section 28**

The Section 28 soil moisture and constituent migration was simulated, but this simulation is also considered representative of the Section 33 profile except that the depth to water is greater in Section 33. The center pivot areas, which contain sandy soils and a large thickness of basalt below the soils, have soil moisture movement rates much greater than those of the clay soils in the flood area. Figure 3-46 presents the predicted and observed soil solution TDS concentrations for the Section 28 center pivot irrigation. The soil solution concentration data for the Section 28 lysimeters are presented on this figure. This data shows that, in general, the TDS soil moisture concentration for 2010 is slightly greater than the observed TDS concentrations from the lysimeters, except for lysimeter LY28-3. The simulation indicates that significant TDS concentrations should exist in the soil moisture that is reaching the water table in 2010. Figure



3-46 also presents the predicted soil moisture concentrations for years 2030, 2050 and 2100 with irrigation discontinued after the 2017 season. This data shows that the soil moisture concentration of TDS for the lower soil profile should essentially be equal for each of these four simulations.

Figure 3-47 presents the predicted and observed soil solution sulfate concentrations for the Section 28 center pivot irrigation. The lysimeter data for the Section 28 lysimeters are presented on this figure. This data shows that in general, the sulfate soil moisture concentration for 2010 is slightly greater than the observed sulfate concentrations from the lysimeters, except for lysimeter LY28-3. Simulation indicates that significant sulfate concentrations should exist in the soil moisture that is reaching the water table in 2010. Figure 3-47 also presents the predicted soil moisture concentrations for years 2030, 2050 and 2100 after irrigation is discontinued in 2017. This data shows that the soil moisture concentration of sulfate near the water table should essentially be equal for each of these four simulations.

The predicted chloride concentrations in the Section 28 center pivot irrigation area are presented in Figure 3-47A. The lysimeter data for Section 28 are also presented on this figure with the chloride concentration in lysimeter LY28-3 larger than the 2010 prediction while the other two chloride concentrations of soil moisture from lysimeters LY28-1 and LY28-2M are less than the 2010 prediction. The 2010 and the remainder of the three additional simulations for 2030, 2050, and 2100 all indicate that the chloride concentration should be approximately 370 mg/l in the water table with time.

The predicted uranium concentrations in the Section 28 center pivot irrigation areas are presented in Figure 3-48. This figure also shows the uranium soil moisture concentrations for the Section 28 lysimeters. This shows that two of the observed soil moisture concentrations are significantly less than the predicted concentration. The observed concentration for lysimeter LY28-3 is slightly greater than the 2010 prediction. The 2030, 2050 and 2100 predictions of soil solution uranium concentration are very similar and indicate essentially no change in the uranium concentration below 50 feet. Movement of the uranium soil moisture concentrations will essentially stop without continued irrigation due to the lack of driving moisture. Therefore, uranium concentrations are not expected to reach the water table in the Section 28 center pivot areas in the foreseeable future.

Figure 3-49 presents the predicted and observed soil solution selenium concentrations for the Section 28 center pivot irrigation area. The observed soil moisture concentrations in these lysimeters are all less than 2010 predictions. The observed concentration in Section 28 lysimeter LY28-3 is closest to the predicted 2010 soil moisture selenium concentration. This figure also presents the predicted 2030, 2050 and 2100 soil moisture concentrations after irrigation through 2017. This shows that very little change in the selenium concentration occurs below 45 feet between 2030, 2050 and 2100.

### **3.5.3 Section 33**

Limited irrigation in Section 33 in 2011 and 2012 is proposed to establish a permanent grass on this area. A simulation of the soil moisture migration for Section 33 was made with the much

smaller planned irrigation (see Table 3-15) in 2011 and 2012 and with the actual irrigation applications from 2000 through 2009. The same soil profile was used for the Section 33 and Section 28 simulations with the recognition that thickness of alluvial material above the alluvial water table in Section 33 is thirty feet greater than that in Section 28. This additional thirty feet would not measurably change the model predictions for the upper 65 feet. The much smaller irrigation amount for 2011 and 2012 for the Section 33 area results in a smaller flux rate through the soil profile. The soil moisture predictions for Section 33 are presented in Figures 3-50 through 3-53. A flux rate during irrigation of 40 mm is representative of the Section 33 area. Figure 3-50 presents the predicted and observed soil solution TDS concentrations for the Section 33 center pivot irrigation. The lysimeter data for the Section 33 lysimeters are presented on this figure. This plot shows that the predicted soil moisture TDS concentration for 2010 fit the observed TDS concentrations from the Section 33 lysimeters. Simulation indicates that a TDS of 3,400 mg/l should exist in the soil moisture that is reaching the water table in 2010. Figure 3-50 also presents the predicted soil moisture concentrations for 2030, 2050 and 2100 with discontinuation of irrigation after the 2012 season. This data shows that the soil moisture TDS concentration should essentially be equal below a depth of 25 feet for each of these four simulations.

Figure 3-51 presents the predicted and observed soil solution sulfate concentrations for the Section 33 center pivot irrigation. The lysimeter data for the Section 33 lysimeters are presented on this figure. Data shows that in general, the predicted sulfate soil moisture concentrations for 2010 are slightly greater than or equal to the observed sulfate concentrations from the lysimeters, except for lysimeter LY4. These simulations indicate that a sulfate concentration of 1,500 mg/l should exist in the soil moisture that is reaching the water table in 2010. Figure 3-51 also presents the predicted soil moisture concentrations for 2030, 2050 and 2100 after discontinuation of irrigation in 2012. This data shows that the soil moisture concentration of sulfate near the water table should essentially be equal for each of these four simulations.

Figure 3-51A presents the predicted and observed soil solution chloride concentrations for the Section 33 center pivot. Four lysimeter 2010 data values are also presented on this figure and shows a good fit for the 2010 prediction for LY1 and LY4. The soil moisture concentrations observed in 2010 in LY4MU and LY4ML are significantly above the predicted values. These predictions indicate that the chloride concentration of approximately 300 mg/l should exist in the soil moisture that is reaching the water table in 2010. The predictions for 2030, 2050 and 2100 also indicate a very similar concentration of chloride in the soil moisture near the water table.

The predicted uranium concentrations in the Section 33 center pivot irrigation areas are presented in Figure 3-52. This figure also shows the soil moisture uranium concentrations for the Section 33 lysimeters. This shows that the observed soil moisture concentrations are similar to the predicted concentrations. The observed concentrations for lysimeters LY4MU and LY4ML are slightly greater than the 2010 prediction. The 2030, 2050 and 2100 prediction of uranium concentration are very similar and indicate essentially no change in the uranium concentration below 50 feet. The movement of the uranium soil moisture concentrations will essentially cease without continued irrigation due to the lack of driving moisture. Therefore, uranium concentrations are not expected to reach the water table in the Section 33 center pivot areas in the foreseeable future.

Figure 3-53 presents the predicted and observed soil solution selenium concentrations for the Section 33 center pivot simulations. The observed soil moisture concentrations in these lysimeters are all less than 2010 predictions except for a very good fit of the sample result from lysimeter LY4ML. This figure also presents the predicted 2030, 2050 and 2100 soil moisture concentrations after irrigation through 2012. This shows that very little change in the selenium concentration occurs below 50 feet between 2030, 2050 and 2100.

Additional LEACHP model runs were made for the Section 33 area without any additional irrigation beyond 2009. These results are useful to see the difference in the model predictions with and without the limited 2011 and 2012 irrigation. Figures 3-54 through 3-57 present the predictions for the Section 33 soil moisture without any additional irrigation. Figure 3-54 shows that there is a small difference between the results without any additional irrigation and the results with the two years of additional irrigation in the upper 25 feet of the soil profile (see Figure 4-23). No difference in the soil moisture TDS concentrations is expected below 25 feet in the future with and without the two years of limited irrigation. The difference for sulfate soil moisture concentrations between no additional irrigation in Section 33 (see Figure 3-55) and two years of additional irrigation (see Figure 3-51) is very similar to the TDS concentration difference.

Figure 3-55A presents the predicted and observed soil solution chloride concentrations for the Section 33 center pivot with irrigation through 2009. This prediction is very similar to that observed for the Section 33 center pivot irrigation through 2012 which is presented in Figure 3-51A. The two additional years of irrigation in Section 33 should not significantly change the soil moisture chloride concentrations in Section 33.

Figure 3-56 presents the uranium predictions for the soil moisture for Section 33 without any additional irrigation. When compared to Figure 3-52, which portrays limited irrigation through 2012, Figure 3-56 shows that a small uranium concentration difference exists in the upper 10 feet of the soil profile but no difference should exist below 10 feet in the future. A comparison of Figures 3-57 and 3-53 also shows that the predicted selenium concentrations without and with the limited two years of irrigations are the same below a depth of 10 feet.

The limited irrigation in Section 33 in 2011 and 2012 to establish grass will not increase the TDS and sulfate concentrations in the soil moisture below 25 feet in the future. Also the uranium and selenium concentrations in the soil moisture will not increase below a depth of 10 feet. The small increase in soil moisture concentrations in the upper portion of the soil profile will not affect the future use of this land.

#### **3.5.4 Section 33 Flood**

Results from the Section 34 soil moisture simulations can be used for the Section 33 Flood. The Section 34 Flood predictions would be conservative (high) for the Section 33 Flood area. The Section 33 Flood area is irrigated with the same concentration in the irrigation water. Section 33 Flood area has been irrigated four years verses the eleven years of irrigation in the Section 34 Flood. The Section 33 Flood area upper soil profile is set very similar to the Section 34 soil profile. The Section 34 predictions indicate that soil moisture constituents will move down to a maximum of approximately 25ft. The basalt in the section 33 Flood area typically starts at a

depth of 25ft. Therefore the basalt should not effect the migration of the soil moisture due to the movement above 25ft.

The soil moisture solution concentration predictions from Section 3.5.1 therefore should be used for the Section 33 Flood area. The soil moisture concentration should be greater than those observed in the Section 33 Flood area and therefore are conservatively high.

### **3.6 Soil Health**

Soil health as related to irrigated crop production is generally monitored as a function of the salt loading of the soils and potential adverse affects on soils due to excessive sodium in the irrigation water and in the soils. In order to understand the possible effects of these parameters on the irrigated soils, it is desirable to know other characteristics of the soil including soil particle size and texture, natural salt and sodium levels, bulk density, clay mineralogy, infiltration rates, hydraulic conductivity, and depth to bedrock. The following sections describe the soil conditions at the Grants irrigation sites and the affects of many years of irrigation on the soil health.

#### **3.6.1 Irrigated Soil Physical Characteristics**

Prior to establishment of the irrigated areas, a detailed assessment of the potential soils to be irrigated was conducted in 1998. Originally, SCS (now NRCS) soil mapping was used to establish baseline conditions at the site and then backhoe trenching was utilized to refine the characteristics of the irrigation areas. Following is a general description of those soils prior to irrigation.

For the Section 33 Center Pivot area, the majority of the area is comprised of the Mespun sandy loam to sandy soil series with minor acreages of Sparank sandy clay loam to clay loam and the Aparejo silty clay loam series. Following the backhoe examination, it was determined that the soils located under the pivot were comprised largely of the Mespun series and another sandy series referred to as the Glenberg, or Glenberg- variant soil series. Both soils have sandy loam to loam surface textures. The Mespun soil developed in wind blown sands and the surface sandy loam layer is shallow, generally 10 inches or less. Below 10 inches are high permeability stratified fine to medium sands. The Glenberg soils developed in fluvial deposits and the sandy loam to loam surface layer is up to 24 inches thick. Below 24 inches are highly permeable stratified fine to medium sands. The Glenberg soils generally have slopes of 1% or less and the Mespun soil slopes range from 1% to 6%.

Irrigation suitability of these soils was based on NRCS suitability ratings, field investigations including backhoe trench analyses and laboratory analyses, and double ring infiltrometer tests. These soils are generally unsuitable for flood irrigation due to their sandy nature, rolling topography, and extremely rapid infiltration rates. While these soils were considered by NRCS to be marginal for sprinkler irrigation due to their droughty nature and rapid infiltration rate, with proper irrigation application rates and pivot cycles, these soils were determined to be acceptable for the establishment of a center pivot irrigation system.

The Section 28 Center Pivot was initially established as a 60 acre system and later expanded to cover 100 acres. The NRCS mapped this area as the Glenberg soil series with San Mateo soils

occurring in swale areas. The backhoe examination confirmed the NRCS mapping and the majority of the area under the Section 28 center pivot is comprised of Glenberg sandy loam soils. This soil generally has sandy loam surface and subsurface soils ranging up to 24 inches in depth. Below 24 inches are stratified medium and fine sands. Swales are dominated by the San Mateo sandy clay loam soils consisting of loam to sandy clay loam surface and subsurface textures up to 28 inches deep. Below 28 inches are fins to medium stratified sands.

The NRCS rated the sprinkler irrigation suitability of the Glenberg soil as somewhat limited due to droughty condition and relatively low water holding capacities. However, these soils were determined to be adequate to support sprinkler irrigation as long as proper irrigation application rates and cycles were maintained.

The Section 34 flood irrigated soils were mapped by the NRCS with the majority of these soils described as the Sparank clay loam soils. These soils are characterized as having clay loam surface horizons with clay loam to clay subsurface horizons ranging up to 24 to 36 inches deep. Generally, stratified clay loam, sandy clay loam, and silty clay loam soils are found below these depths. Field examinations, including backhoe trenches, indicate that the northern one third of these soils in the flood irrigation area are the San Mateo soils with sandy clay loam to clay loam surface textures and clay loam sub-surface textures to 24 inch depths. Below 24 inches in these soils are stratified fine and medium sands. The remaining soils were determined to be the Sparank series as described by the NRCS. However, these soils were found to have stratified fine and medium sands located at depths of about 36 inches.

The NRCS rated these soils as somewhat limited for flood irrigation due to very slow percolation or infiltration rates. However, these soils had been flood irrigated historically since the 1950's. The biggest factor in flood irrigation of these soils was excessive cracking if they were allowed to dry. Extensive laser leveling was conducted on the site prior to irrigation in 2000 and the site was seeded to alfalfa forage production. Irrigation was accomplished through gated irrigation piping.

The Section 33 flood irrigated soils were mapped by the NRCS as the Sparank soils. These soils are characterized as having clay loam surface horizons and clay loam to clay subsurface horizons to depths of 72 inches. Field investigations for these soils showed that the southwest portion of the Section 33 flood irrigated soils were comprised of the Aparejo clay loam soil series, sandy substratum phase. The remainder of the soil was the Sparank clay loam soils as mapped by NRCS. Like some of the Section 34 flood irrigated soils, these soils had fine to medium sands at depths of 24 to 36 inches. As with the Section 34 flood irrigated area, these soils were historically flood irrigated in the 1950's and 1960's. These soils were seeded to grasses and irrigated in 2004, 2005 and 2008. They were tilled and seeded to triticale in the fall of 2008.

### **3.6.2 Soil Salt and Sodium Relationships with Irrigation Water Quality**

Measurement of soil chemistry, particularly sodium levels and salt (Electrical Conductivity - EC) levels provides an understanding of the amount of soil constituents that remain in the soil after an irrigation season. In the case of soil salinity, it is desirable to leach salts through the root zone to

prevent crop toxicity from occurring. The concentration of sodium and salt in the site irrigation water has been examined to assess their affect on the irrigated soils.

Sodium affects soil physical properties by causing soil clays to expand and disperse. The expansion of clay results in a significant decrease in soil permeability making it difficult to push irrigation water through the soil profile. Because potential adverse affects of sodium on soils are related to the amount of exchangeable sodium that can adsorb on the soil cation exchange complex, measurement of the exchangeable sodium and cation exchange capacity provides a valuable tool for predicting and monitoring potential adverse affects on soil health due to sodium in the irrigation water.

Since soil clays are directly affected by sodium, it stands to reason that sandy center pivot soils are not generally affected by the presence of high sodium levels. Conversely, heavy clay irrigated soils have a higher risk for being adversely affected by higher sodium levels. In addition, the salinity concentrations in the soil and irrigation water will alter how significant the affect of sodium is on the soil clays. Salts tend to flocculate clays, reducing the amount of expansion. When salts are significant, soil permeability may not be affected by higher concentrations of the sodium.

Historically, since ESP and CEC are more difficult and expensive to analyze, scientist developed an empirical relationship comparing soluble sodium to exchangeable sodium (U.S.D.A. Handbook 60) and assumes the soils are in chemical equilibrium. The sodium adsorption ratio (SAR) compares soluble sodium concentrations to the concentration of soluble calcium and magnesium in the soil. In soils that were in chemical equilibrium, a SAR of 12 was comparable to an ESP of 15. For irrigated soils like those at the Grants irrigation sites, the soil may not be in chemical equilibrium and the historical comparison of SAR to ESP may not be as accurate. However, SAR is still a useful parameter to examine for potential sodium risks to soil health.

Irrigation wells have been analyzed for sodium and salinity concentrations. This data is useful in assessing the current and potential adverse risk to the soil associated with the irrigation water. The mean SAR of these wells was 5.2 and the SAR range was 4.2 to 6.1. The mean electrical conductivity (EC) of these wells was 2690 umhos and the range was 2205 to 3440 umhos.

As described previously, the concentration of salts in irrigation water can be useful to counteract the possible adverse effects of sodium on expanding soil clays. Table B-1 in Appendix B shows the level of exchangeable sodium, at varying clay contents, which would cause a 25% reduction in soil hydraulic conductivity at three concentrations of salt in the irrigation water. Without considering all other factors that ameliorate the effects of sodium on soils, an ESP of 15% (SAR 12) was historically considered risky for successful irrigation of all soils.

For the Section 33 and 28 center pivot soils, the average clay content would be approximately 15%. Referring to Table B-1, the estimated critical ESP of these soils would be 25%, 30%, and 40% for irrigation water with salt concentrations of 1000 umhos/cm, 2000 umhos/cm, and 4000 umhos/cm, respectively. Essentially, this data confirms that because of low clay content, little risk exists for irrigation of these soils in relation to adverse affects due to sodium.

For the Section 33 and 34 flood irrigated areas, the average clay content will be 35 to 40%. Referring to Table B-1, the critical ESP for these soils would be 15%, 21%, and 28% for the

1000 umhos/cm, 2000 umhos/cm, and 4000 umhos/cm salt levels, respectively. In relation to the average site irrigation water electrical conductivity of 2690 umhos/cm, adverse soil problems associated with sodium would not likely occur as long as the ESP of the soils stayed below about 25% (SAR < 20).

Table B-2 in Appendix B shows the soil health risk when the sodium level (SAR) of the irrigation water is included with the salinity concentrations effects. The table summarizes the associated risk for all soil textural families ranging from sandy (center pivot irrigation) soils to fine loamy to fine clay (flood irrigation) soils. The average SAR of the irrigation water is 5.2 and, when coupled with the 2690 umhos/cm salinity levels, the resulting irrigation water quality class is a C4S1. For the sandy center pivot irrigated soils, the soil health risk associated with irrigation of the C4S1 water will be very low to low in relation to possible reductions in permeability and hydraulic conductivity. For the fine loamy to clayey flood irrigated soils, the soil health risk is low.

While sodium effects are primarily a physical problem in soils, high salinity levels could cause problems related to crop toxicity to salts. Without specific crop knowledge, a soil salinity level in excess of 2200 umhos/cm may be considered toxic to plants. However, individual crops respond differently to salinity levels. The primary crops grown at the site are alfalfa and grass. Both of these crops are adapted to the growing conditions for the Grants area and are moderately to strongly salt tolerant. Soil salt levels around 4500 umhos/cm may prevent some germination of these crops. However, once germinated they are strongly salt tolerant and can withstand salt concentrations in excess of 4500 umhos/cm. Regardless of the individual crop salt tolerance, it is important for all crops to overall soil health to leach a portion of the salts below the root zone to prevent the buildup of salts over time.

### **3.6.3 Effects of Current Irrigation Practices on Soil Health**

ESP is not generally available in the HMC irrigated soil data base; therefore, any discussions in this report on possible sodium soil changes will focus on the use of SAR. Table 3-4 provides a summary of the soluble sodium, calcium, magnesium, SAR, and EC annual monitoring data for both background and irrigated soils for the life of the irrigation project. Note that the Section 33 and 28 center pivot soils did not receive irrigation water in the 2010 irrigation season.

For the Section 33 center pivot area, the SAR for background soil samples before irrigation was approximately 1.0. After the 2009 irrigation season, the reported SAR under the center pivot for the 1 foot, 2 foot, and 3 foot sampling depths was 6.71, 8.53, and 7.856, respectively. While these values appear to have increased significantly over the past ten years, these SAR values more appropriately reflect the migration of the soluble constituents in the irrigation water. And, as stated before, sodium at these levels will have limited adverse affects on the sandy center pivot soils.

The background electrical conductivity levels for this site ranged from 200 to 1740 umhos/cm. After the 2009 season, the average EC for the three sampling depths for all years was 3472, 3906, and 4271 umhos/cm. Keep in mind that the EC of the irrigation water can range up to 3400 umhos/cm and while the EC has increased over time, the salinity levels are reflective of the

migration of the irrigation water constituents and are lower than levels that will create concern over potential toxicity for the crops that have been grown.

For Section 28, the average background SAR in the soil for all depths is 1.21. After the 2010 irrigation season, the average SAR in the 3 foot sampling depth was 5.56 and the SAR for the 1 foot depth, 2 foot depth, and 3 foot depth was 5.78, 5.07, and 5.84, respectively. Again, the presence of an apparent increase in SAR is indicative of the movement of the irrigation water through the soil profile. Evidence of this process is that the SAR increased immediately after the first irrigation season. Again, the sodium has little effect on the permeability of sandy soils. The average EC of the 3 foot soil profile for Section 28 is 773 umhos/cm and the individual 1 foot depth, 2 foot depth, and 3 foot depth averages for all years was 704, 802, and 814 umhos/cm, respectively. In 2010 the average EC was 4193 umhos/cm and the 1 foot, 2 foot, and 3 foot depths were 4290, 4130, and 4160 umhos/cm, respectively. Again, these increases occurred immediately after the first irrigation and are reflective of the irrigation water quality and mass water balance. All EC levels are lower than levels expected to cause salt toxicity problems in the site crops.

For the Section 34 flood area the average background SAR for the 3 foot root zone is 4.43 and the average for all years of the individual 1 foot, 2 foot, and 3 foot sampling depths was 4.10, 4.70, and 4.48, respectively. Following the 2010 irrigation season, the average SAR level for all depths was 6.27 and the 1 foot, 2 foot, and 3 foot depths were 6.56, 7.06, and 5.19, respectively. Review of the yearly data shows that the SAR, reflective of the soluble sodium, is variable from year to year. That is, depending on the amount of leaching through the soil profile, the SAR goes up or down on a yearly basis. Based on SAR numbers and irrigation infiltration observations, these soils are not showing any significant reduction in soil permeability or hydraulic conductivity. These findings are consistent with the predictions described in Section 6.2 for the C4S1 water quality class.

The average background EC of the 3 foot sampling depth is 3265 umhos/cm and for the 1 foot, 2 foot, and 3 foot depths the EC was 2555, 3358, and 3873 umhos/cm, respectively. After the 2010 irrigation season, the average EC for the 3 foot sampling depth was 4165 umhos/cm and for the 1 foot, 2 foot, and 3 foot depths, the EC were 4110, 4560, and 4090 umhos/cm, respectively. Keep in mind that this area was irrigated previously and the background salt levels are indicative of that previous irrigation. However, review of the yearly EC data as shown in Table 7 shows that the salts concentrations can vary up or down on a yearly basis and are directly related to the amount of yearly leaching of the salts through the root zone. While these EC levels may be marginal for some crops, particularly some row crops, they are suitable for the hay and grass crops grown on the site.

For the Section 33 flood irrigated soils, the average background SAR was 1.43 and the average for all years of the individual 1 foot, 2 foot, and 3 foot sampling depths was 1.49, 1.27, and 1.52, respectively. At the end of the 2010 irrigation season, the average SAR for all depths was 3.26 and the 1 foot, 2 foot, and 3 foot SAR values were 3.57, 3.14, and 3.07, respectively. As with the other irrigated areas, the increase in SAR was immediately reflected in the first year and the values move up or down annual depending in leaching. The SAR value after five years of



irrigation is still well below levels of concern for reducing hydraulic conductivities and permeability.

The average background EC for the 3 foot sample depth is 828 umhos/cm and the background EC for the 1 foot, 2 foot, and 3 foot individual sample depths is 876, 754, and 855 umhos/cm, respectively. At the end of the 2010 irrigation season, the average 3 foot EC was 2348 umhos and the individual 1 foot, 2 foot, and 3 foot depth EC was 1610, 1170, and 2530 umhos/cm, respectively. Again, as with all sites, the increases were evident immediately after the first irrigation season and are reflective of the overall water balance and the quality of the irrigation water. These EC levels are well within the desired toxicity range for the crops grown at the site.

As noted earlier, it is important to leach salts from the root zone to prevent buildup of salts to the level that they affect crop production. The combined irrigation well water is routinely analyzed for chloride, a major component of soil salts. By measuring the applied irrigation water chloride and comparing that data to the mass soil chloride concentrations, the net chloride passing through the root zone over time can be determined on a mass balance basis. This measurement is directly related to salt concentrations and allows for a direct assessment of the yearly and cumulative leaching of salts through the root zone.

Detailed tabular data on chloride leaching for all sites is provided in Table 7. For Section 33 center pivot soils, a net 82percent of all applied chloride for all the years of irrigation has been leached through the soils. Evaluation of the data shows that the leaching may be variable and in one year, no leaching occurred although the net leaching is significant over time. Routine irrigation practices are sufficient to allow for leaching of salts from the sandy soils.

For the Section 28 center pivot site, 86 percent of the applied chloride has passed through the root zone for all of the years of irrigation. As with the Section 33 irrigation, salts are easily leached below the root zone.

For the Section 34 flood irrigated soils, the mass balance of applied chloride versus stored soil chloride indicates that 68 percent of the chloride has been leached through the root zone or did not enter the soil. Since this is a mass balance calculation using total applied chloride, the percent leaching is likely distorted because the calculation has not been corrected for chloride not entering the soil profile due to tail water losses. If one assumes that tail water accounts for 25 percent of the applied water only 51 percent of the chloride was leached. This data is reflected in the annual residual concentration of salts (EC) in the Section 34 flood irrigated soils. The very heavy clay soils make it more difficult to maintain salt leaching and prevent salt toxicities over time. However, review of the soil EC data on a yearly basis shows that sufficient salts are leached over time to prevent the concern to soil health for salt toxicity.

While EC levels are lower in the Section 33 flood irrigation area than in the Section 34 area, the relationship is very similar. Note that the differences are related primarily to the lower background EC levels at the start of irrigation. When accounting for chloride lost due to tail water, the net leaching level of the chloride in Section 33 flooded soils is 46%. As in Section 34, the leaching has been sufficient so far to prevent concern for salt toxicity to occur.

### 3.6.4 Conclusions

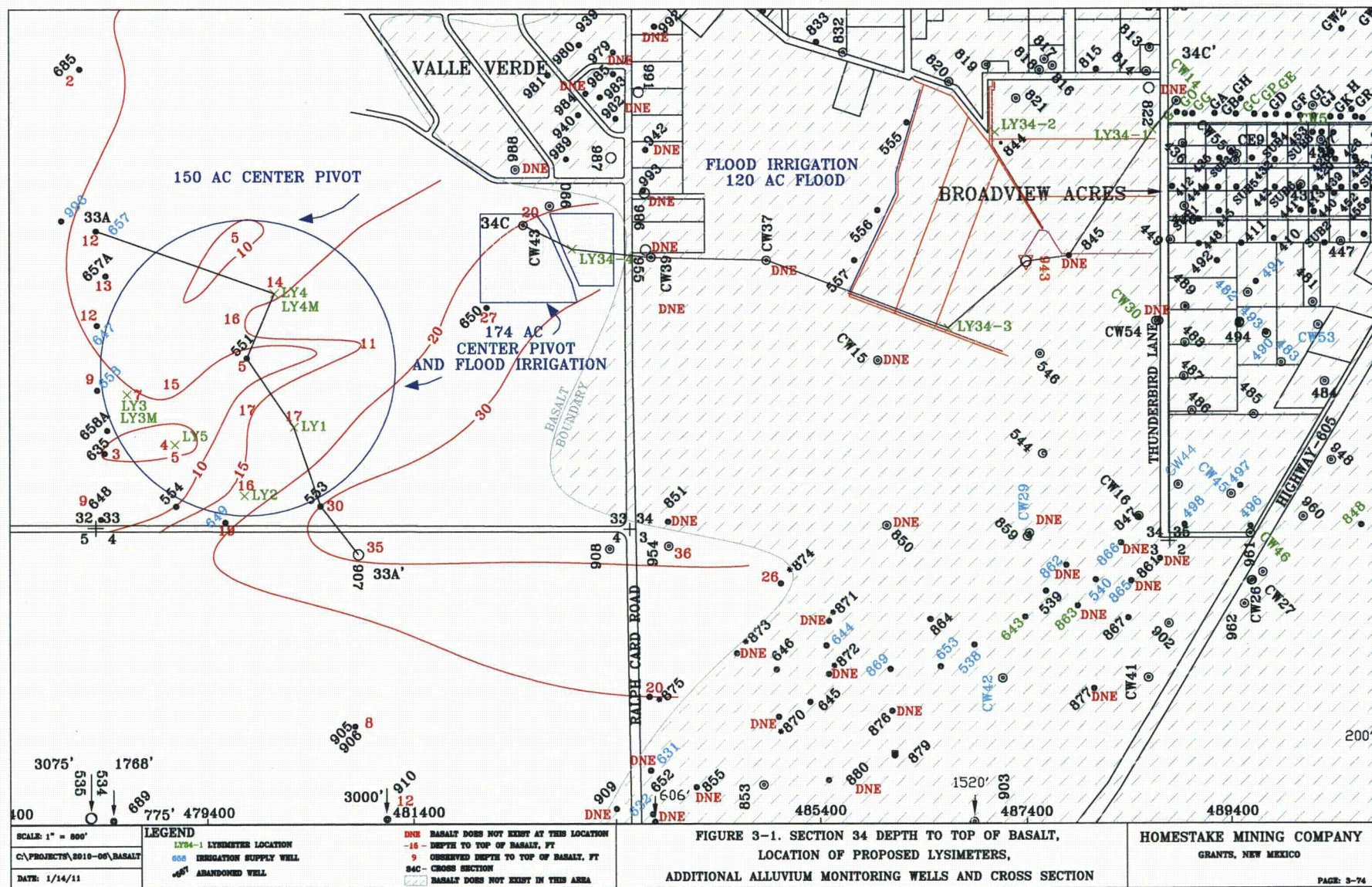
Soil Health associated with irrigation programs is generally centered around the affects of excess sodium on soil physical properties and on salt buildup to potentially toxic levels for vegetation or crops. The potential risk that these elements pose is much different for sandy soils than for heavier clay or clay loam soils. The low clay content of sandy soils allows for much higher sodium concentrations because sodium has no adverse affect on sand particles. The irrigation water quality for the site wells can be classified as C4S1 water with SAR levels less than 10 and EC levels greater than 2250 umhos/cm. The average SAR for the site water is 5.2 and the average EC is 2690 umhos/cm. This water quality is rated as very low to low sodium risk on sandy soils and low sodium risk on fine loamy soils, due to the flocculation effects that salts have on soil clays.

While salt concentrations are important to counteract the affect of higher sodium levels on soil clays, the salts may have a toxic affect on vegetation. For the alfalfa and grasses grown at the site, the soil salt toxicity level of concern is in excess of 4500 umhos/cm. Leaching of salts at all sprinkler and flood irrigated sites has prevented the buildup of salts to toxic levels. Review of the annual data indicates that the soil health, as related to salts and sodium, has not been adversely affected over the years.

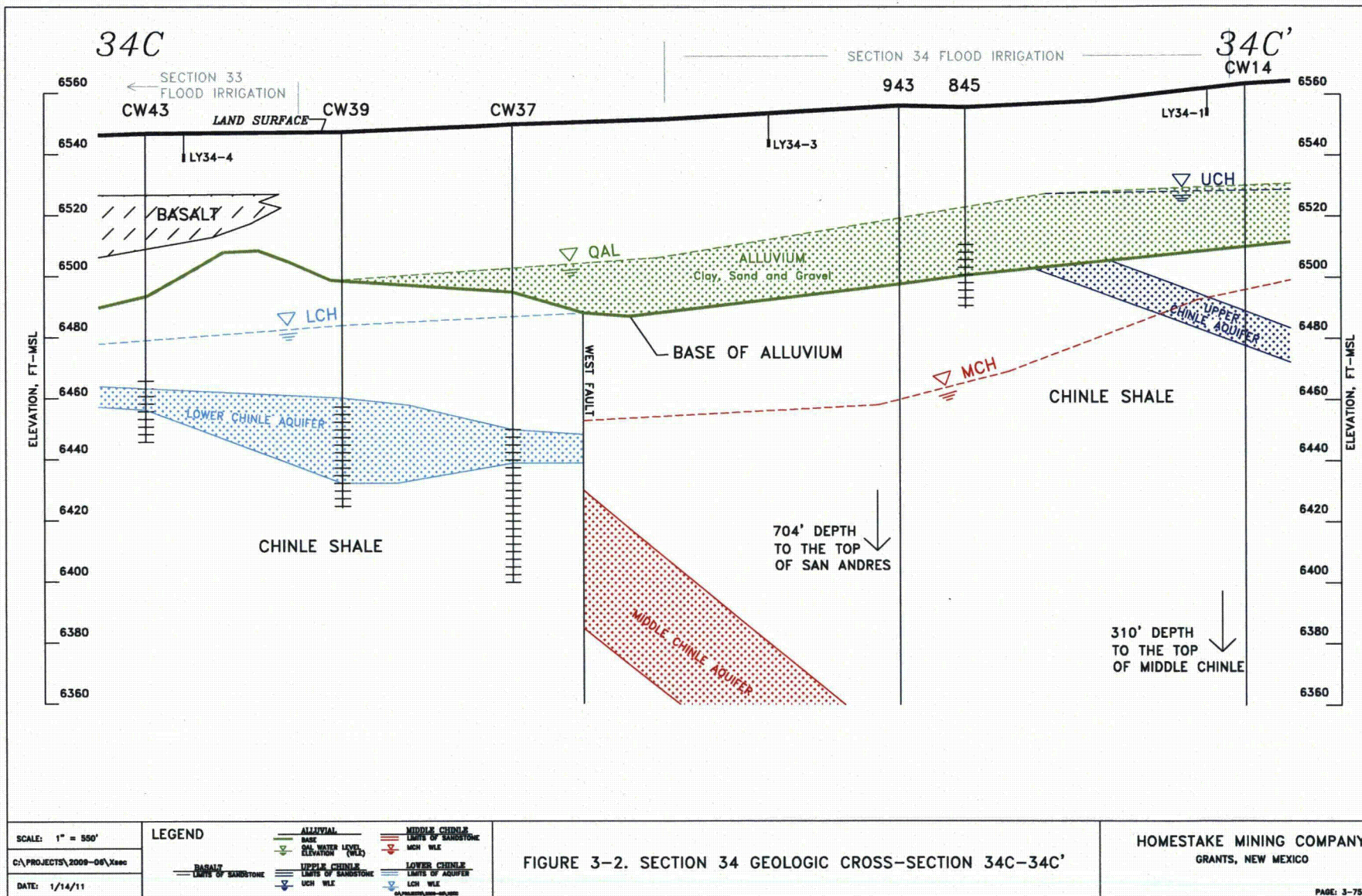
The above-background concentrations (gain) of uranium in each section, in mg/kg are tabulated in Table 3-6 and are: Section 33 Center Pivot (6.08); Section 33 Flood (1.55); Section 34 (4.88); and Section 28 (3.83). Based on this series of calculations, the ratios of measured to applied masses of uranium in the total footage of soil are: Sections 33 Pivot (1.44), 33 Flood (0.76), 34 (1.00), and 28 (1.02).

In Section 33 Pivot and Section 28, 144 and 102 percent of the applied uranium is accounted for, respectively, indicating that all of the applied uranium is likely still in the soil profile. Gains in the upper 17 feet of soil were used in calculating these percentages. The presence of more applied uranium deeper in the soil profile in these fields may be due to the sandy loam soils, which have less adsorptive capacity than clay soils. On the other hand, most of the uranium applied to Section 34 has been retained in the upper seven feet and this is attributed to the presence of clay soils. Only the results in the upper seven feet are thought to indicate some gain in the treated soil in Section 34. The measured concentrations in Section 33 Flood are thought to not produce a reliable retention value.

Accumulating uranium concentrations for each of the upper three layers in each irrigation area are shown in Figures 3-8 (Sections 33 and 34 Flood), 3-12 (Section 28 Center Pivot) and 3-16 (Section 33 Center Pivot). Each figure is subdivided into upper, middle, and lower intervals. The horizontal line on each figure represents the mean background concentration.







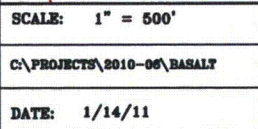
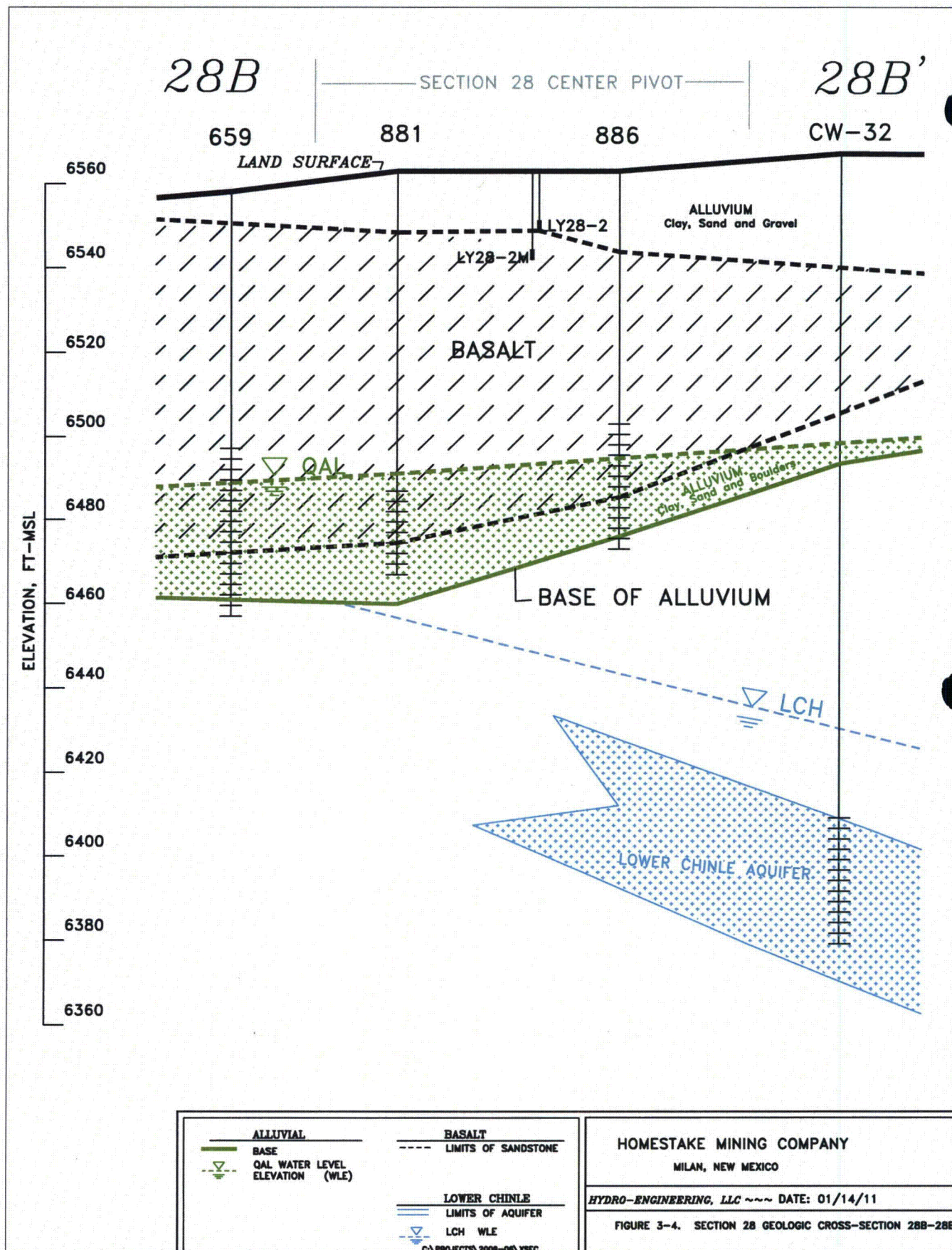
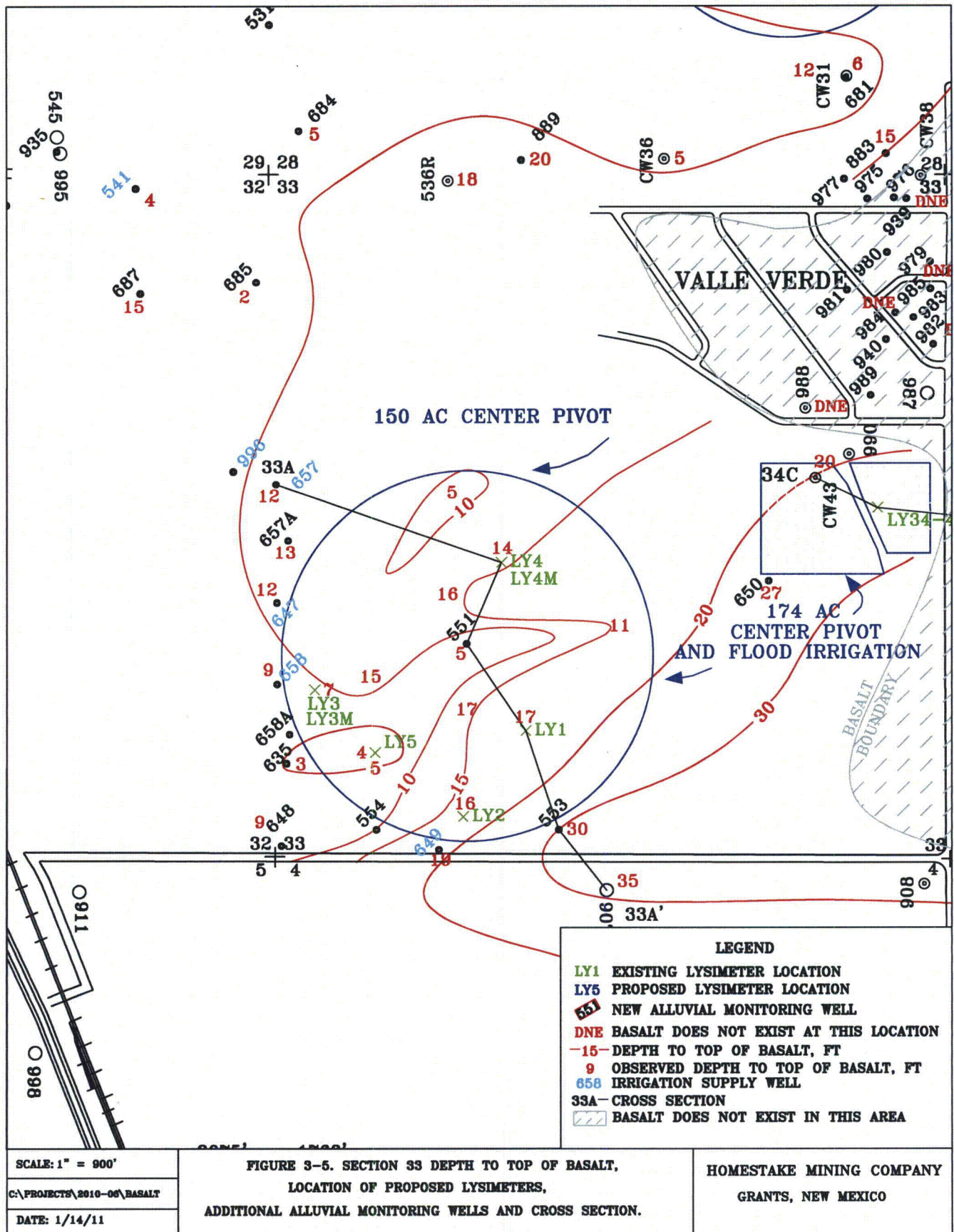


FIGURE 3-3. SECTION 28 DEPTH TO TOP OF BABSALT,  
LOCATION OF PROPOSED LYSIMITERS,  
ADDITIONAL ALLUVIUM MONITORING WELLS AND CROSS SECTION

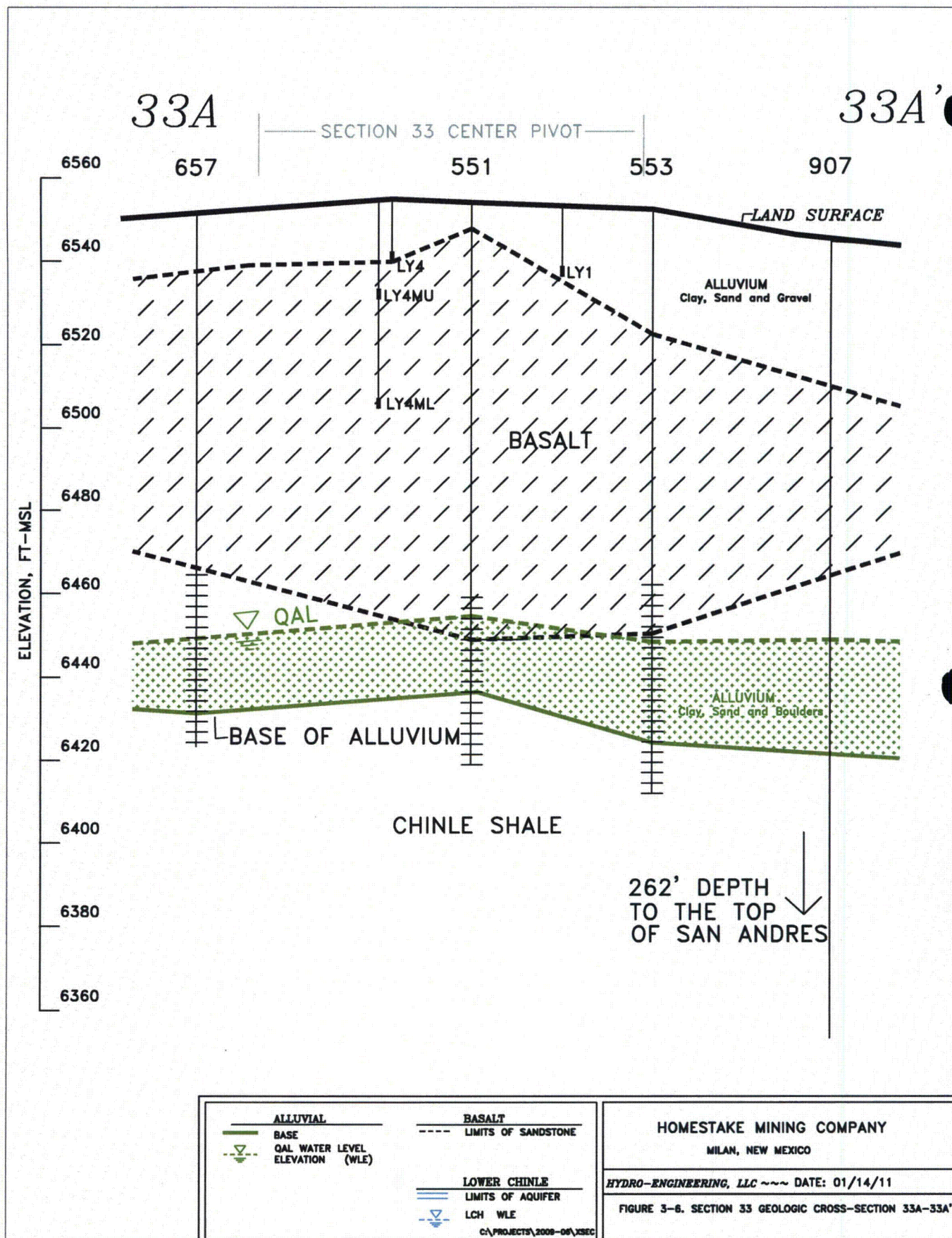
**HOMESTAKE MINING COMPANY**  
**GRANTS, NEW MEXICO**



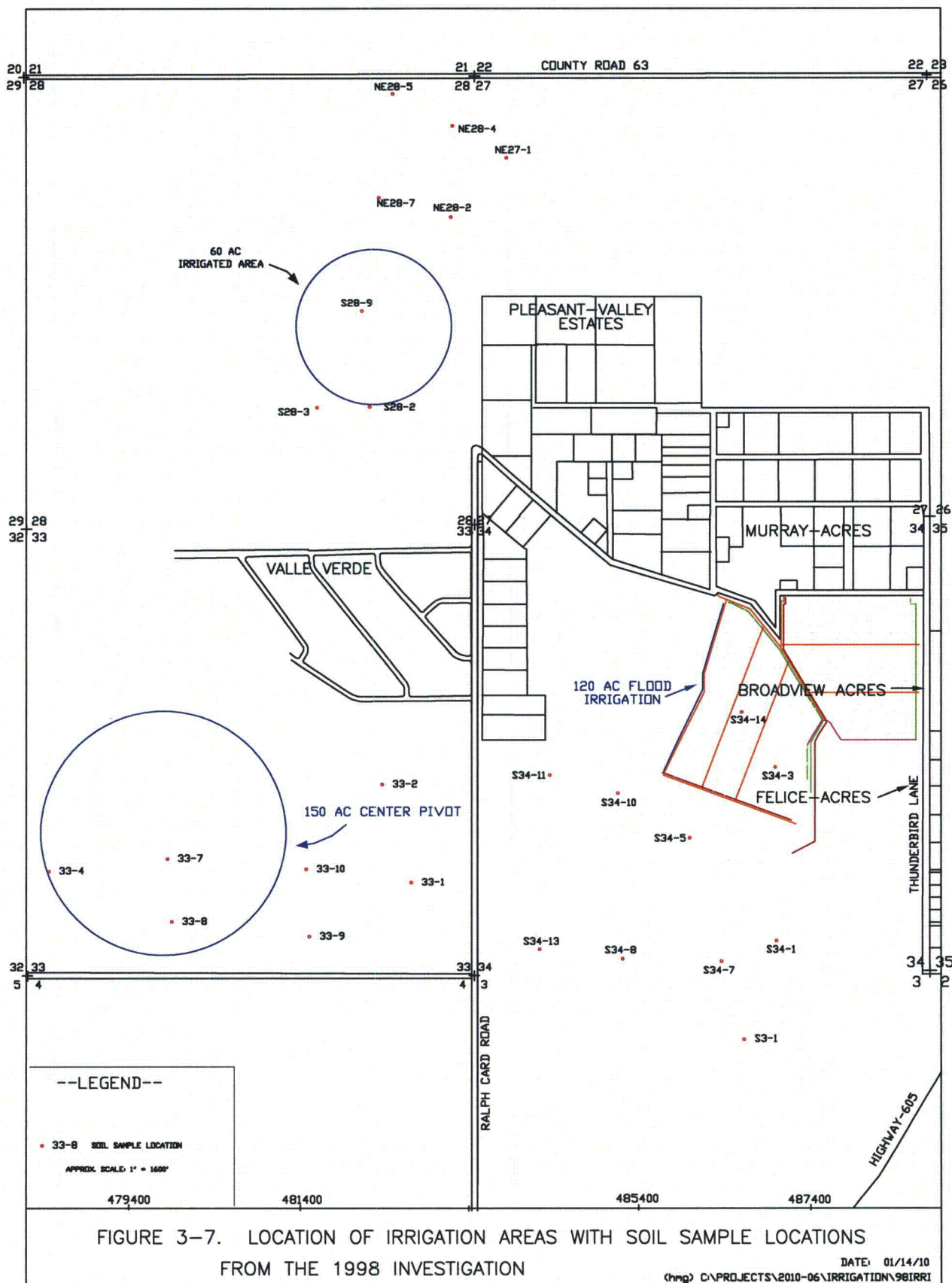


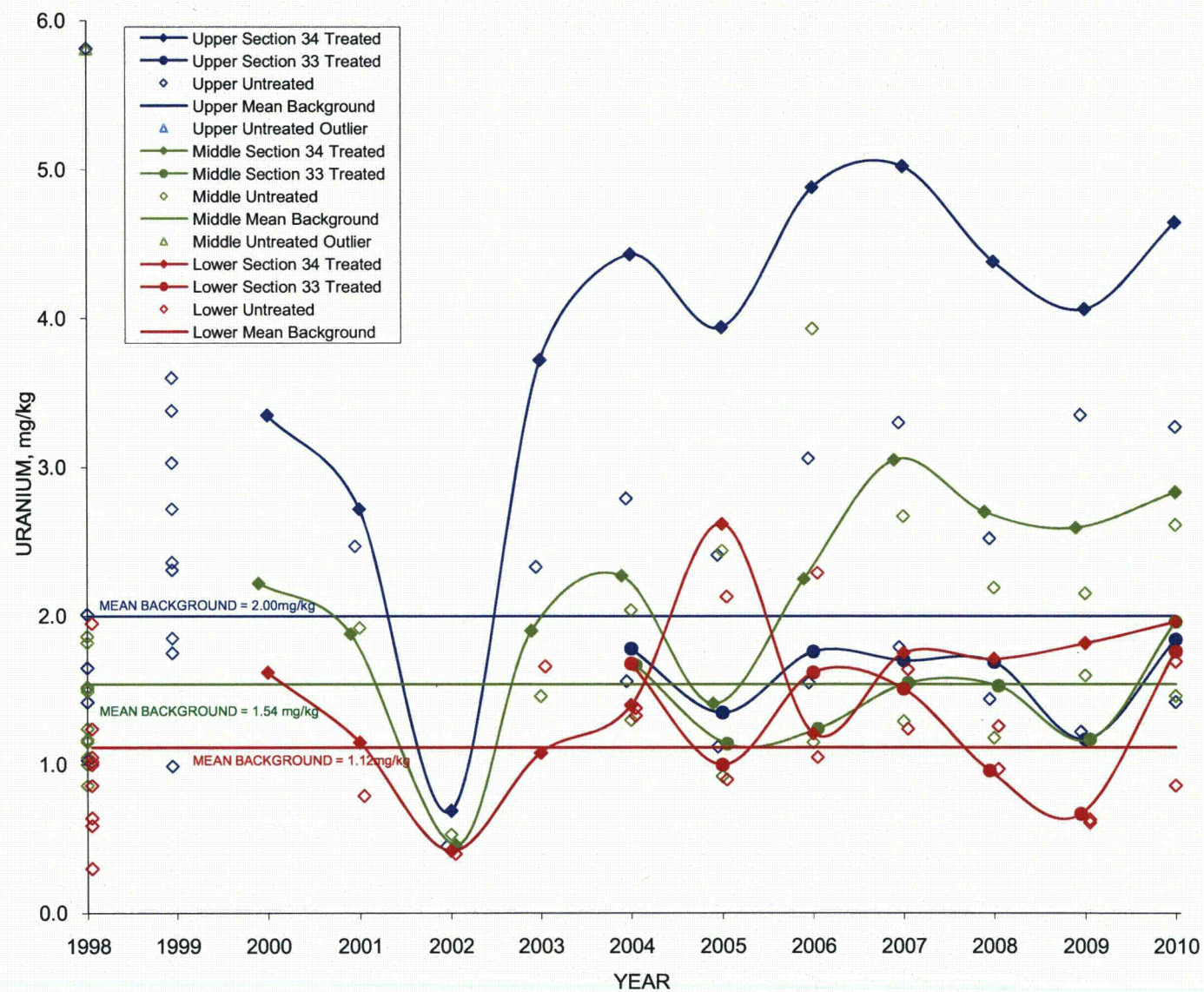






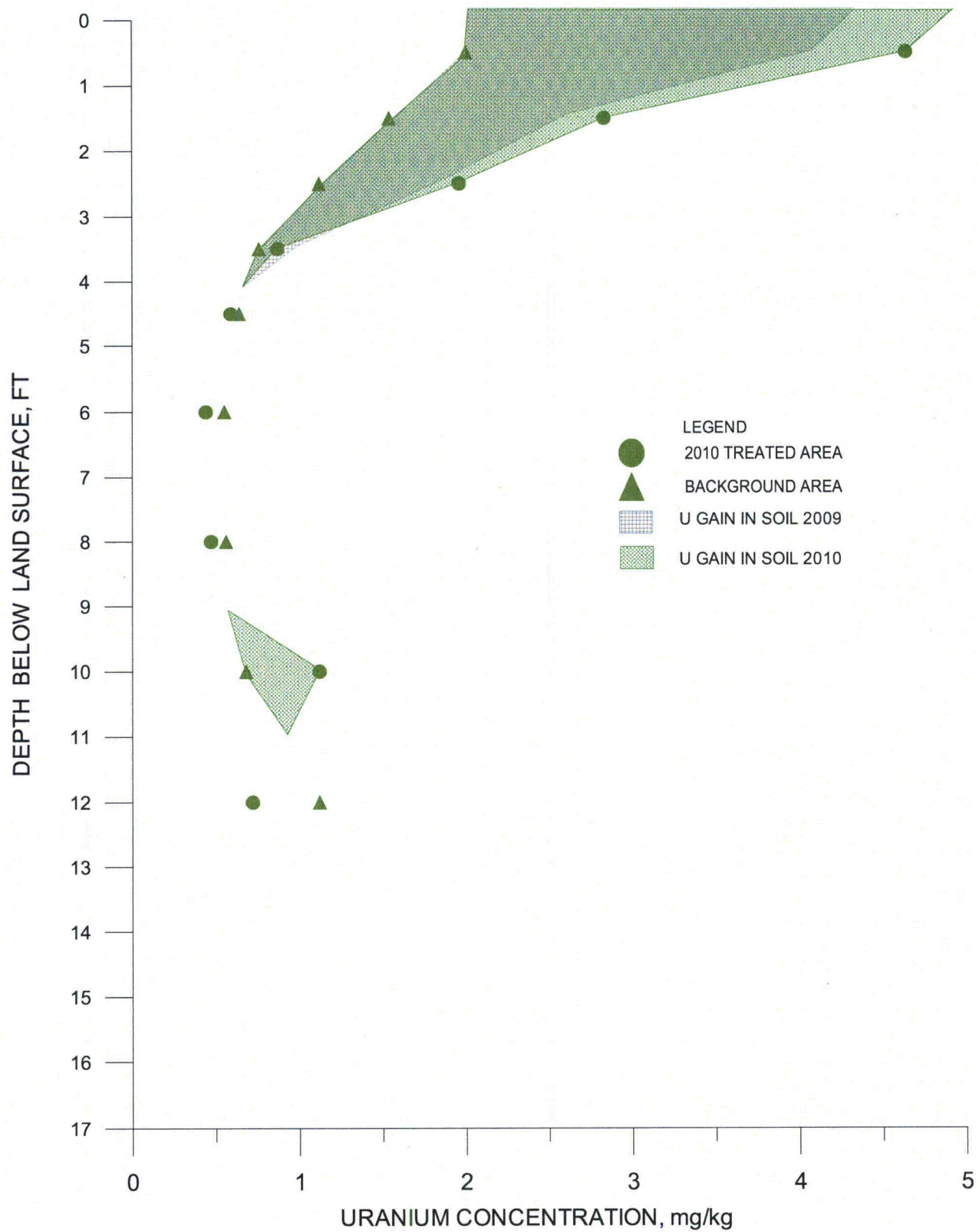




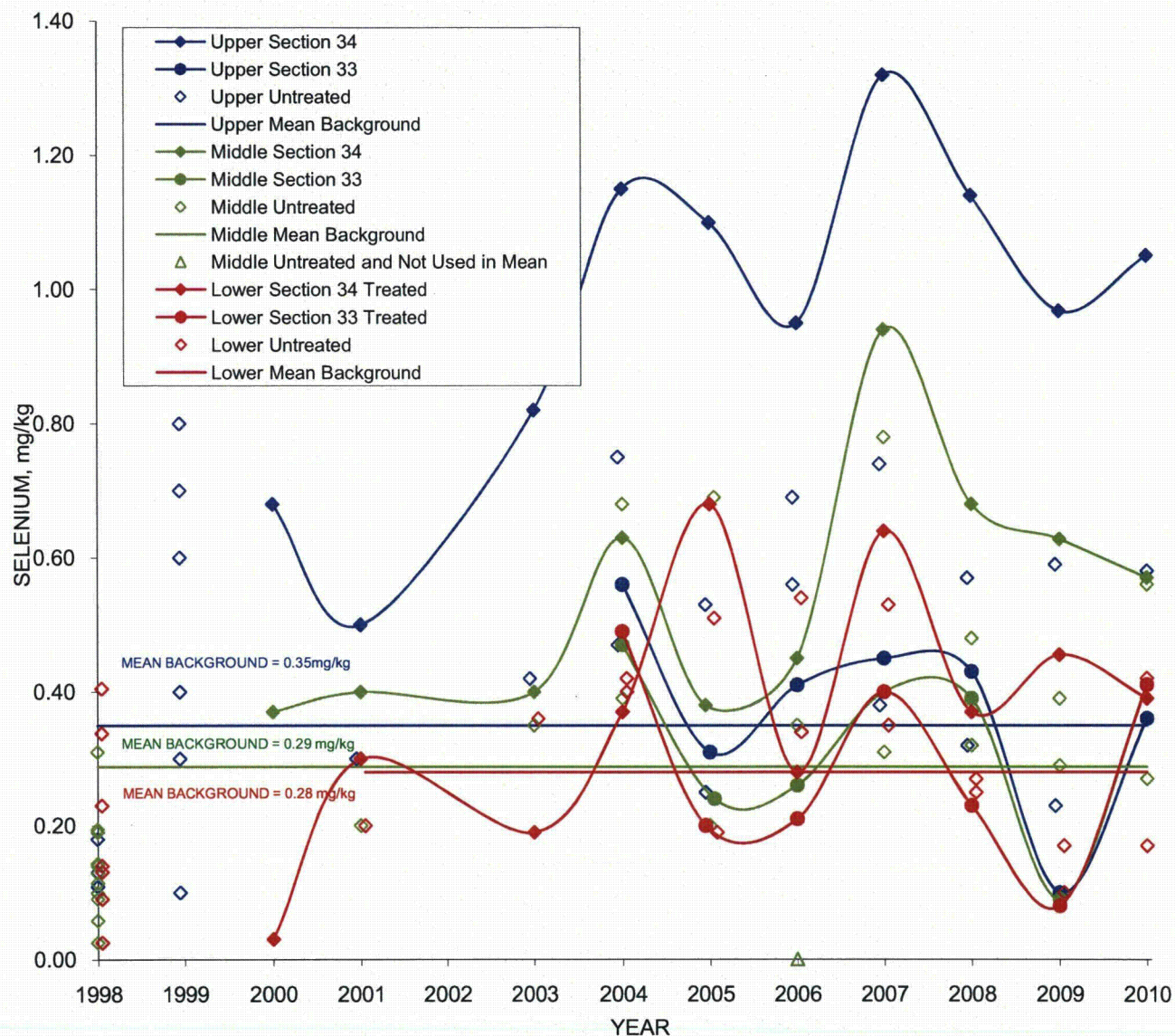


**FIGURE 3-8. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTIONS 33 AND 34 FLOOD SOIL SAMPLES**

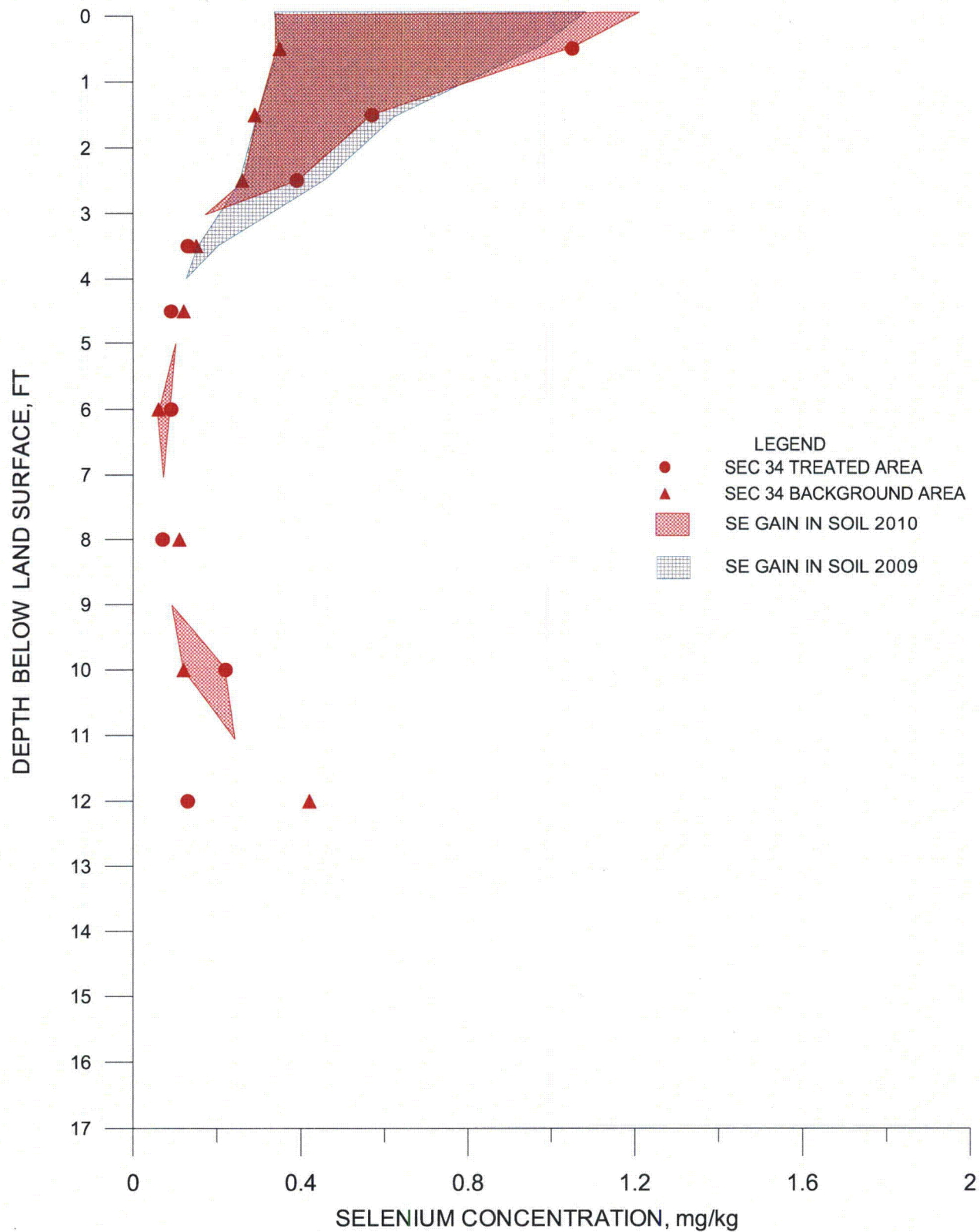




**FIGURE 3-9. URANIUM CONCENTRATION IN THE SOILS WITH DEPTH IN SECTION 34 IRRIGATION AREA**

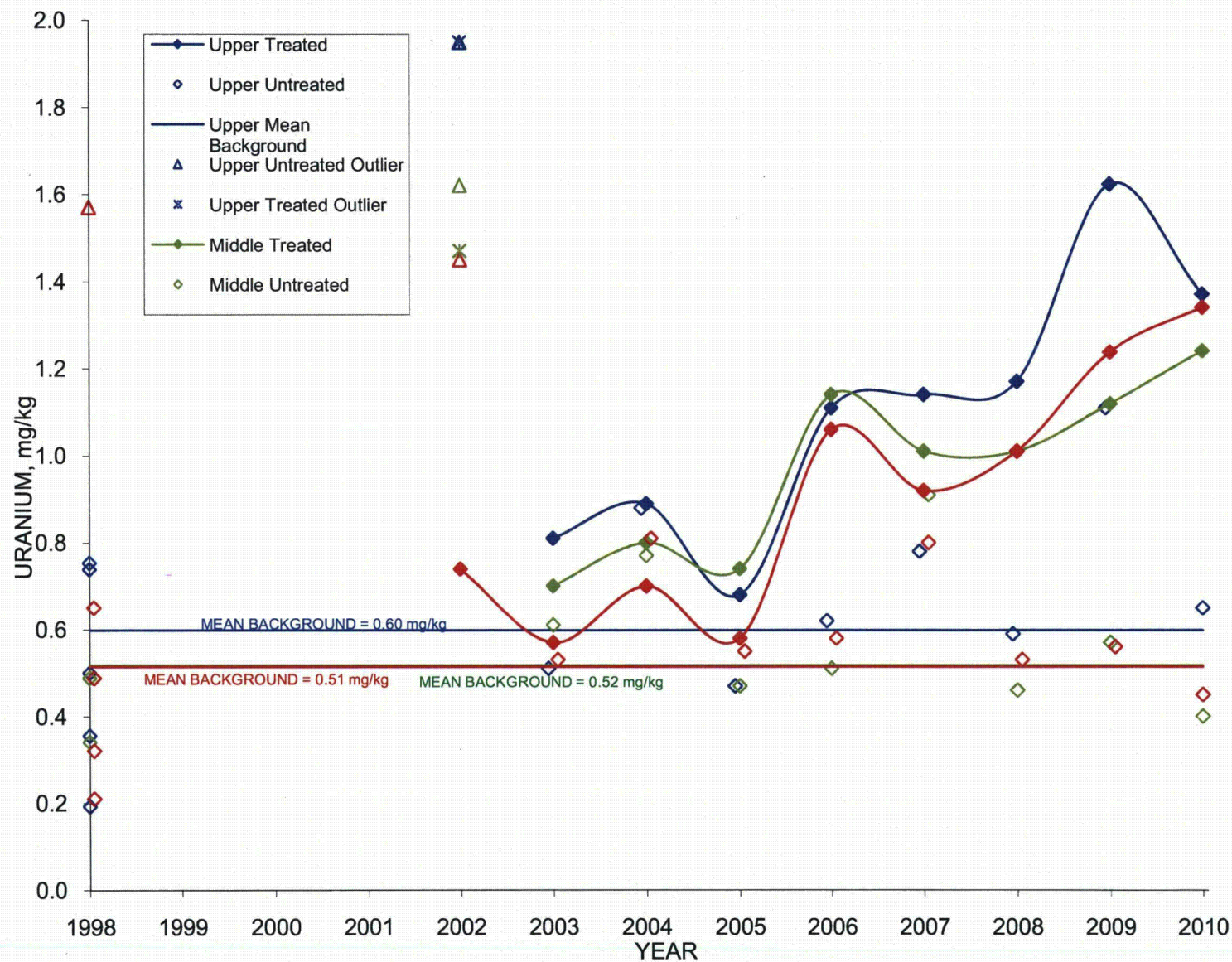


**FIGURE 3-10. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTIONS 33 AND 34 FLOOD SOIL SAMPLES**

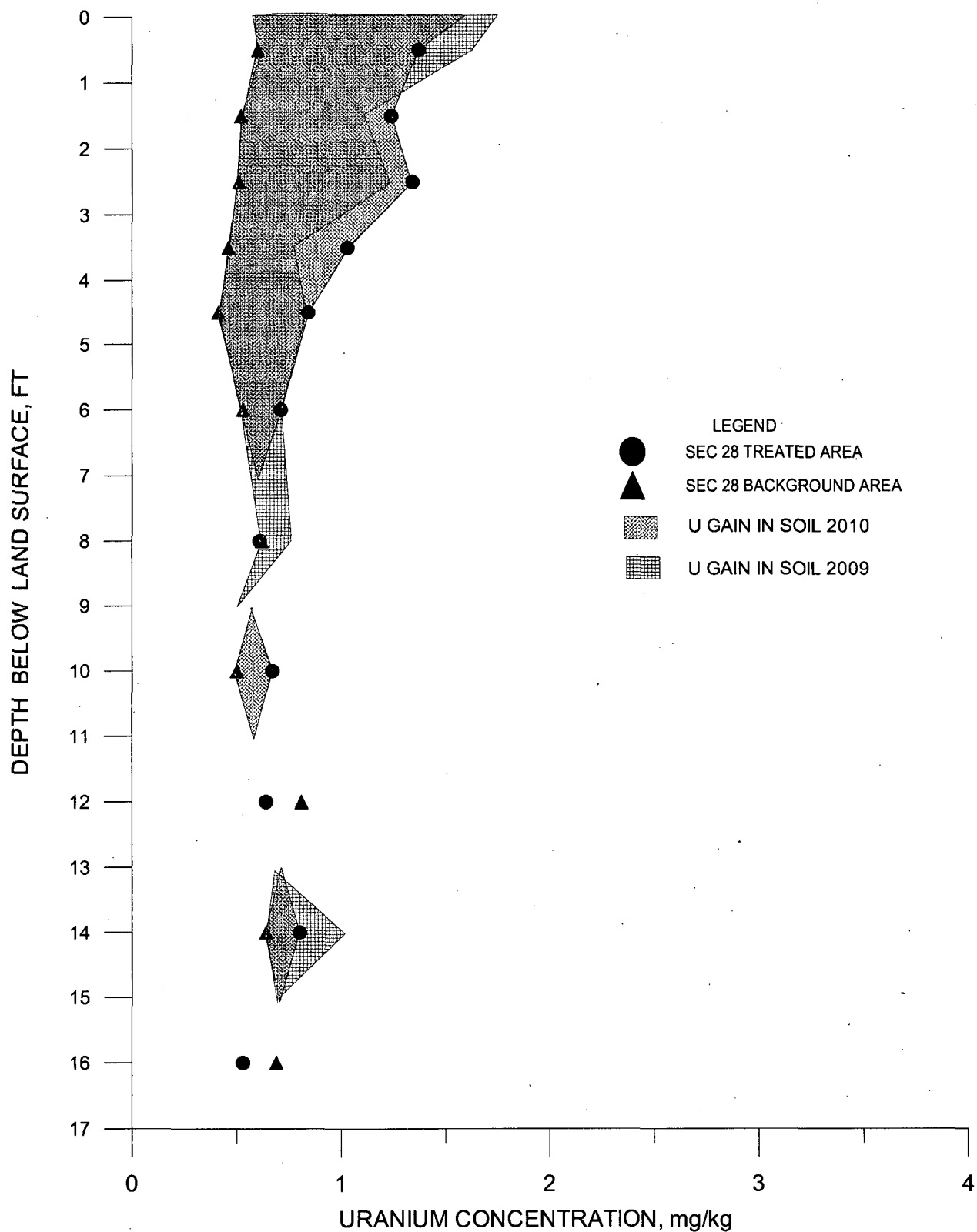


**FIGURE 3-11. SELENIUM CONCENTRATION IN THE SOILS WITH DEPTH IN SECTION 34 IRRIGATION AREA**

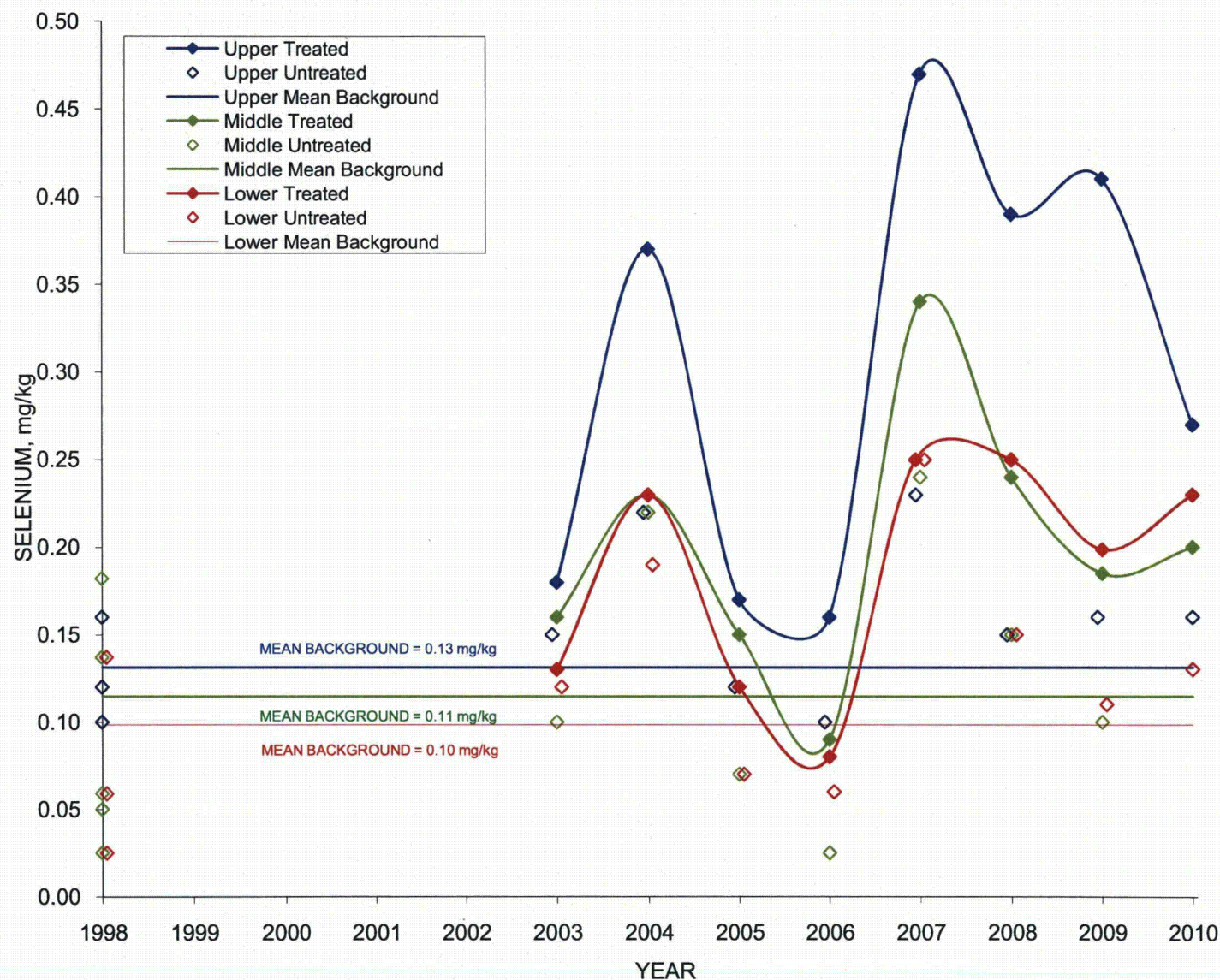




**FIGURE 3-12. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTION 28  
CENTER PIVOT SOIL SAMPLES**

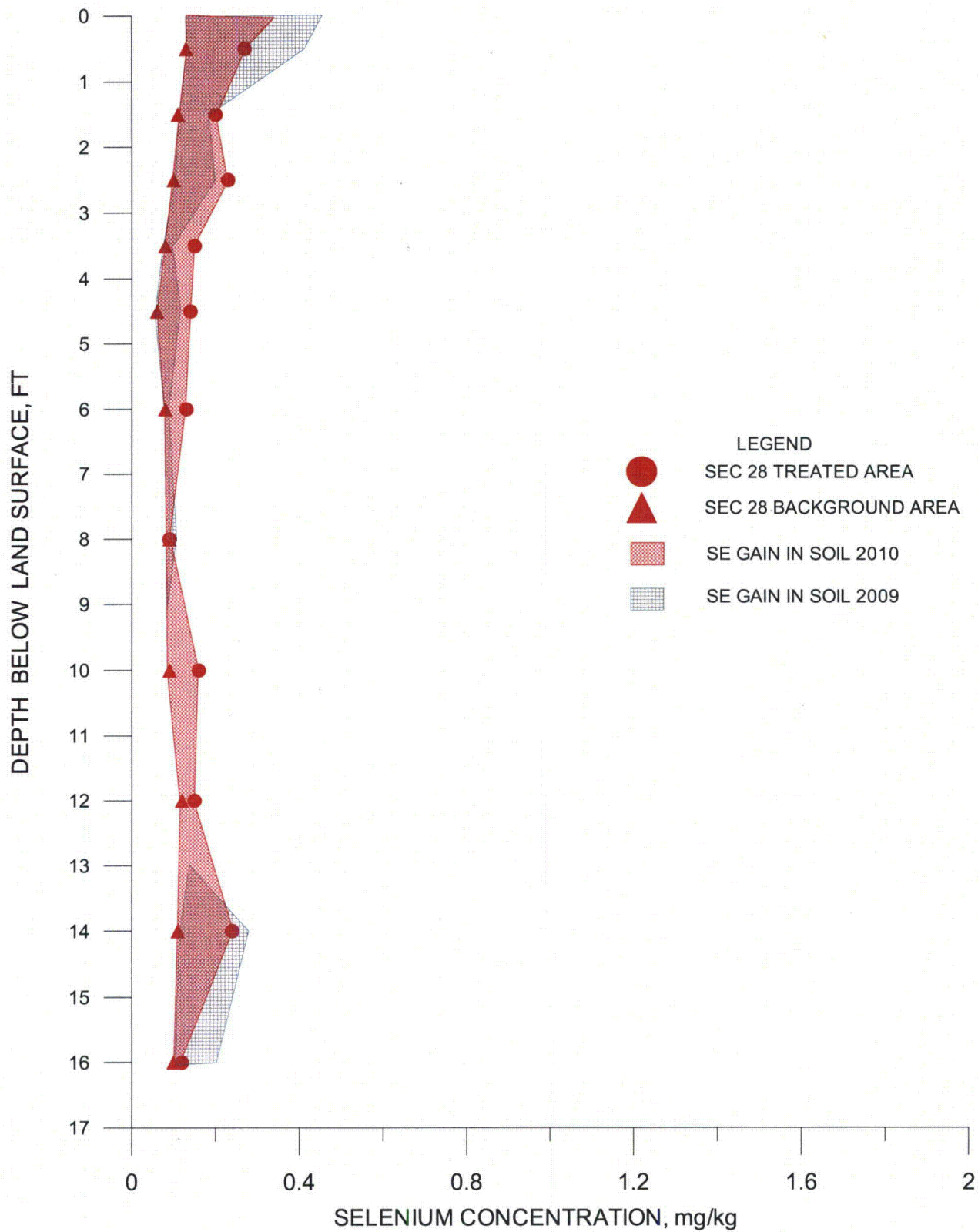


**FIGURE 3-13. URANIUM CONCENTRATION IN THE SOILS WITH DEPTH IN SECTION 28 IRRIGATION AREA**

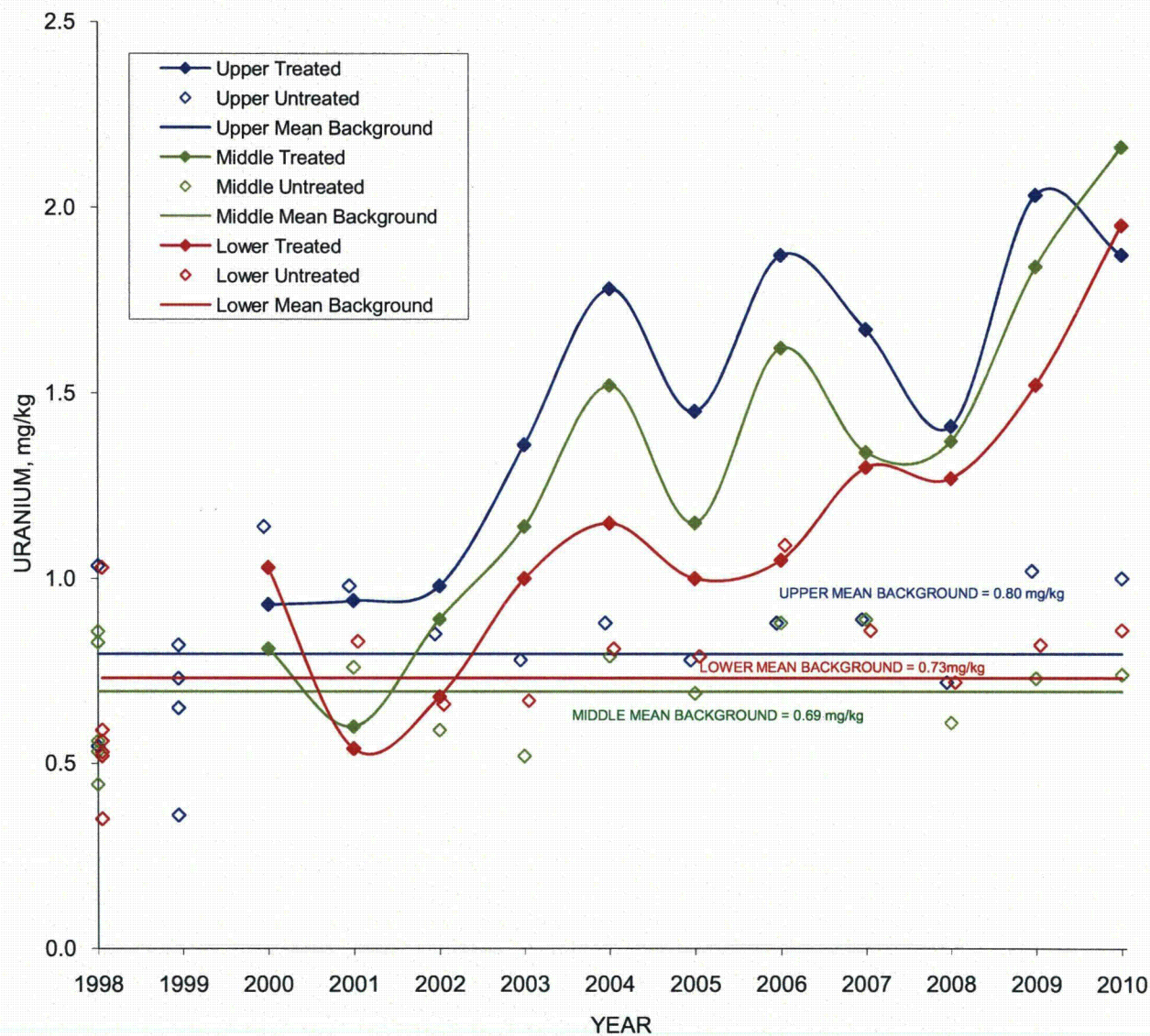


**FIGURE 3-14. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTION 28  
CENTER PIVOT SOIL SAMPLES**

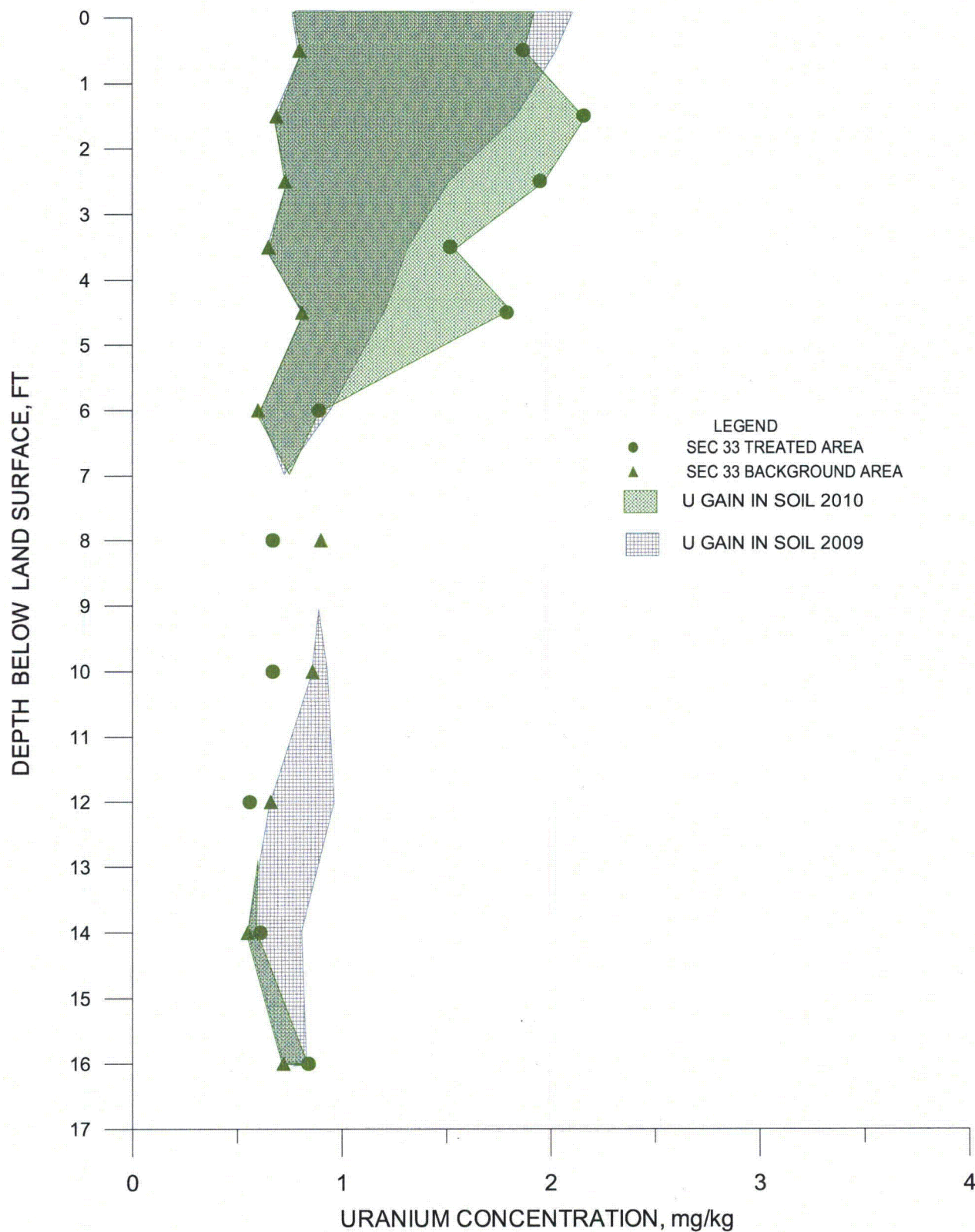




**FIGURE 3-15. SELENIUM CONCENTRATION IN THE SOILS WITH DEPTH IN SECTION 28 IRRIGATION AREA**

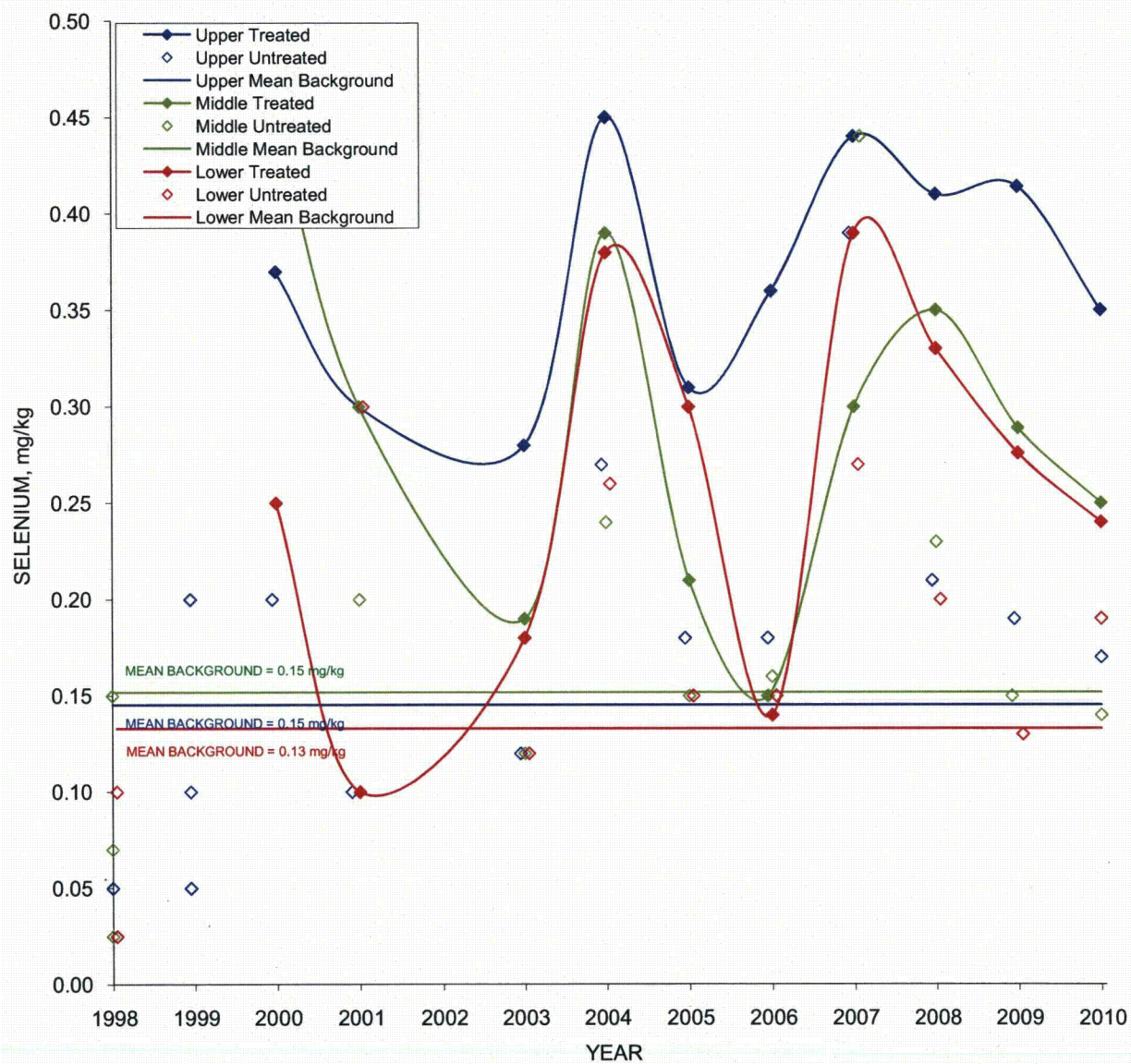


**FIGURE 3-16. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTION 33  
CENTER PIVOT SOIL SAMPLES**

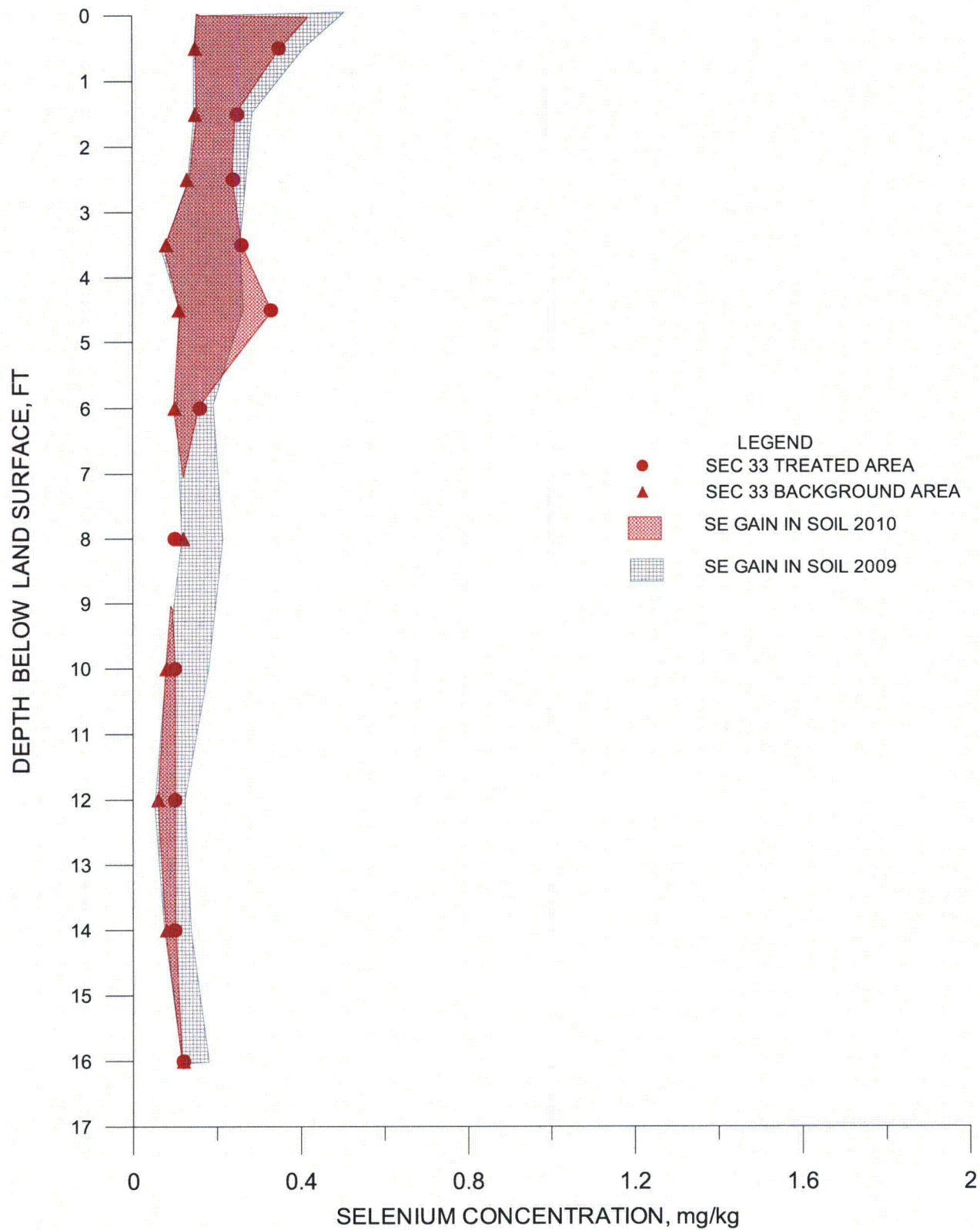


**FIGURE 3-17. URANIUM CONCENTRATION IN THE SOILS WITH DEPTH IN SECTION 33 IRRIGATION AREAS**

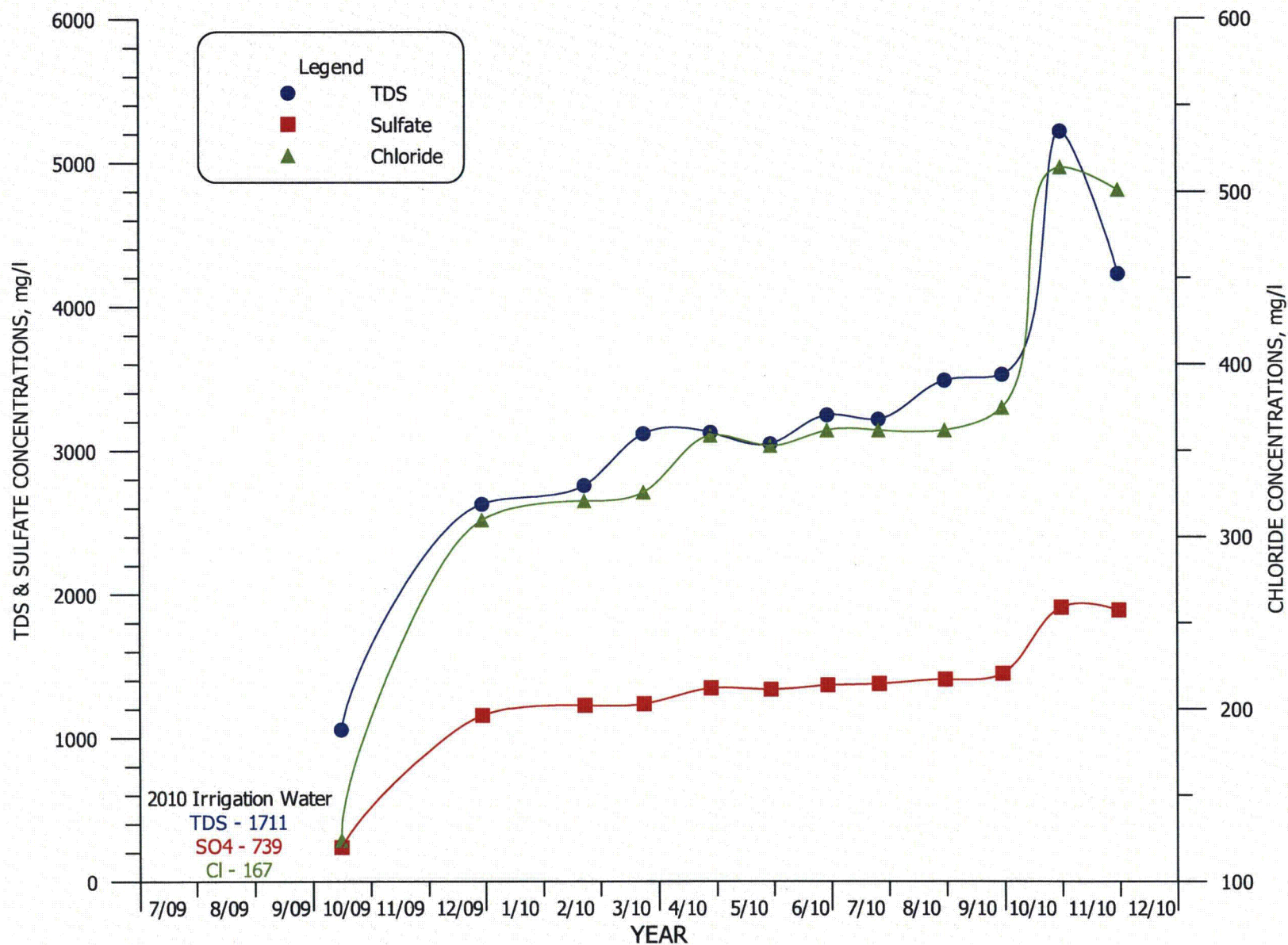




**FIGURE 3-18. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTION 33  
CENTER PIVOT SOIL SAMPLES**

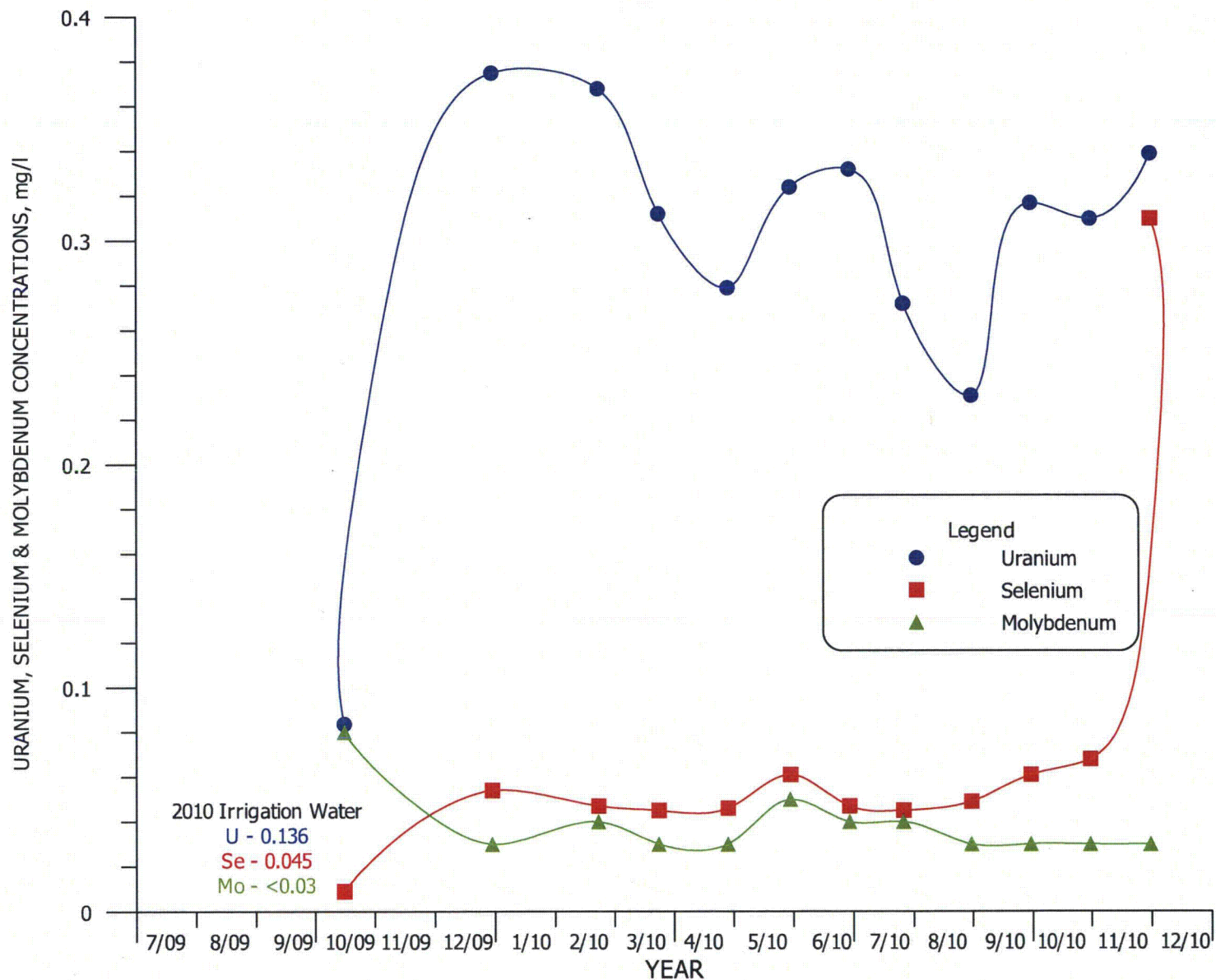


**FIGURE 3-19. SELENIUM CONCENTRATION IN THE SOILS WITH DEPTH IN SECTIONS 33 IRRIGATION AREA**

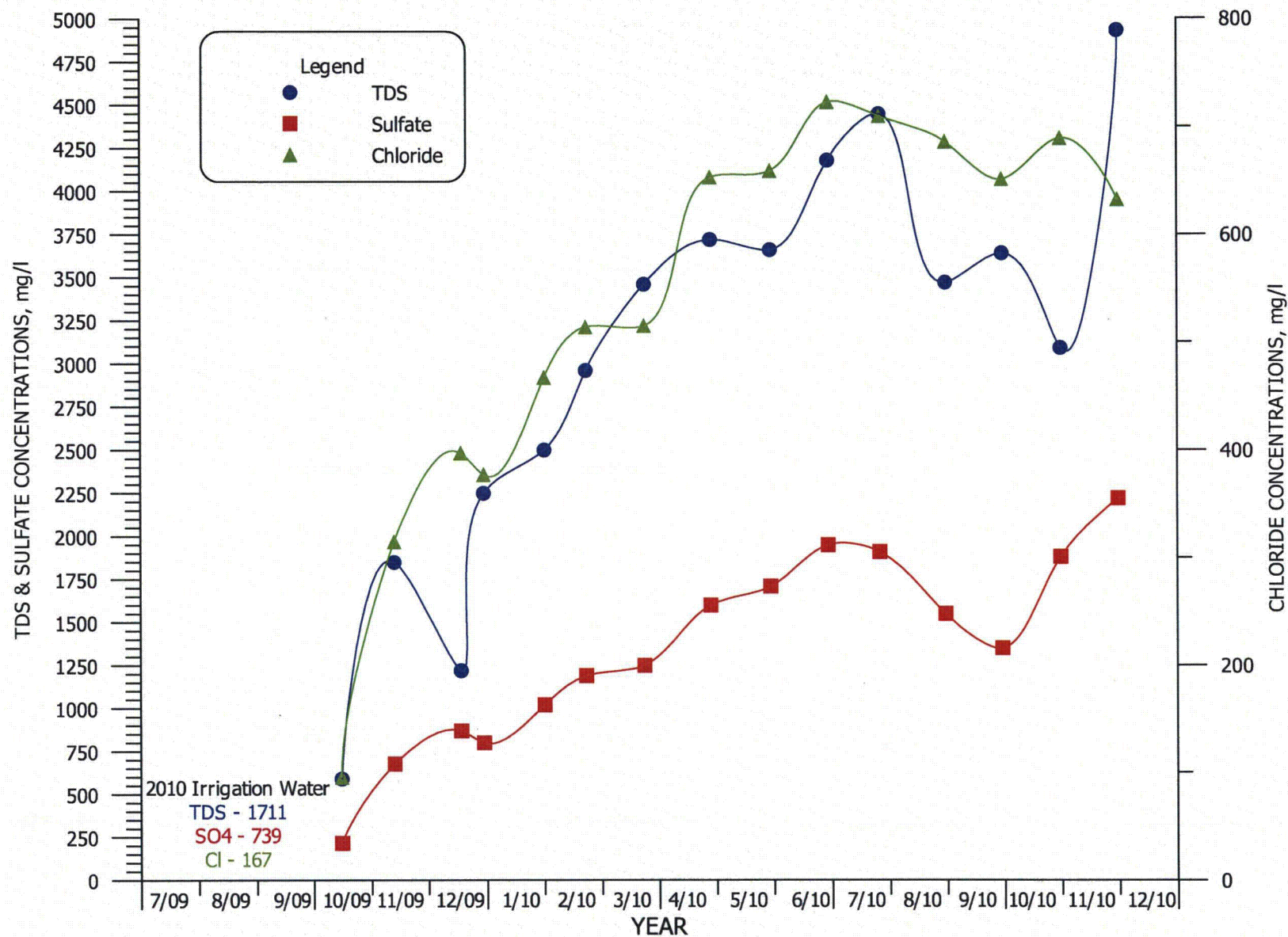


**FIGURE 3-20. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY34-1.**



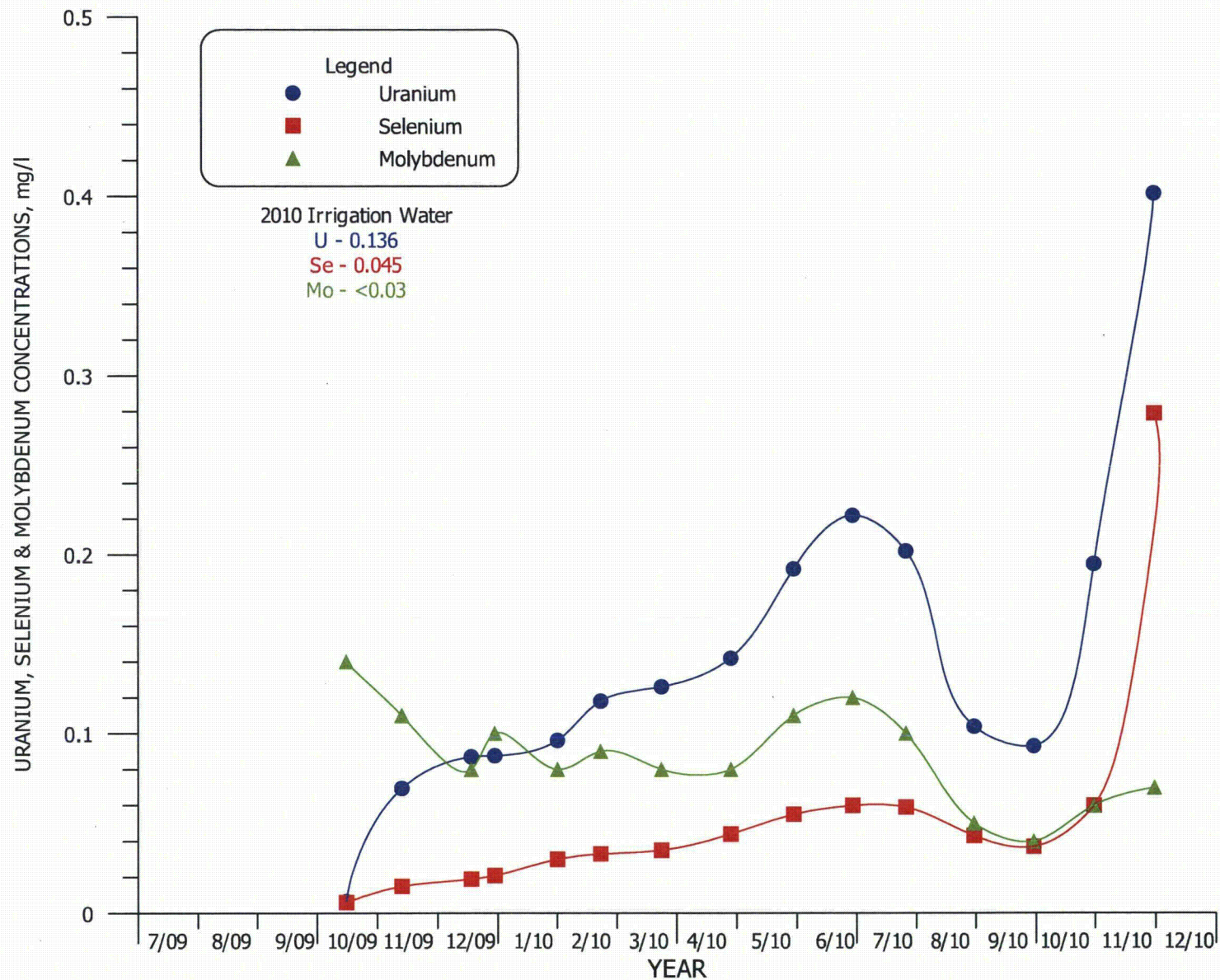


**FIGURE 3-21. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY34-1.**

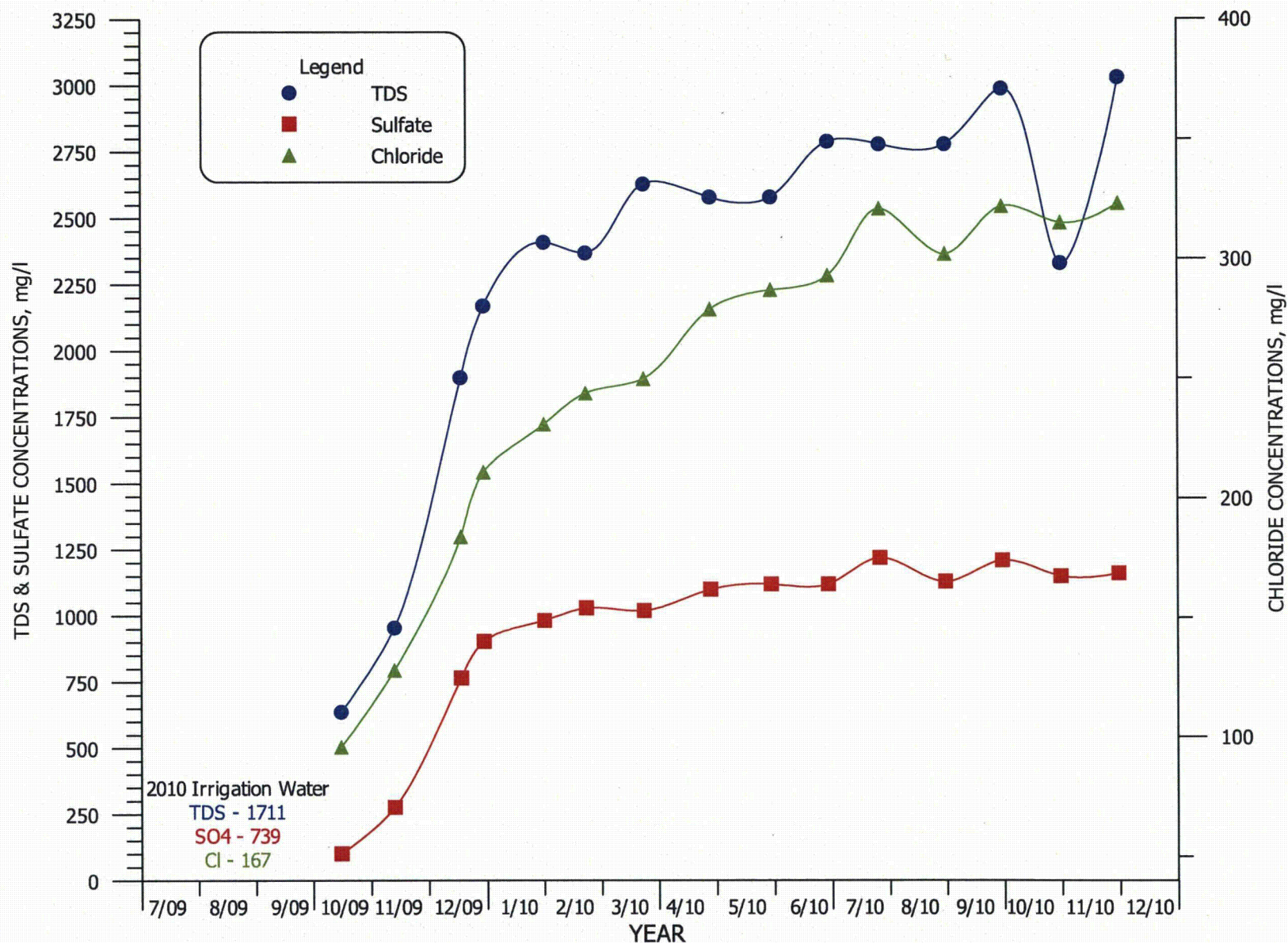


**FIGURE 3-22. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY34-2.**



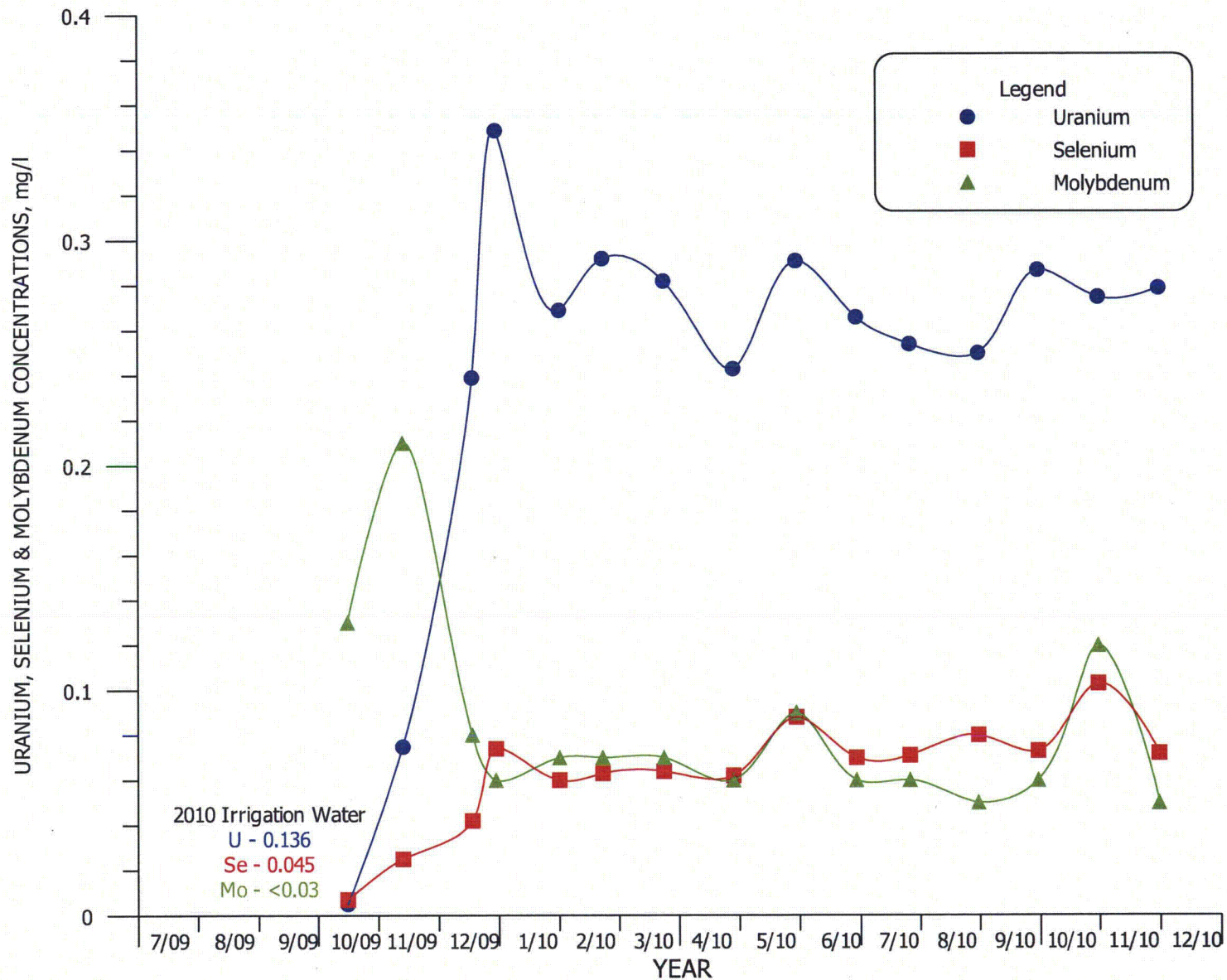


**FIGURE 3-23. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY34-2.**

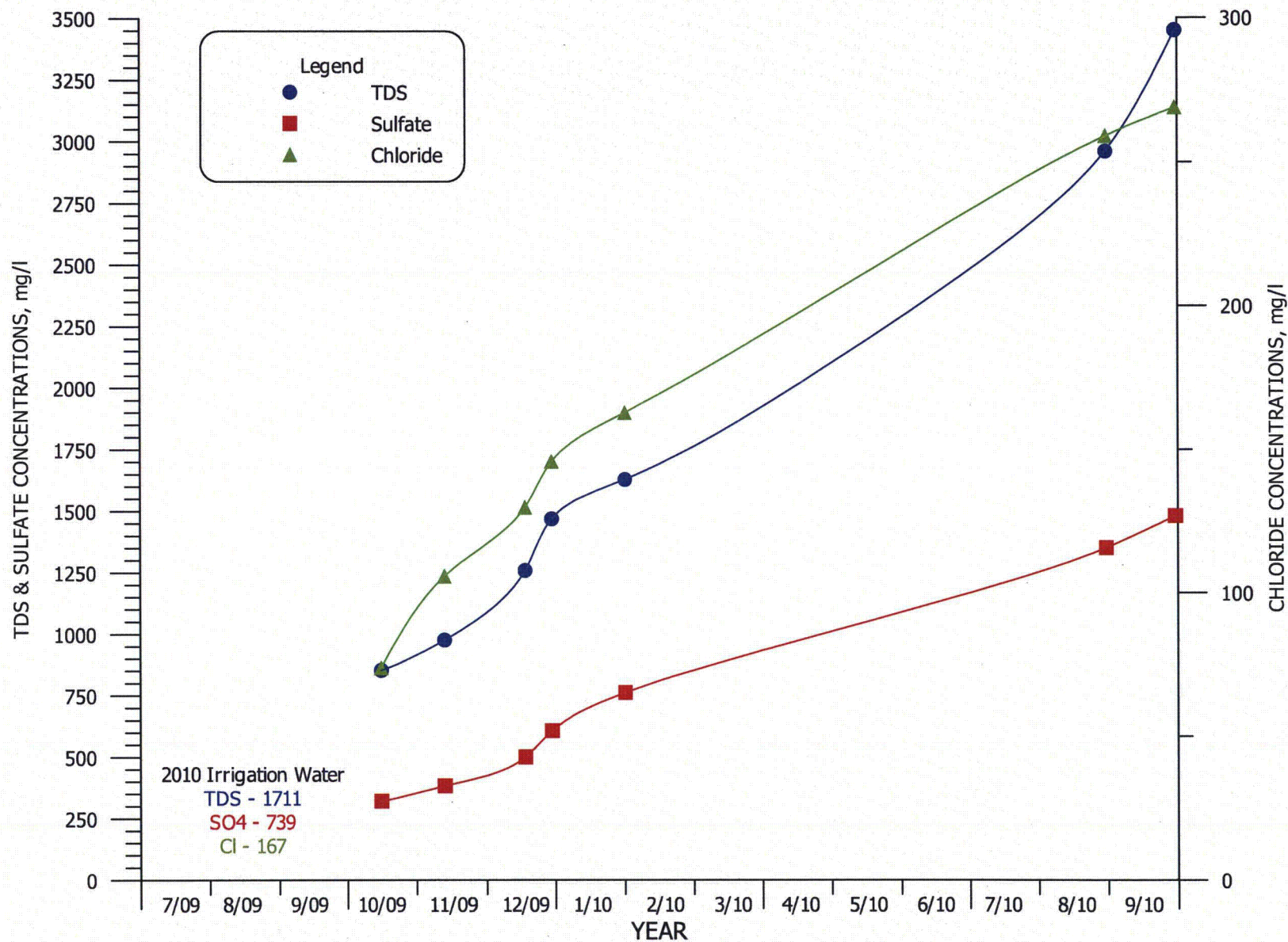


**FIGURE 3-24. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY34-3.**



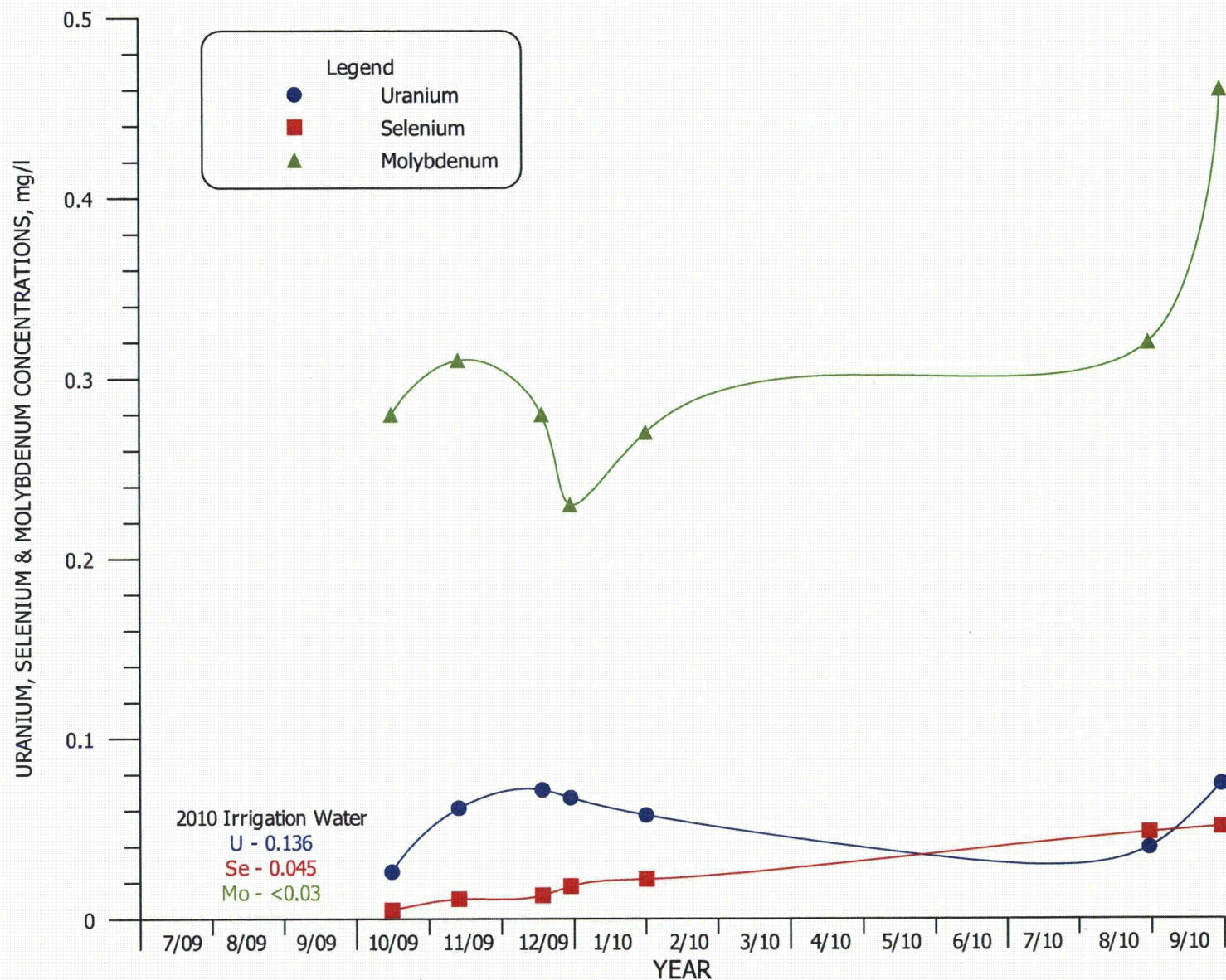


**FIGURE 3-25. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY34-3.**

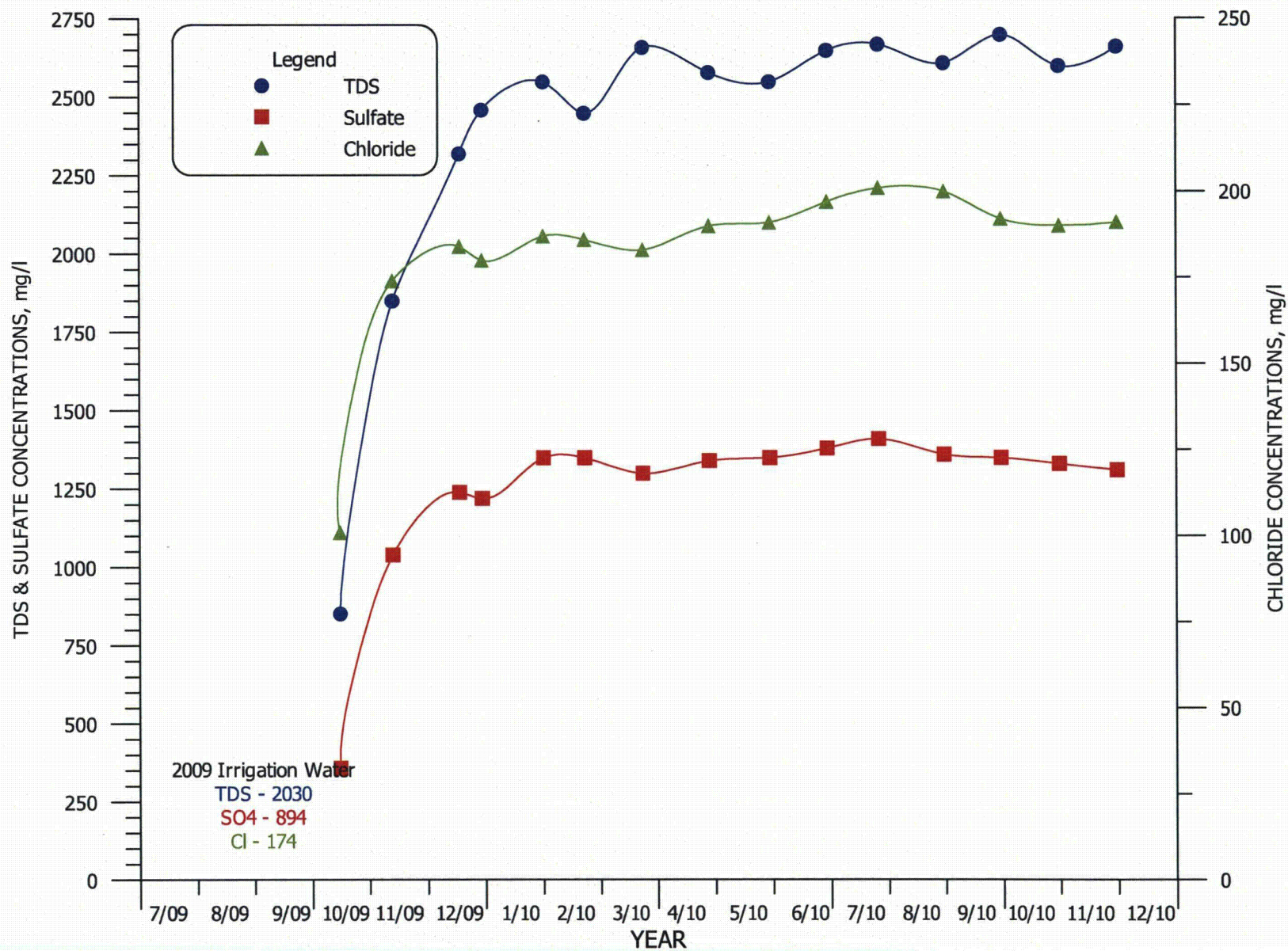


**FIGURE 3-26. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY34-4.**



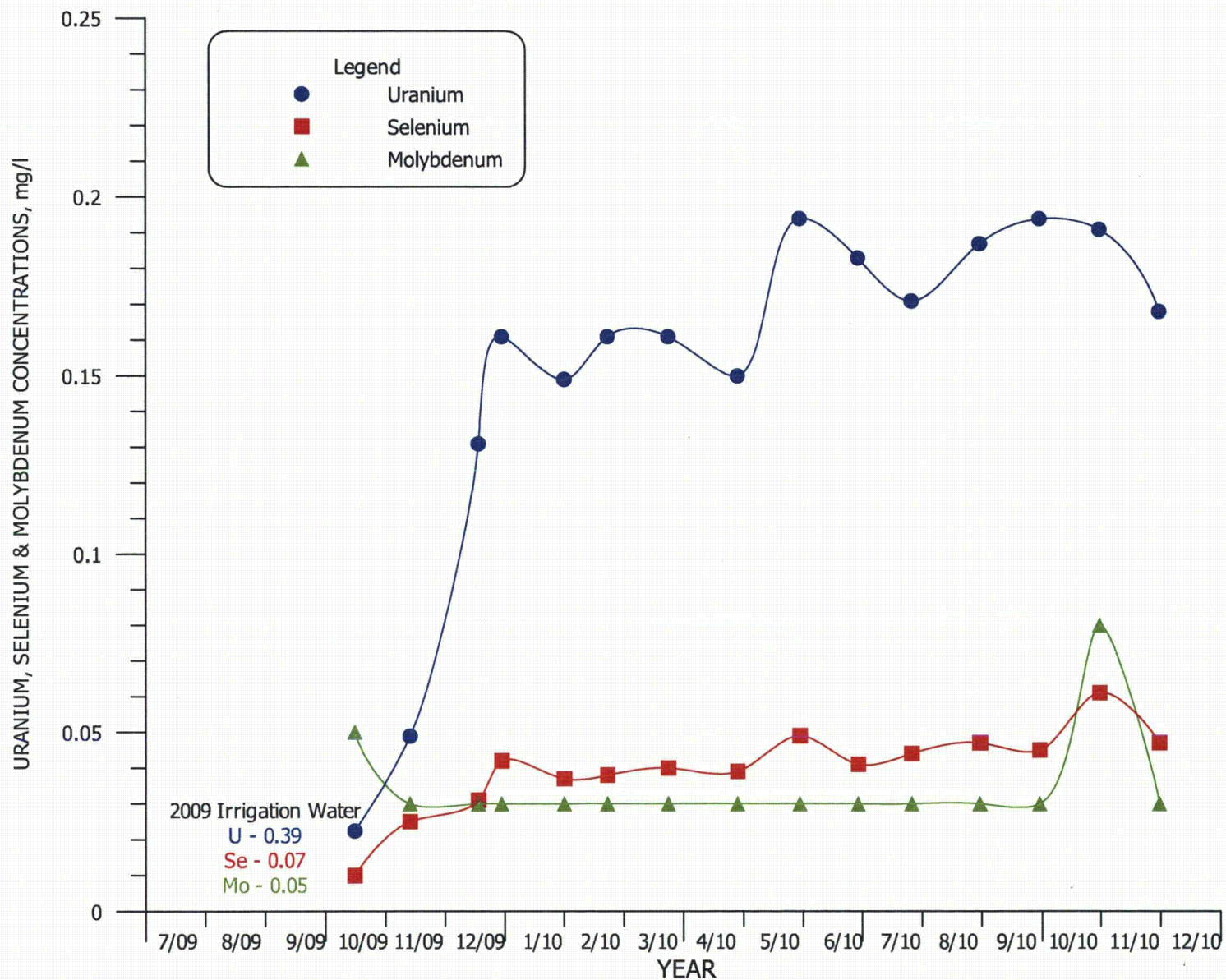


**FIGURE 3-27. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY34-4.**

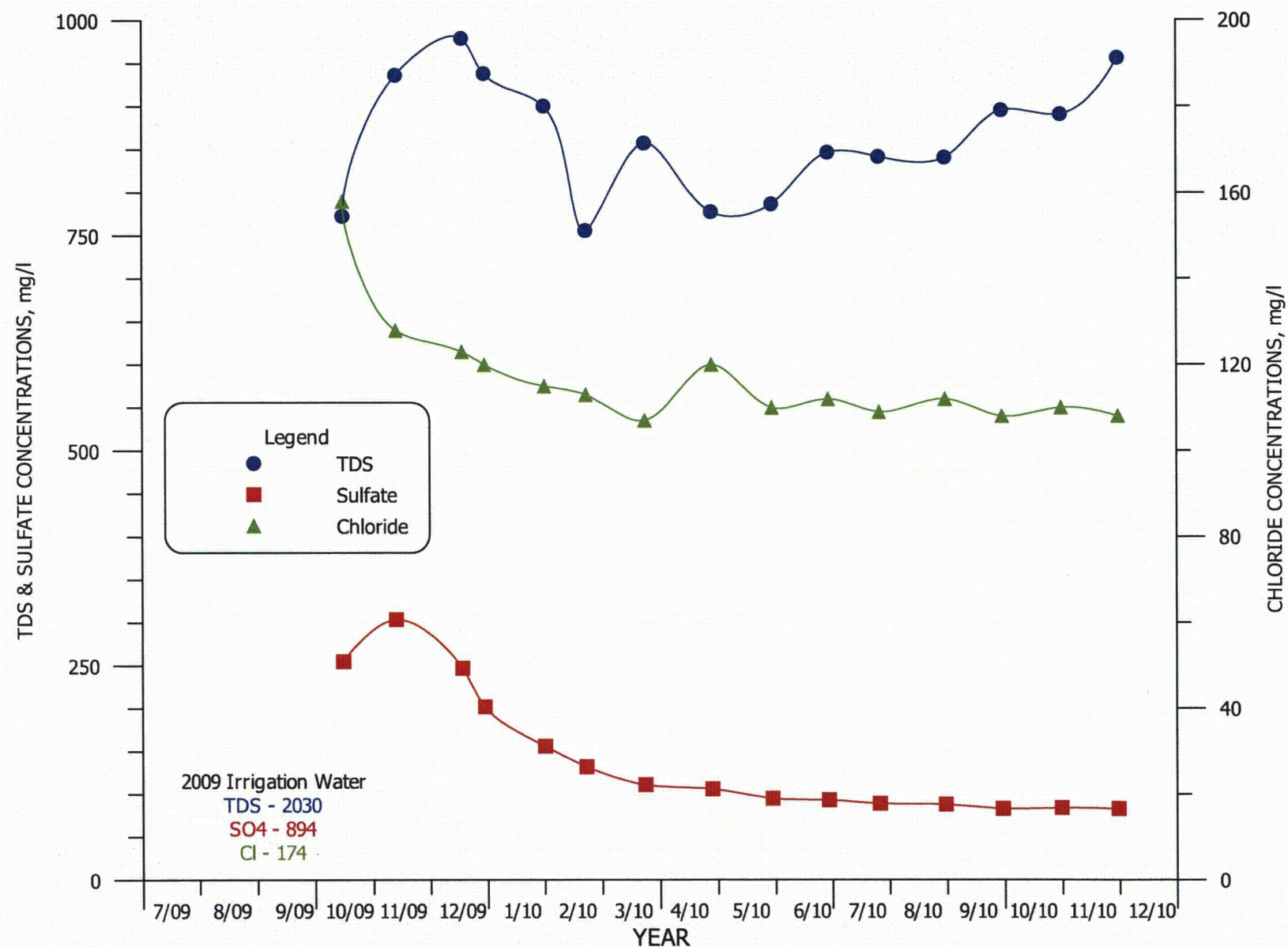


**FIGURE 3-28. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY28-1.**



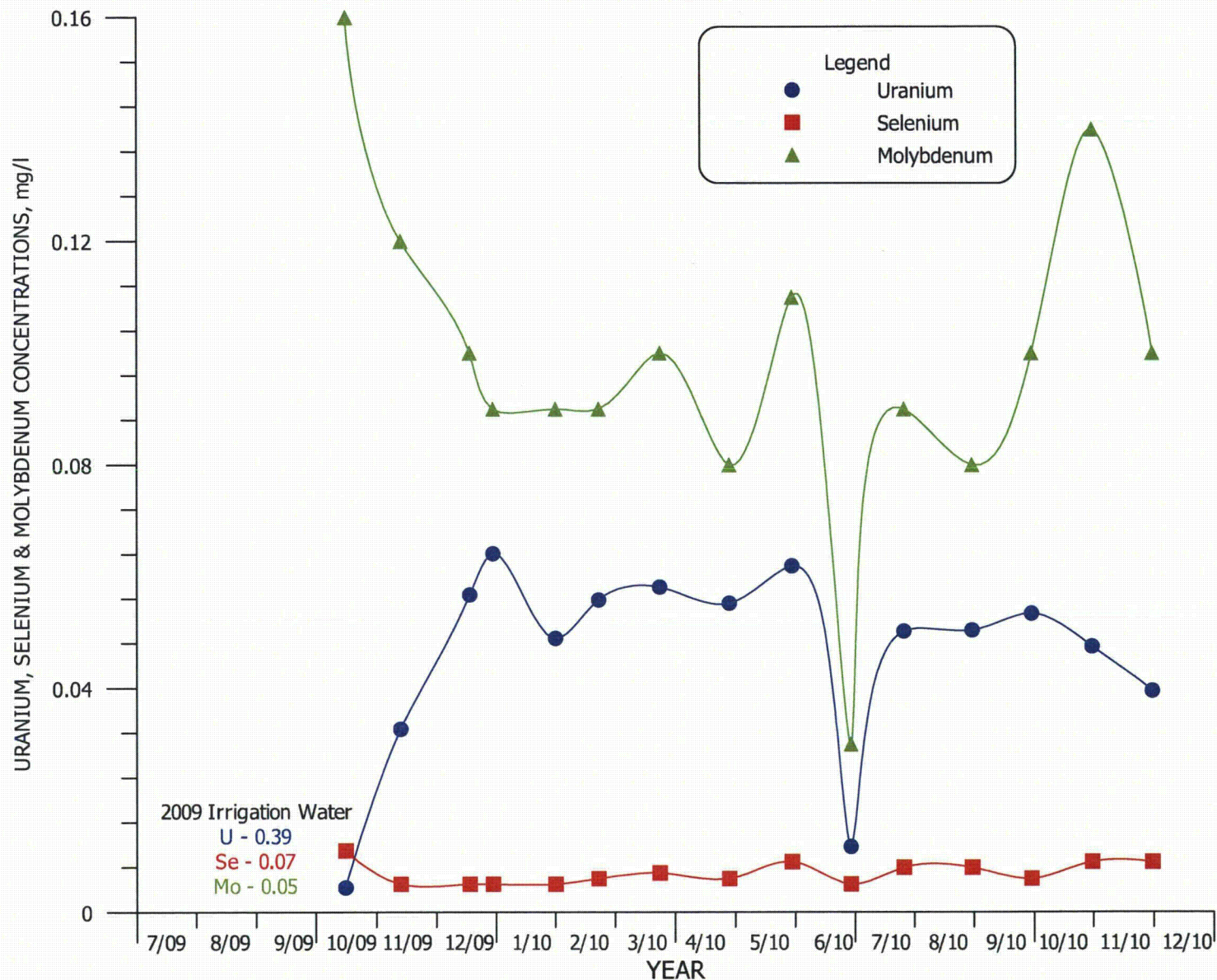


**FIGURE 3-29. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY28-1.**

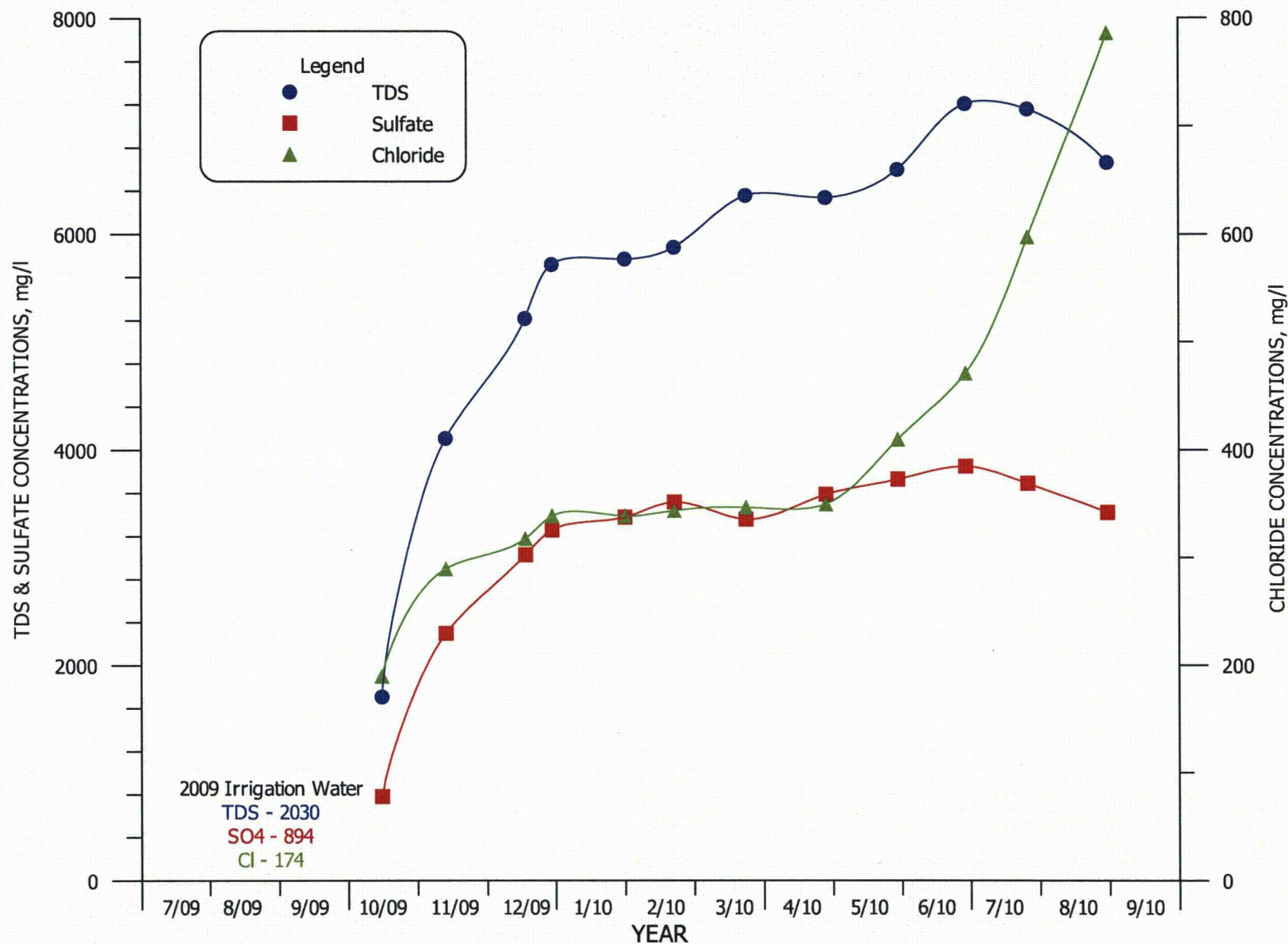


**FIGURE 3-30. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY28-2M.**

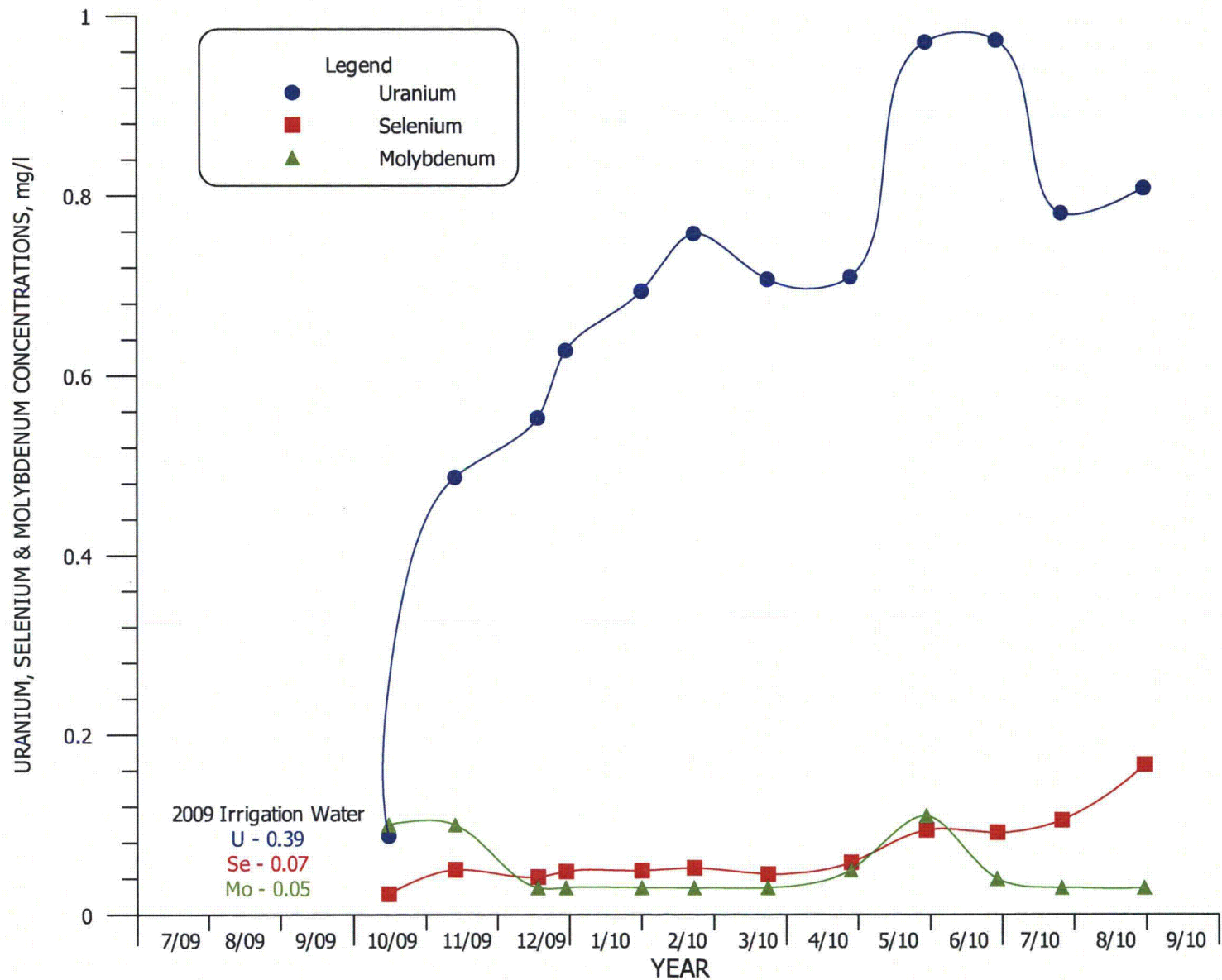




**FIGURE 3-31. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY28-2M.**

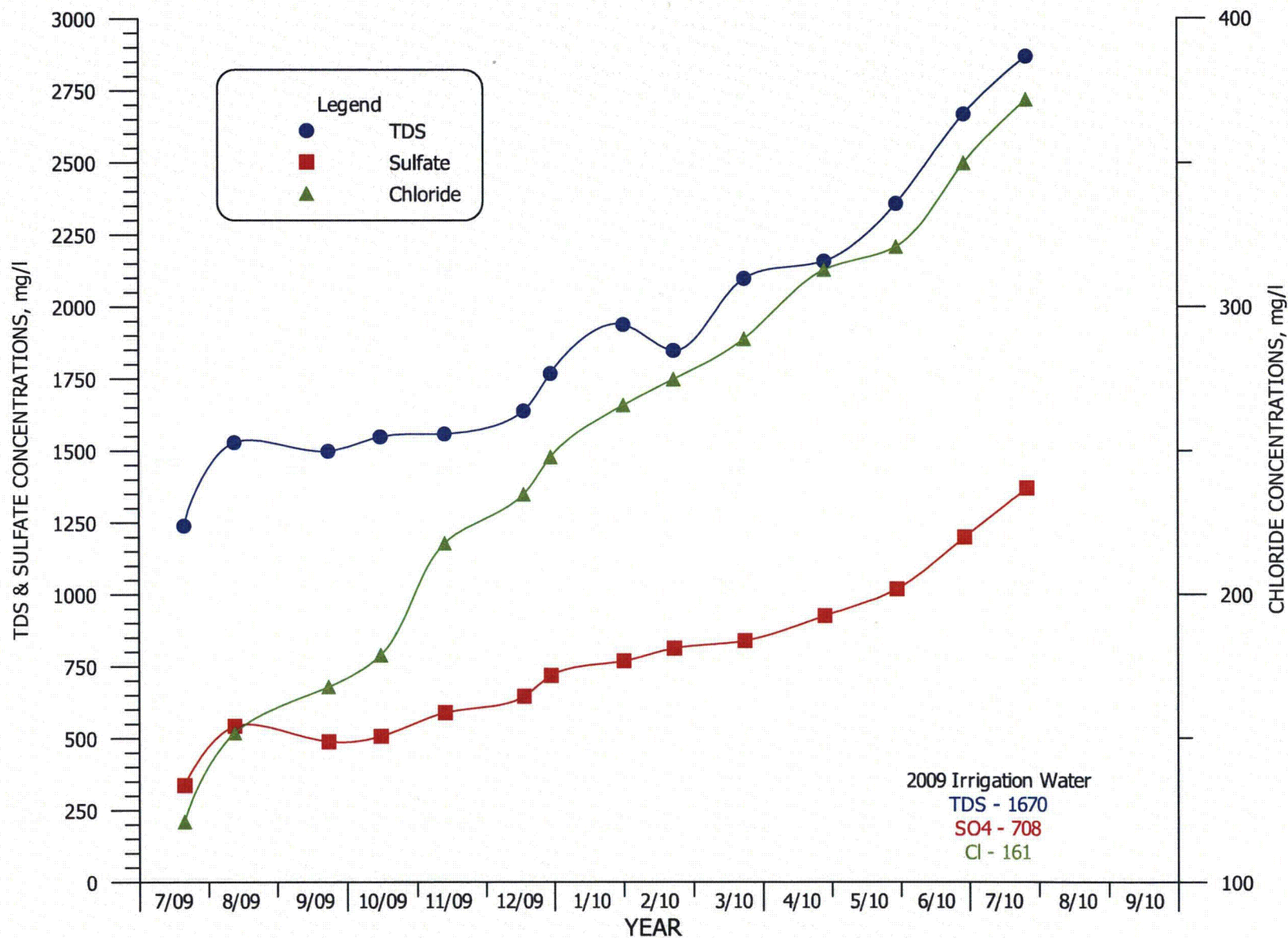


**FIGURE 3-32. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY28-3.**

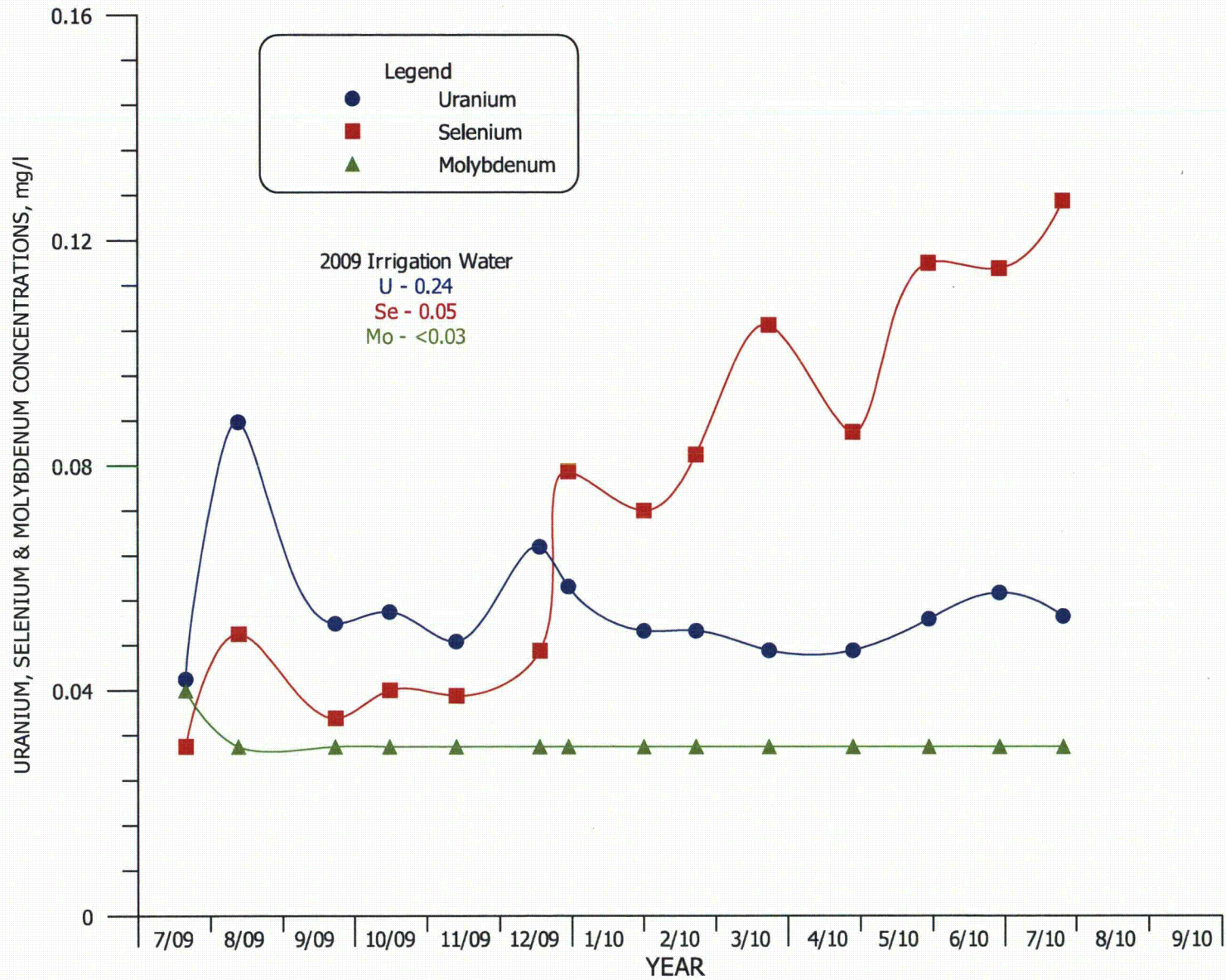


**FIGURE 3-33. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY28-3.**



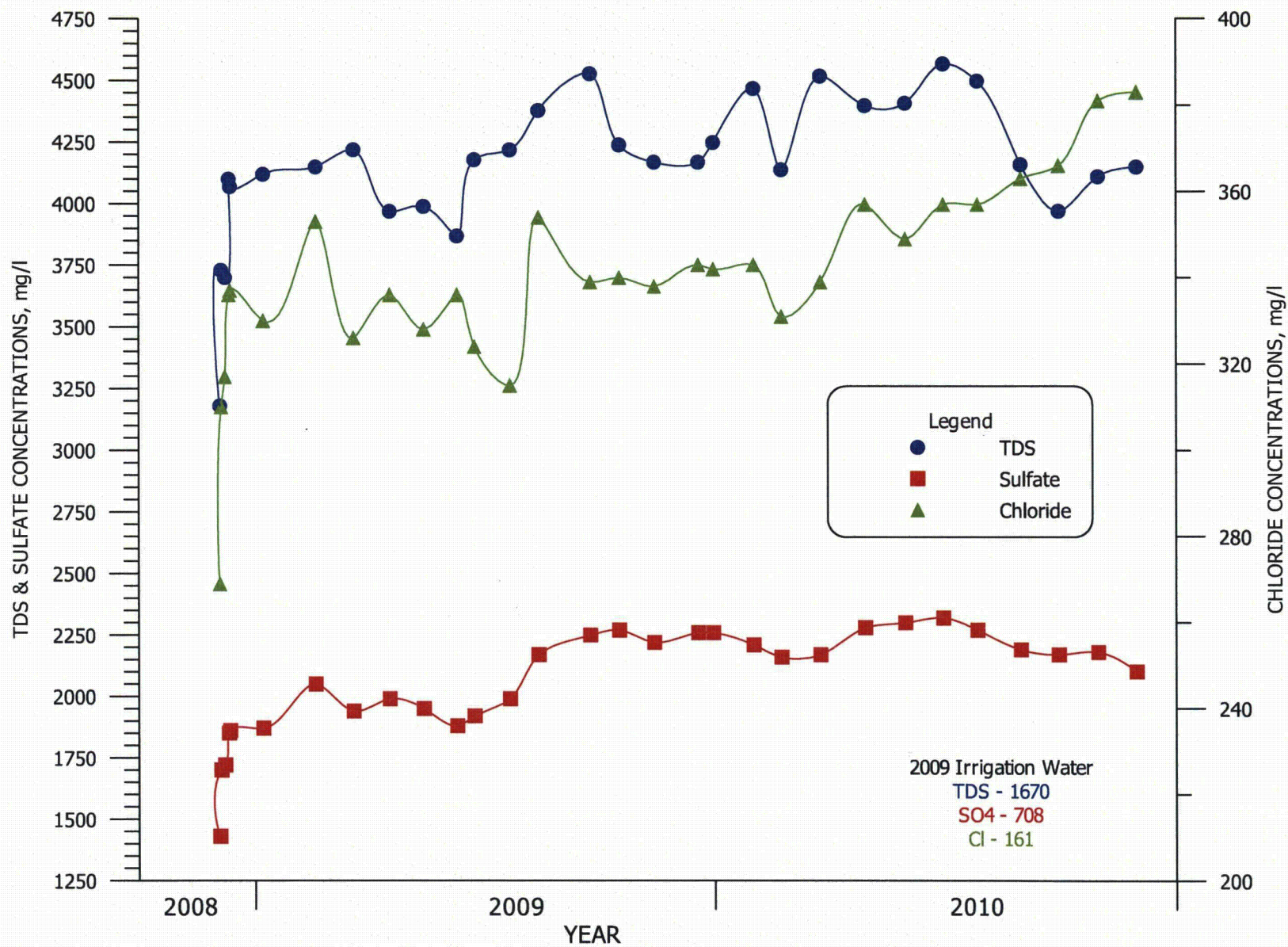


**FIGURE 3-34. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY1.**



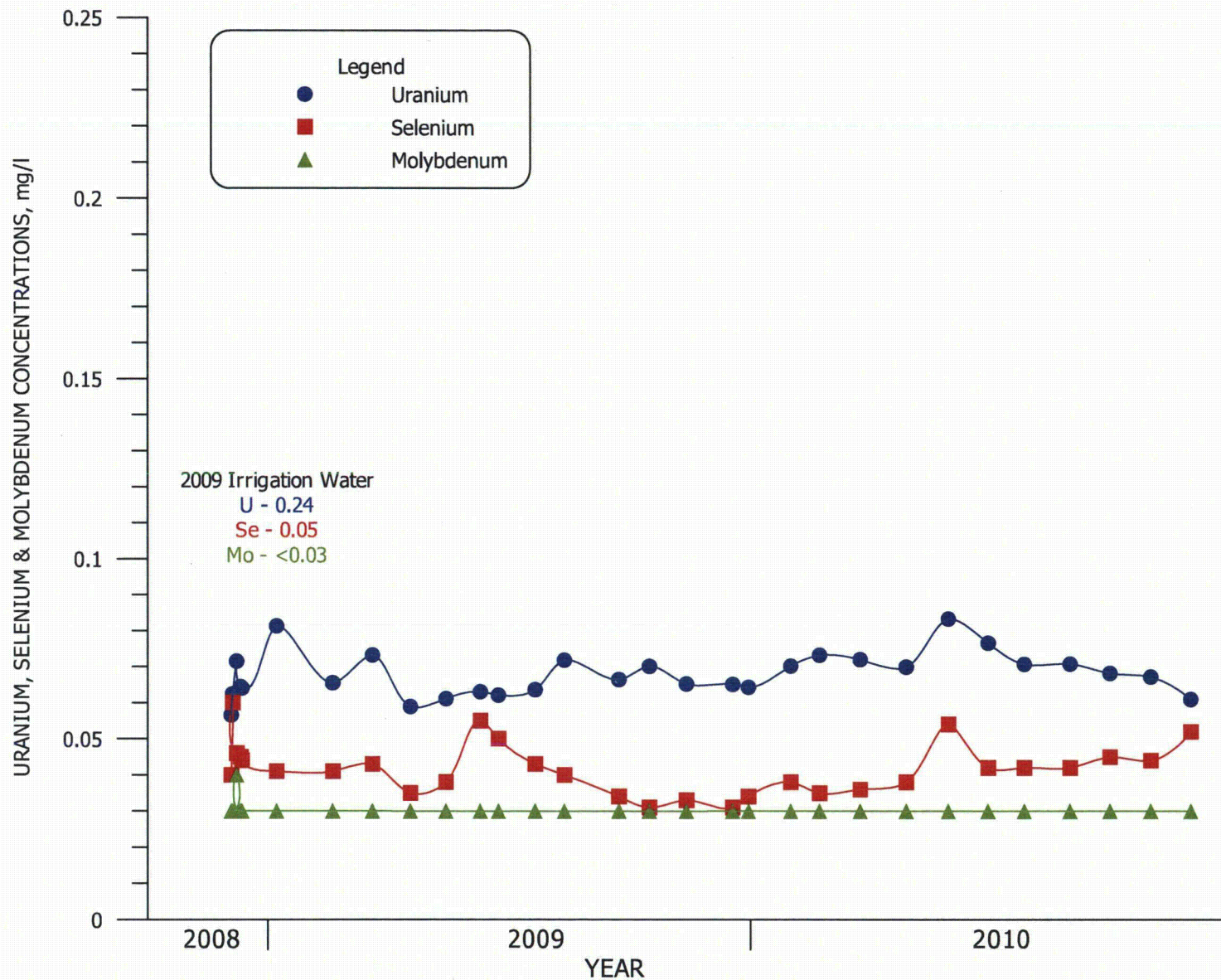
**FIGURE 3-35. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY1.**



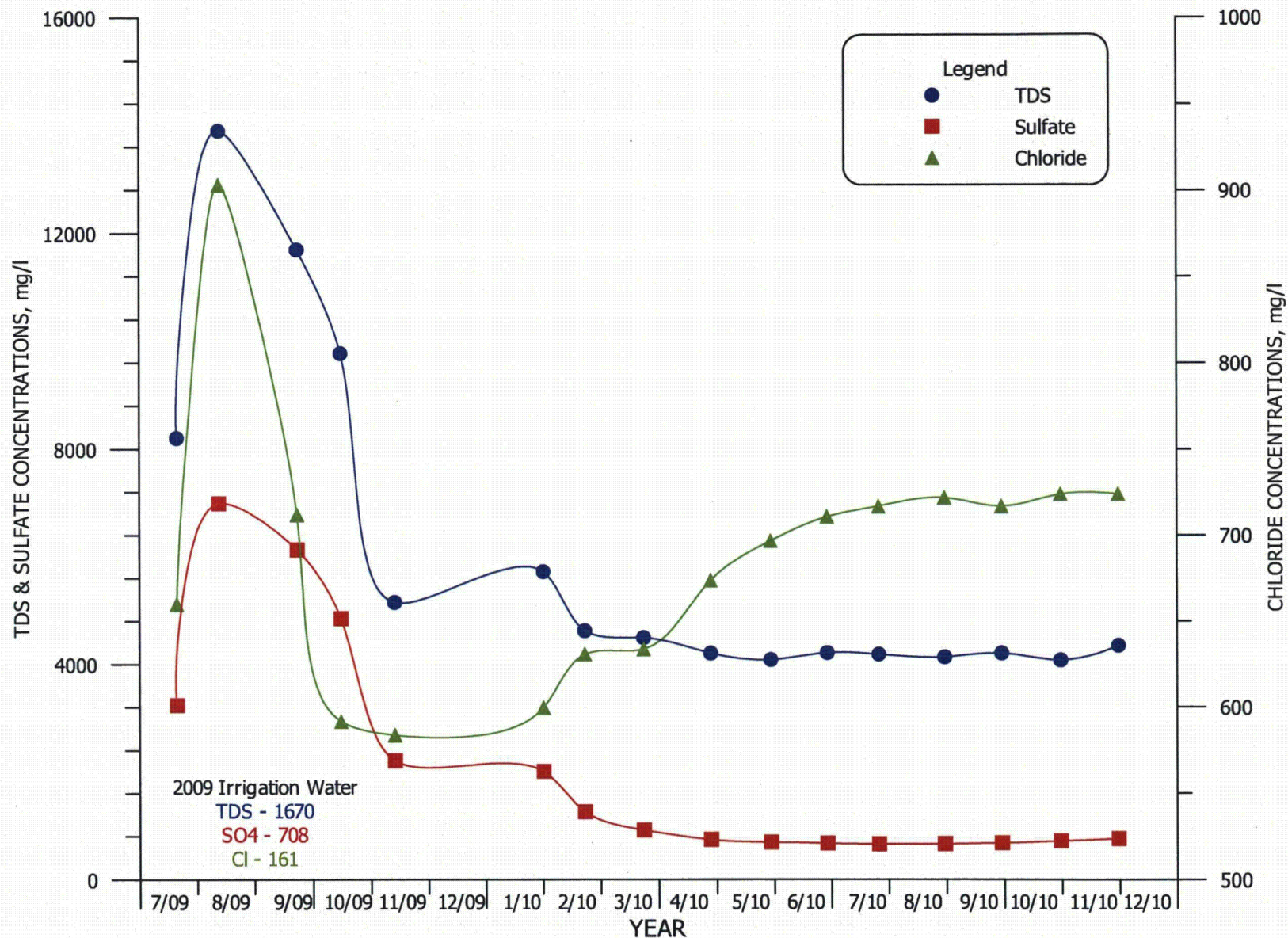


**FIGURE 3-36. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY4.**



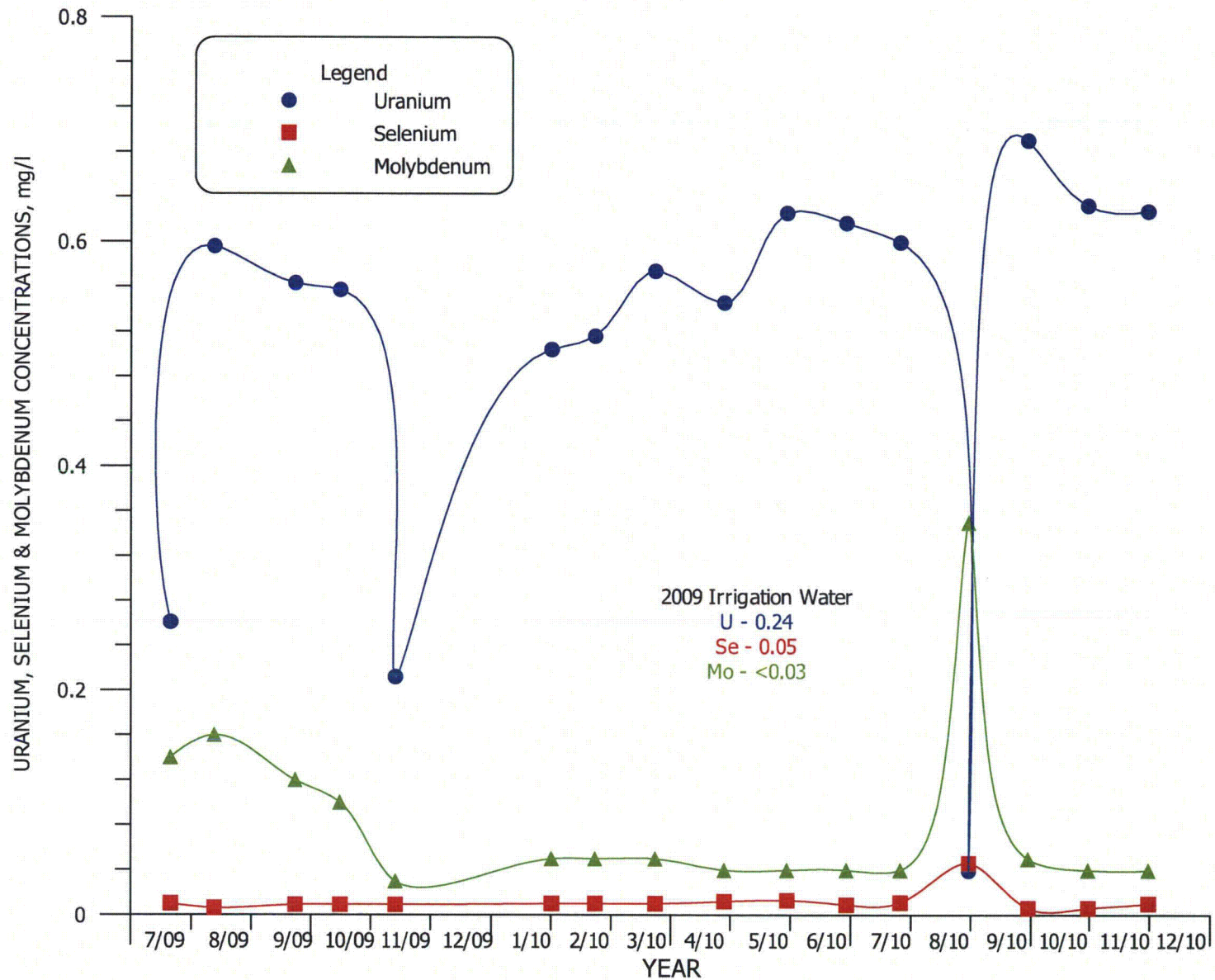


**FIGURE 3-37. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY4.**

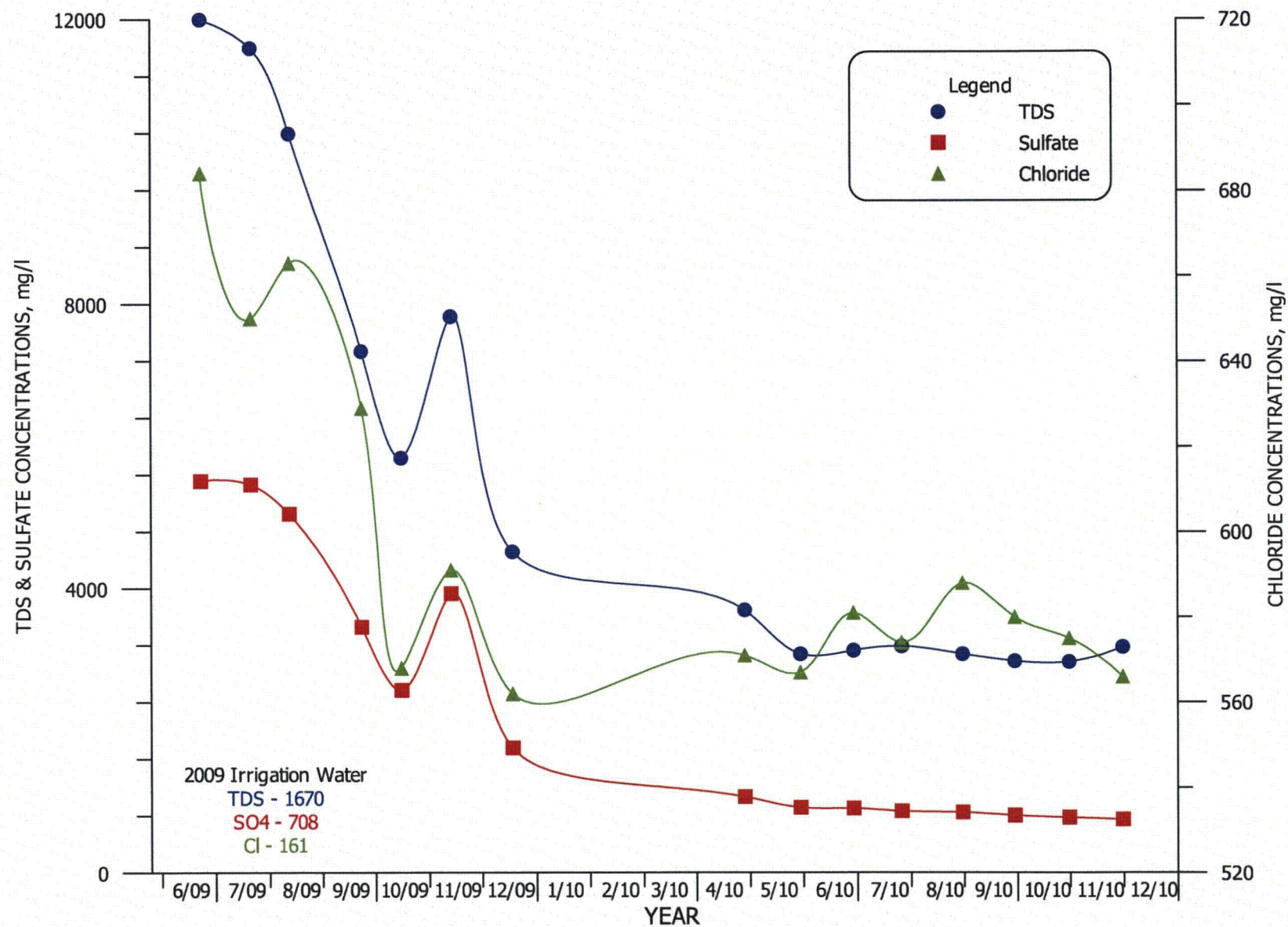


**FIGURE 3-38. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY4MU.**



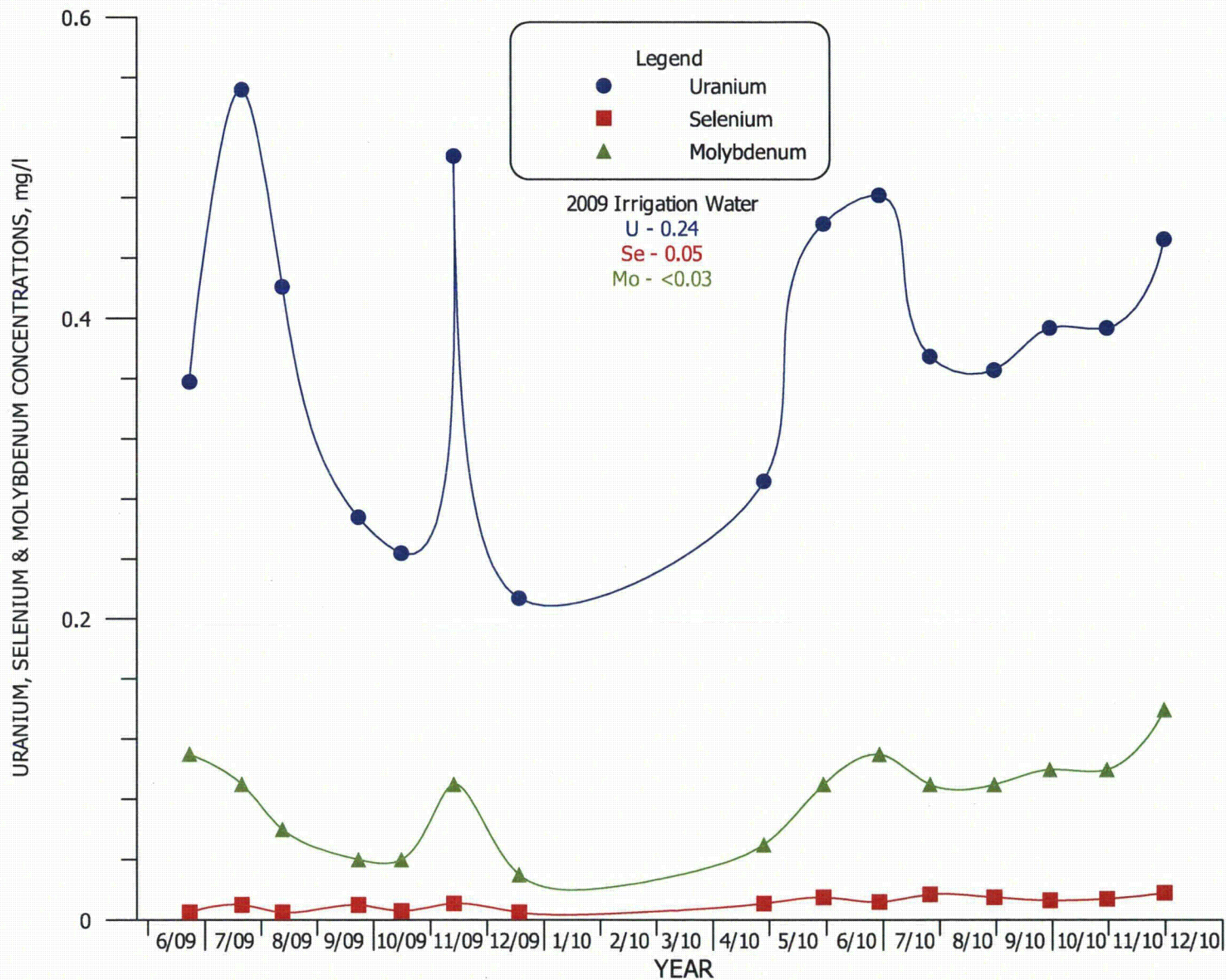


**FIGURE 3-39. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY4MU.**



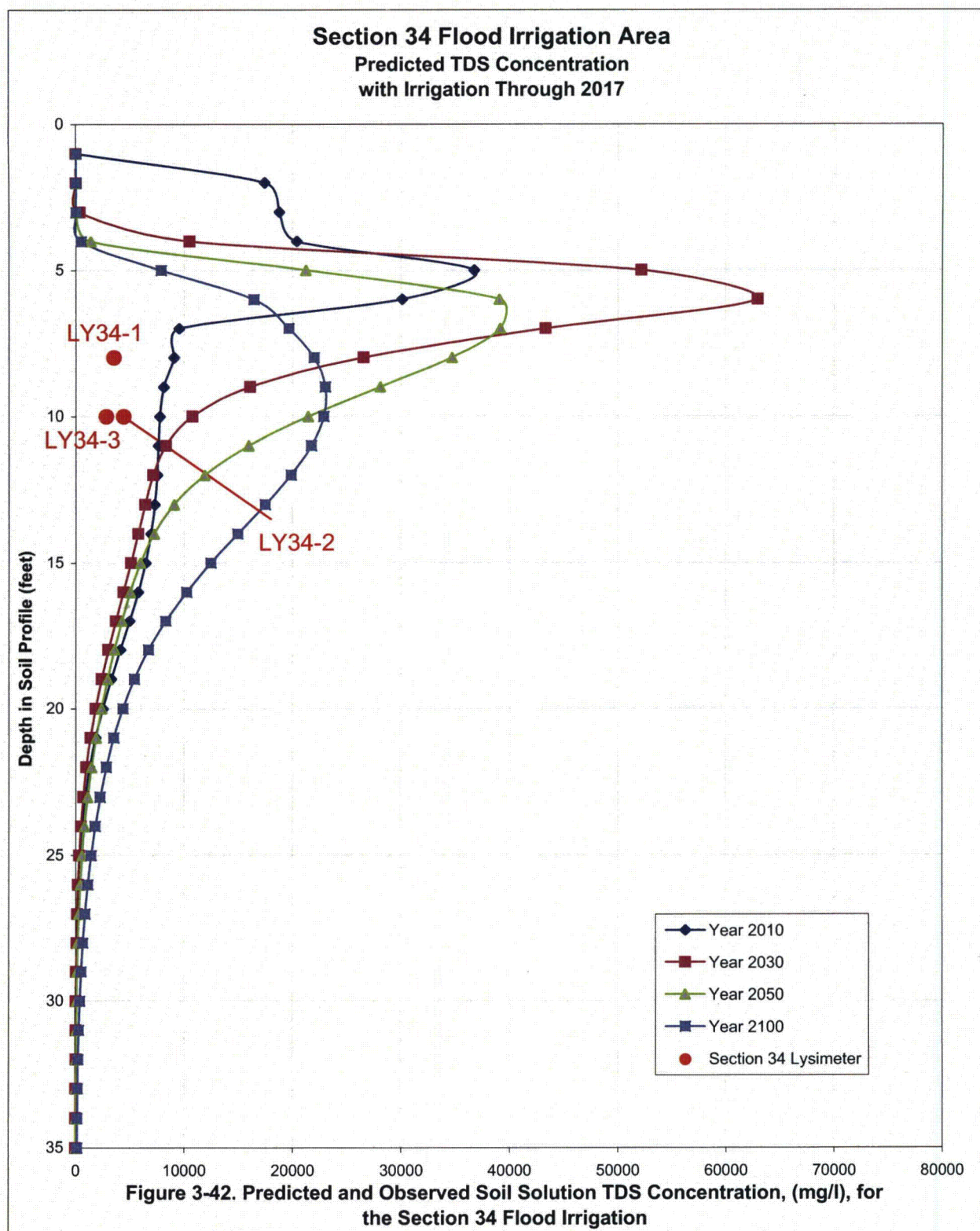
**FIGURE 3-40. TDS, SULFATE AND CHLORIDE CONCENTRATIONS FROM LY4ML.**

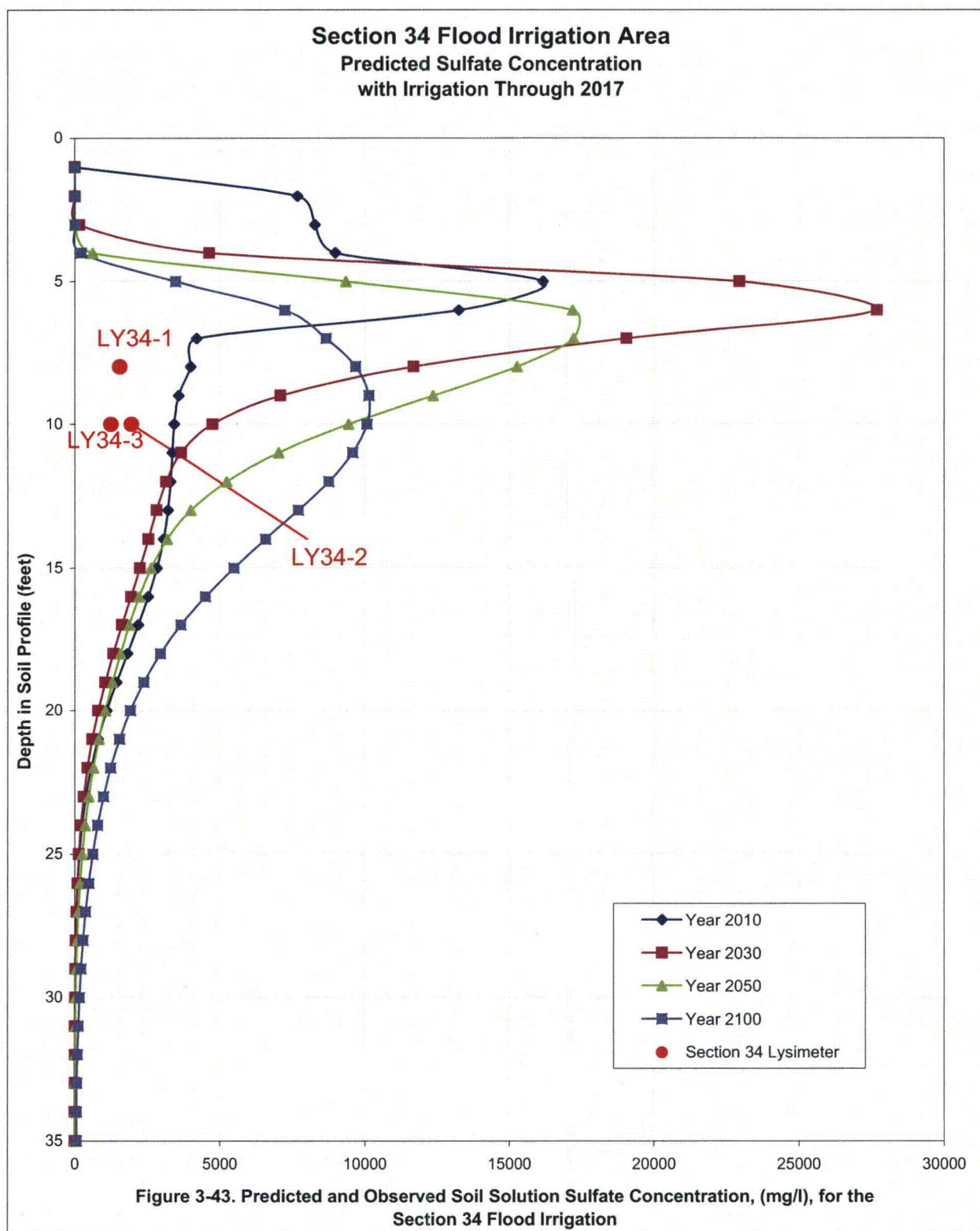


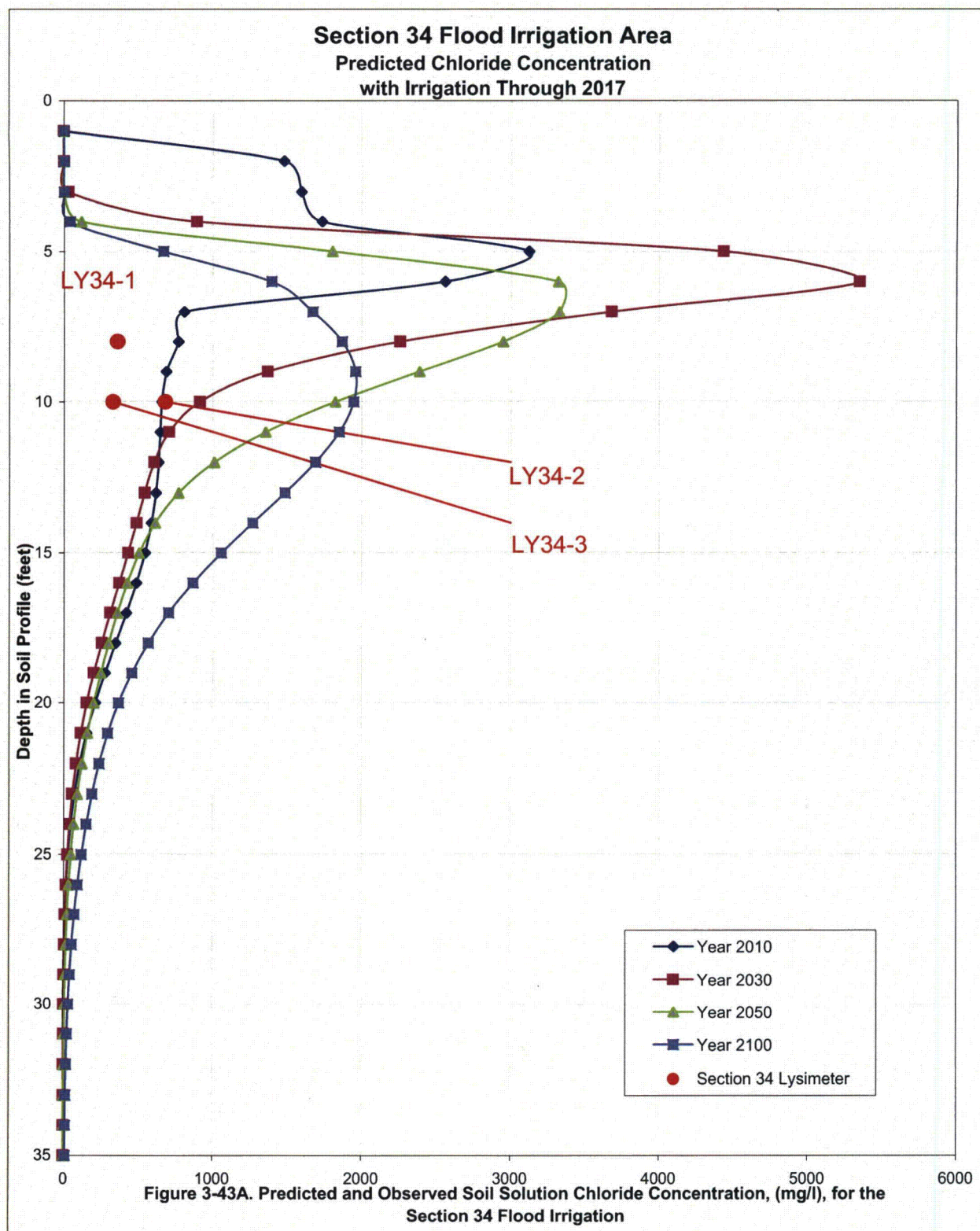


**FIGURE 3-41. URANIUM, SELENIUM AND MOLYBDENUM CONCENTRATIONS FROM LY4ML.**

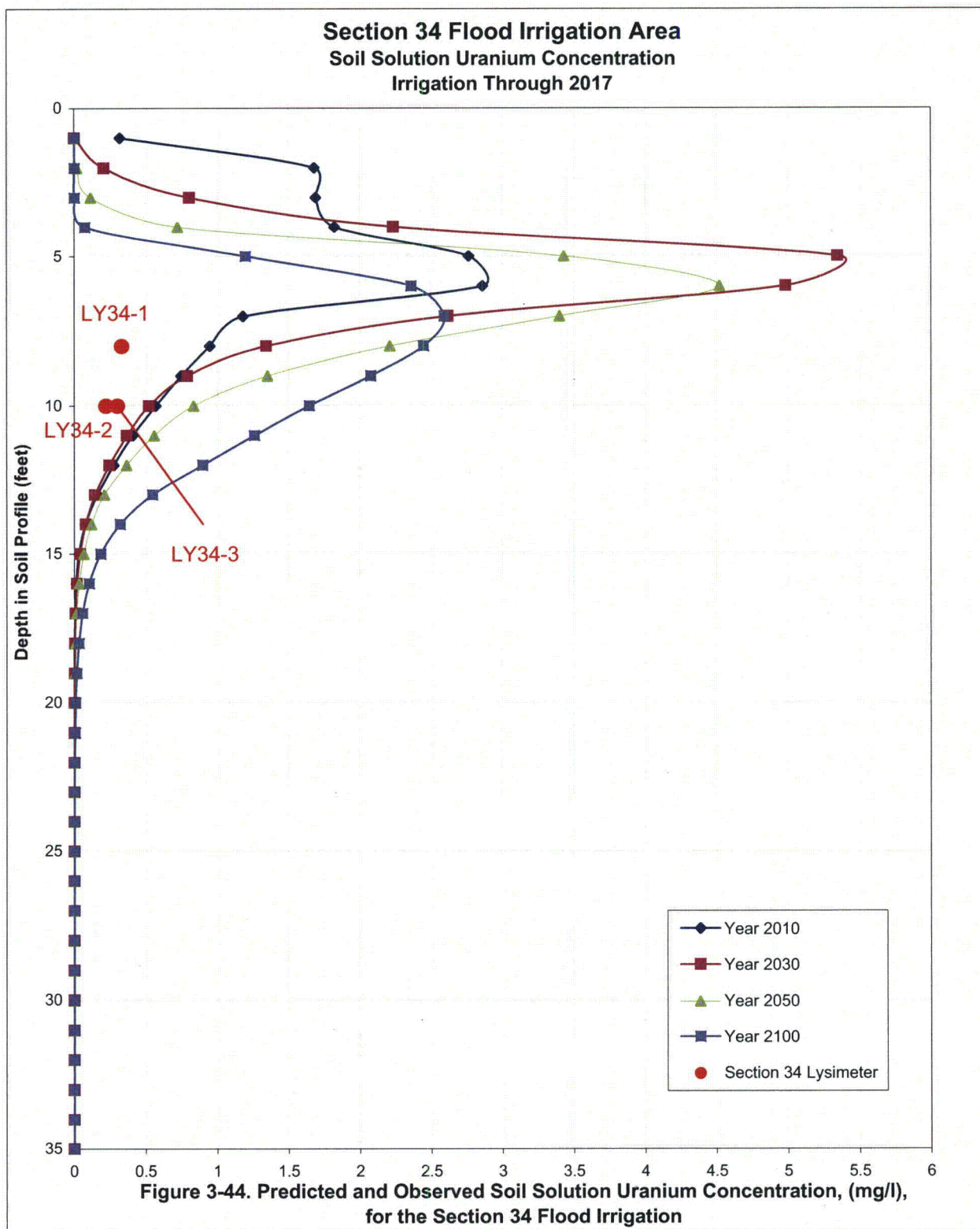




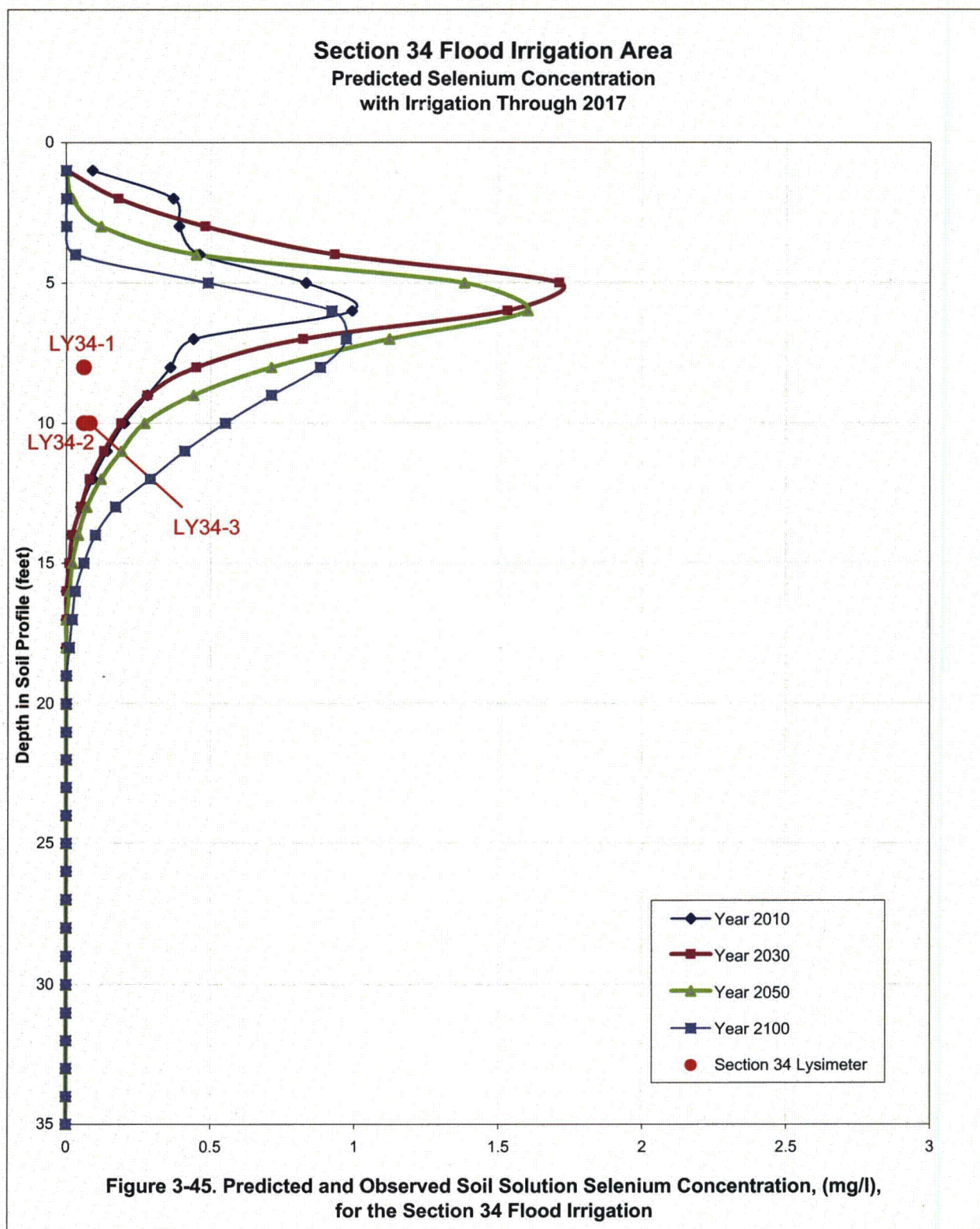












# Section 28 Center Pivot Irrigation Predicted TDS Concentration with Irrigation Through 2017

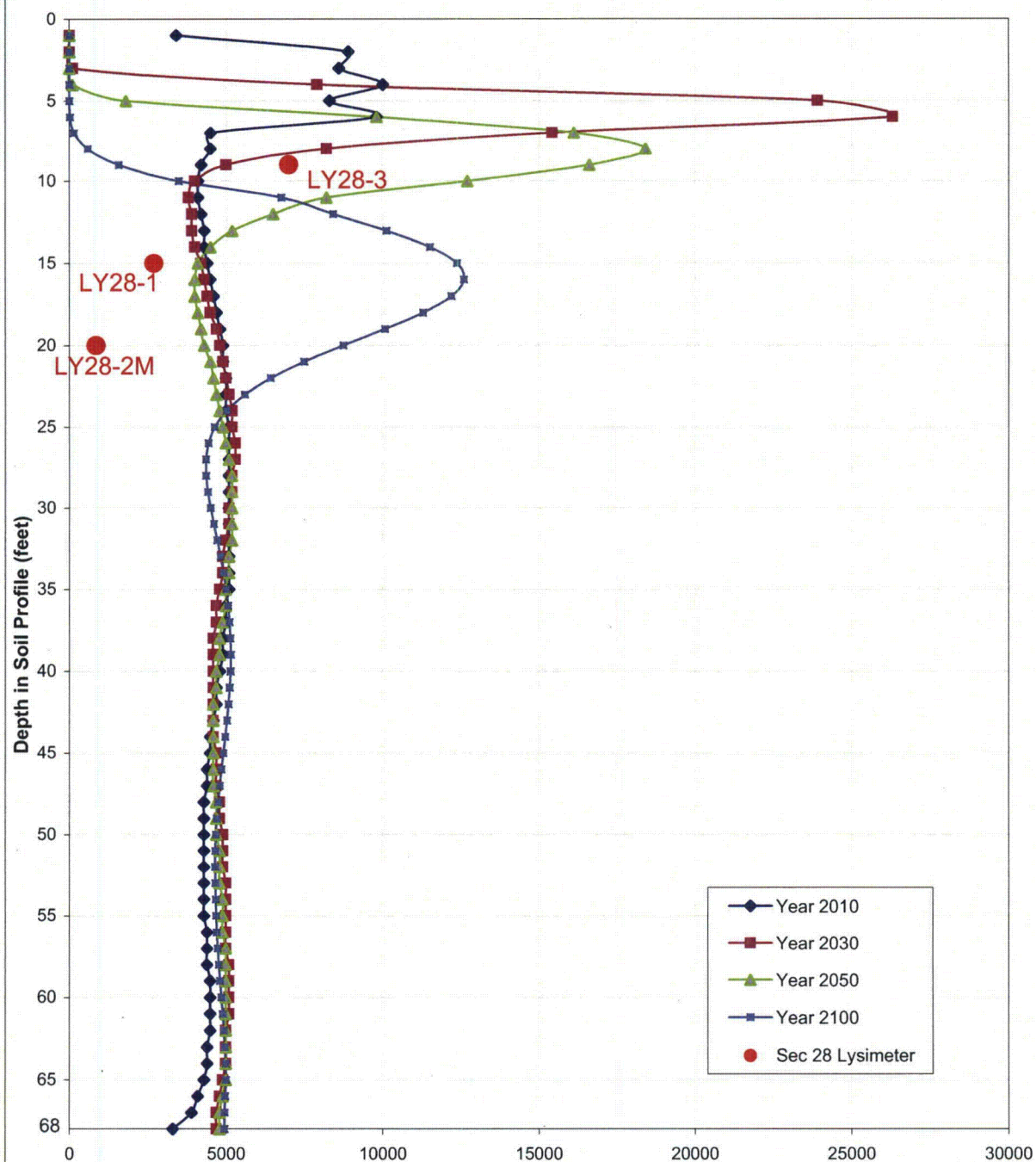
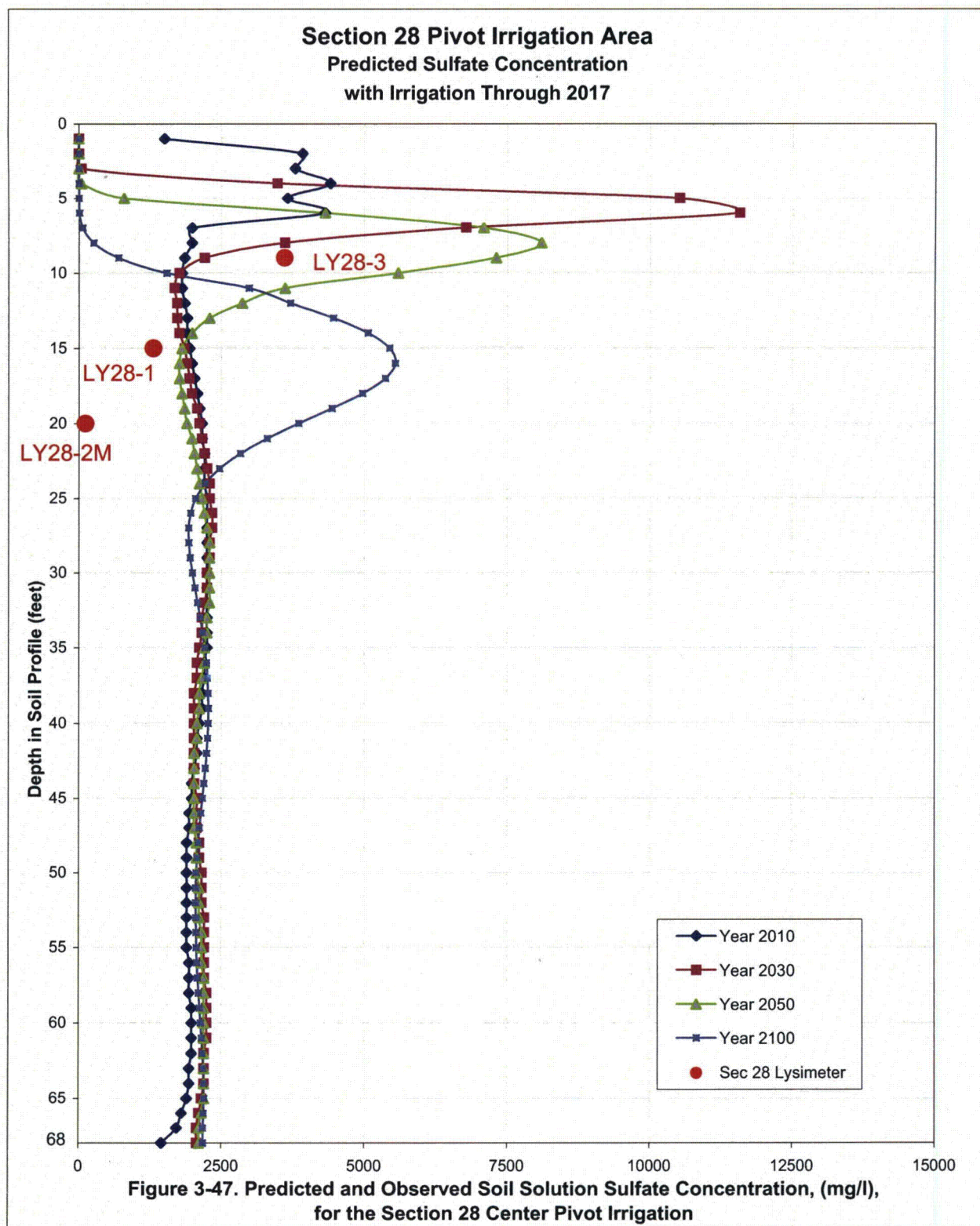
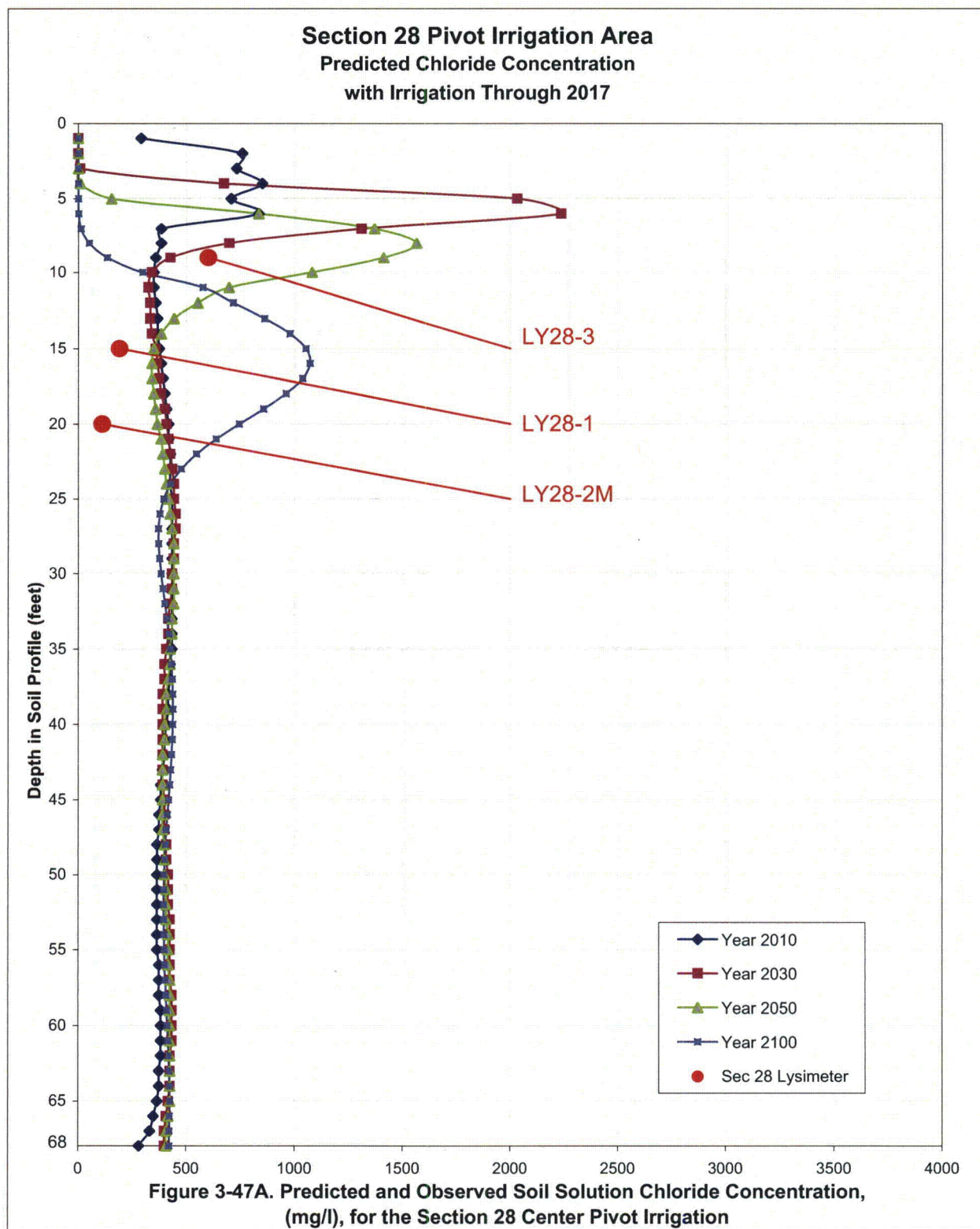


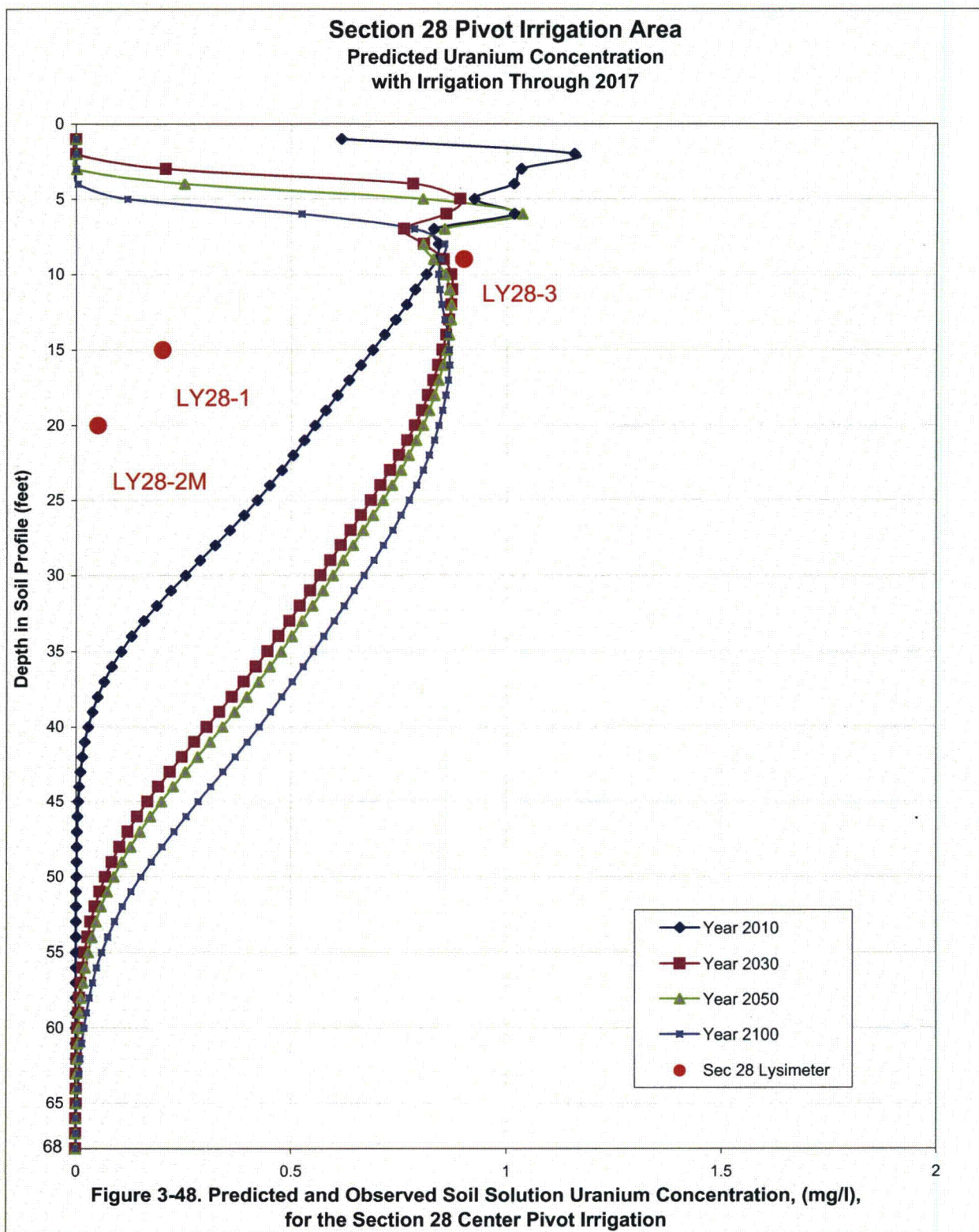
Figure 3-46. Predicted and Observed Soil Solution TDS Concentration, (mg/l), for the Section 28 Center Pivot Irrigation

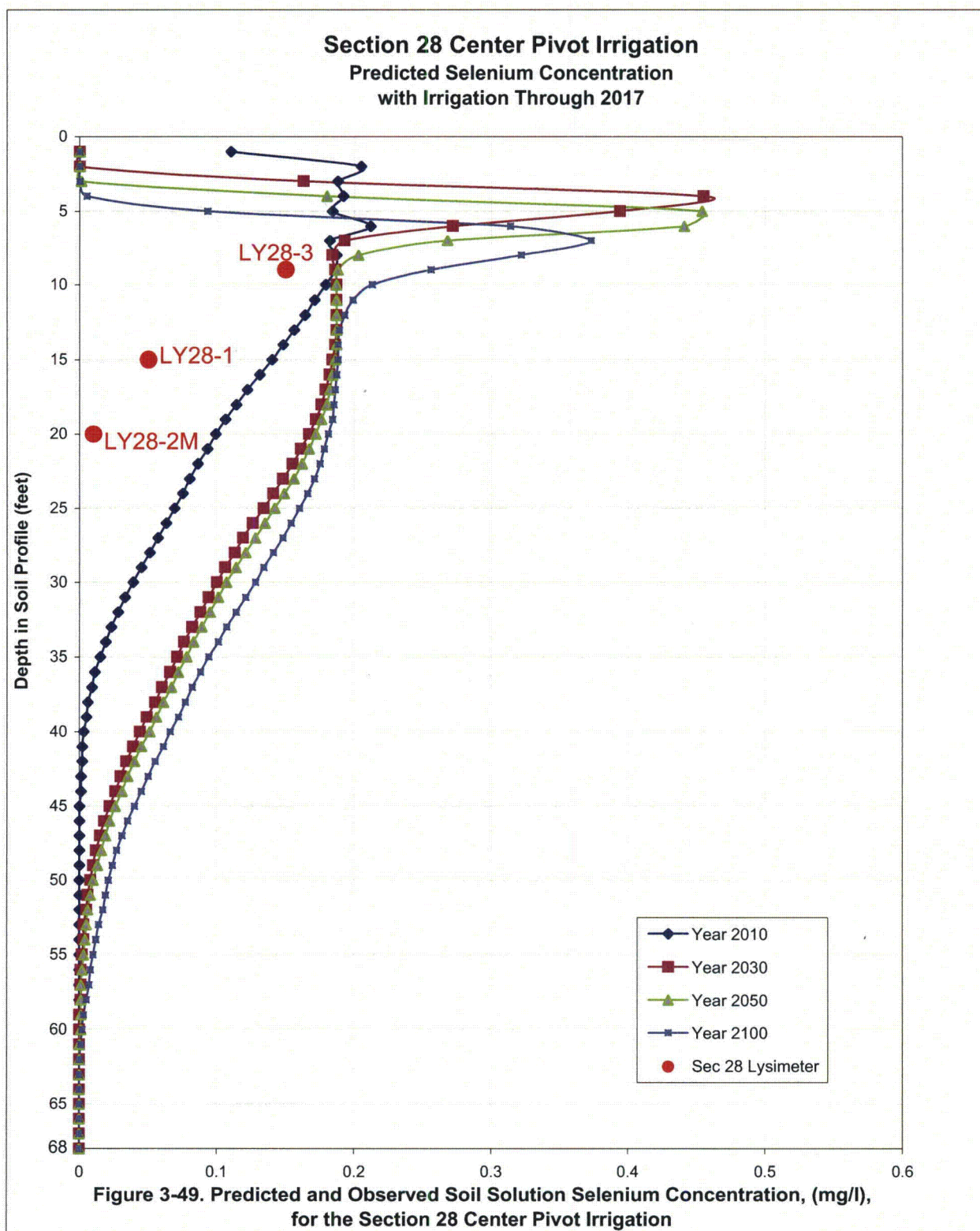




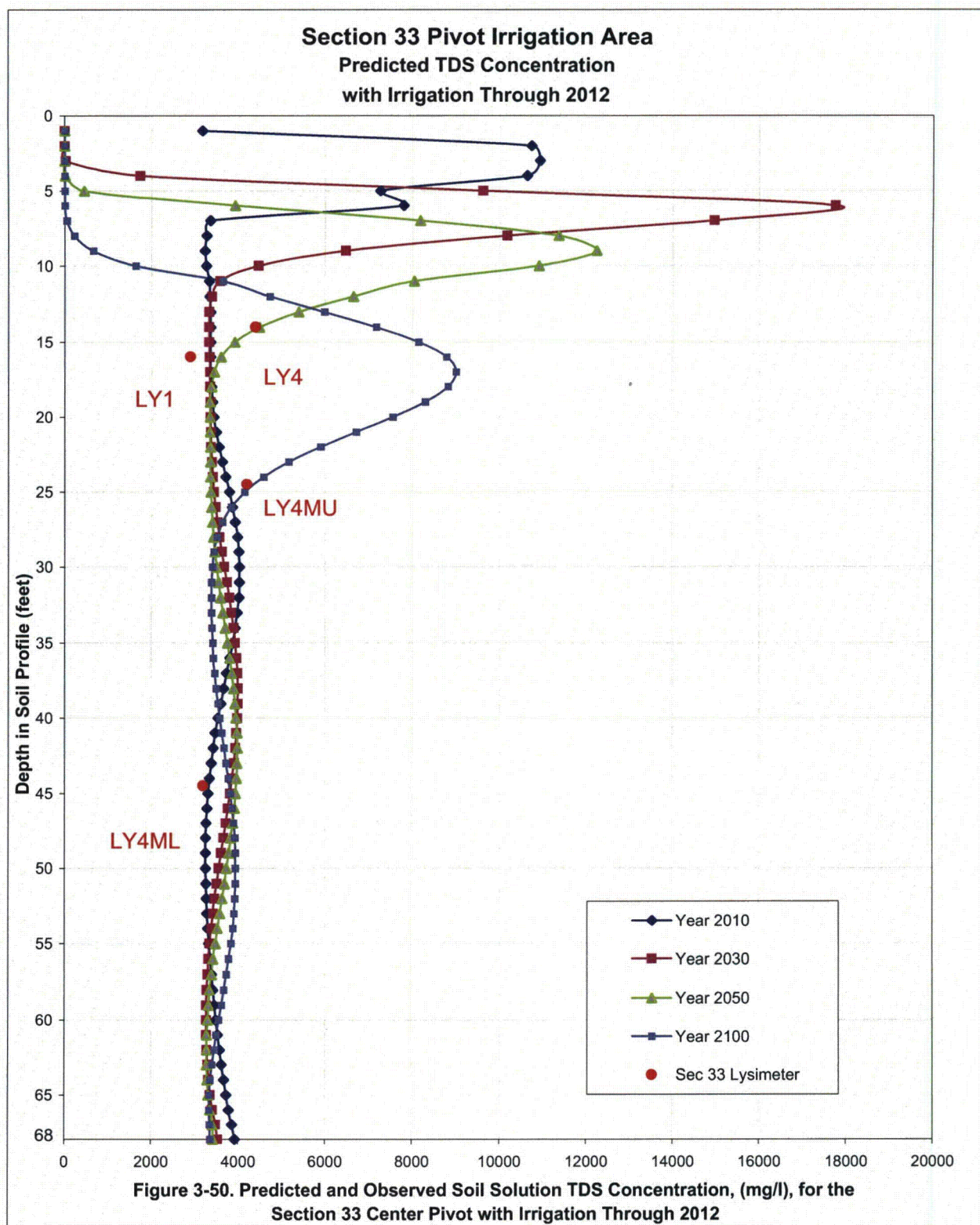


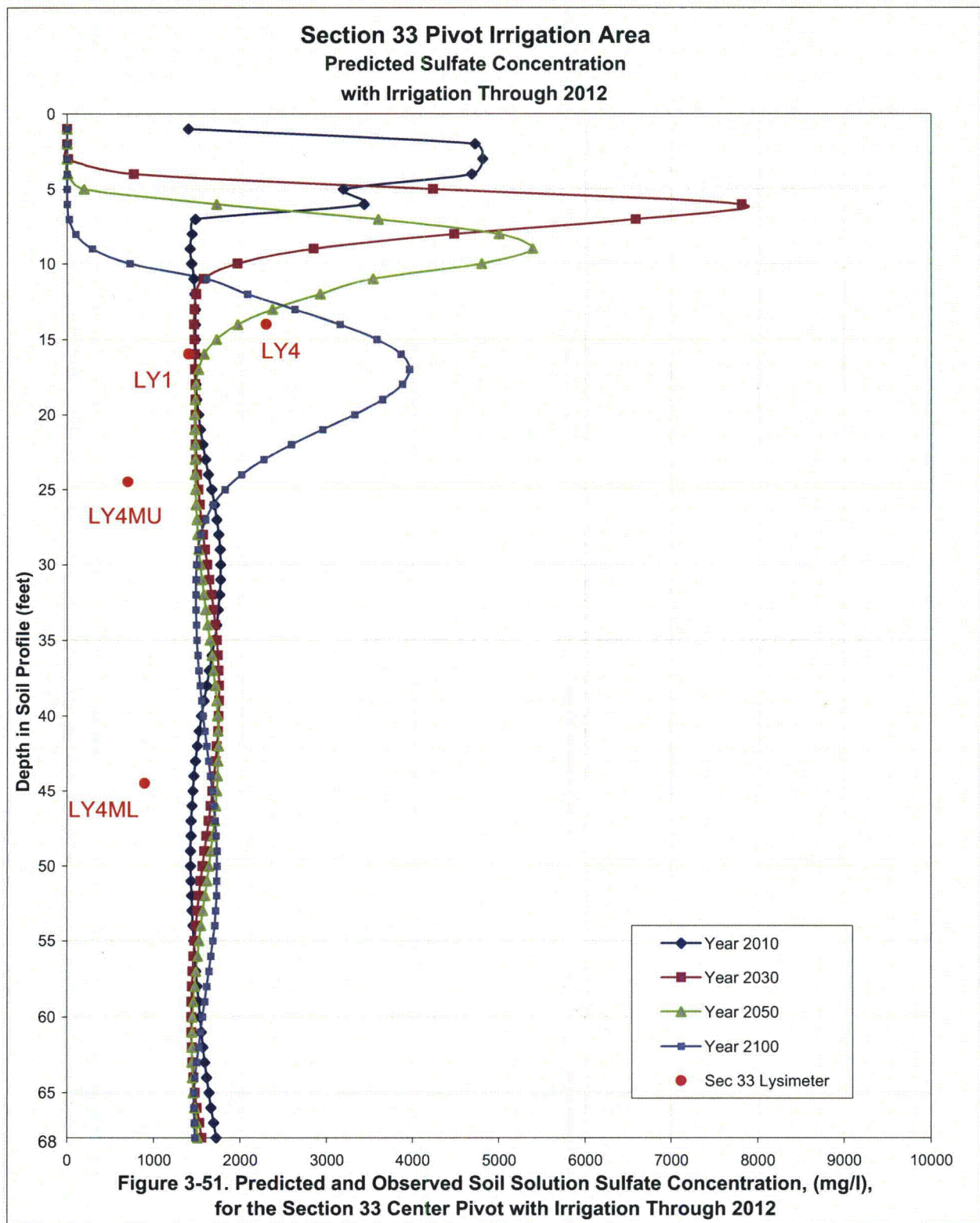




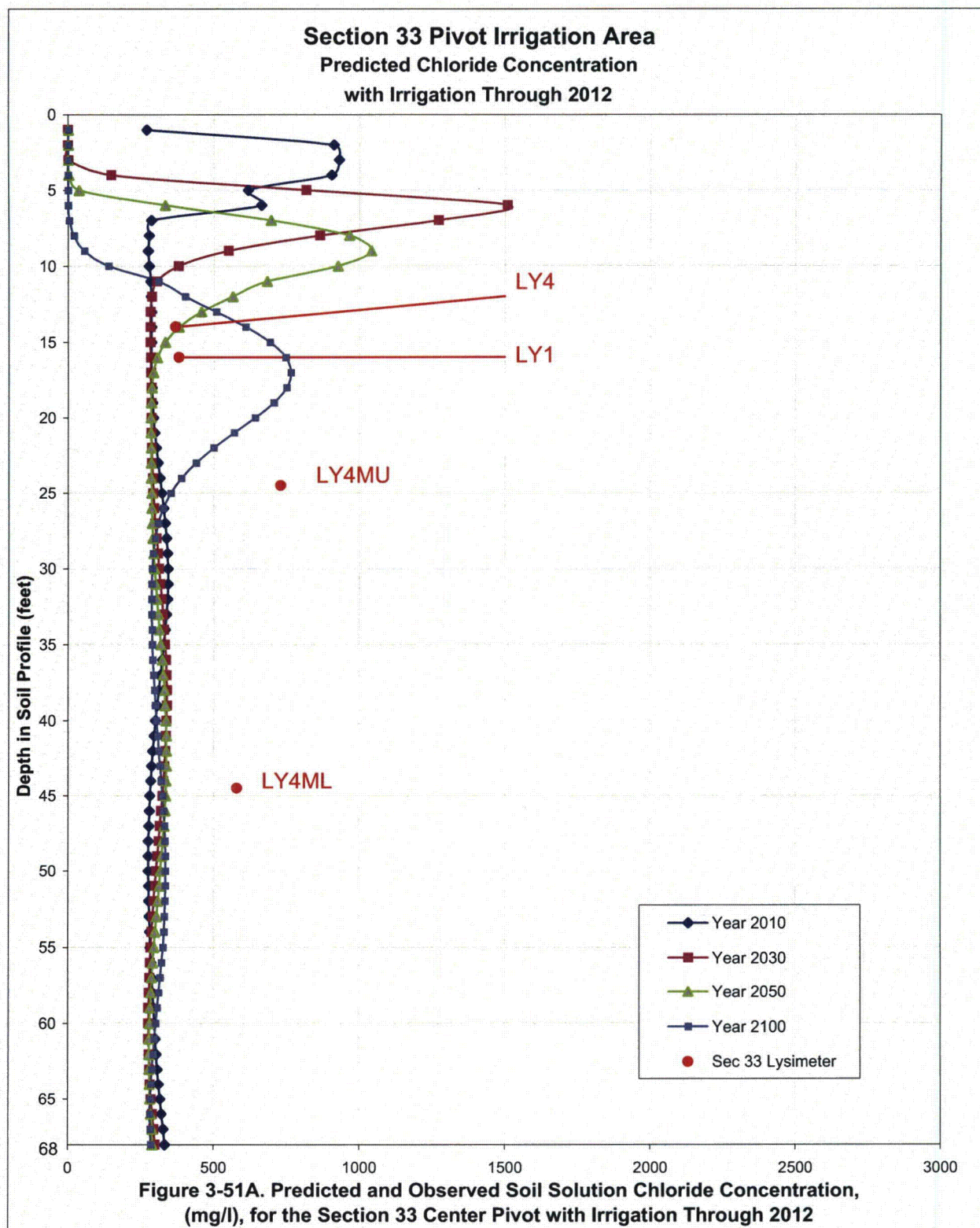


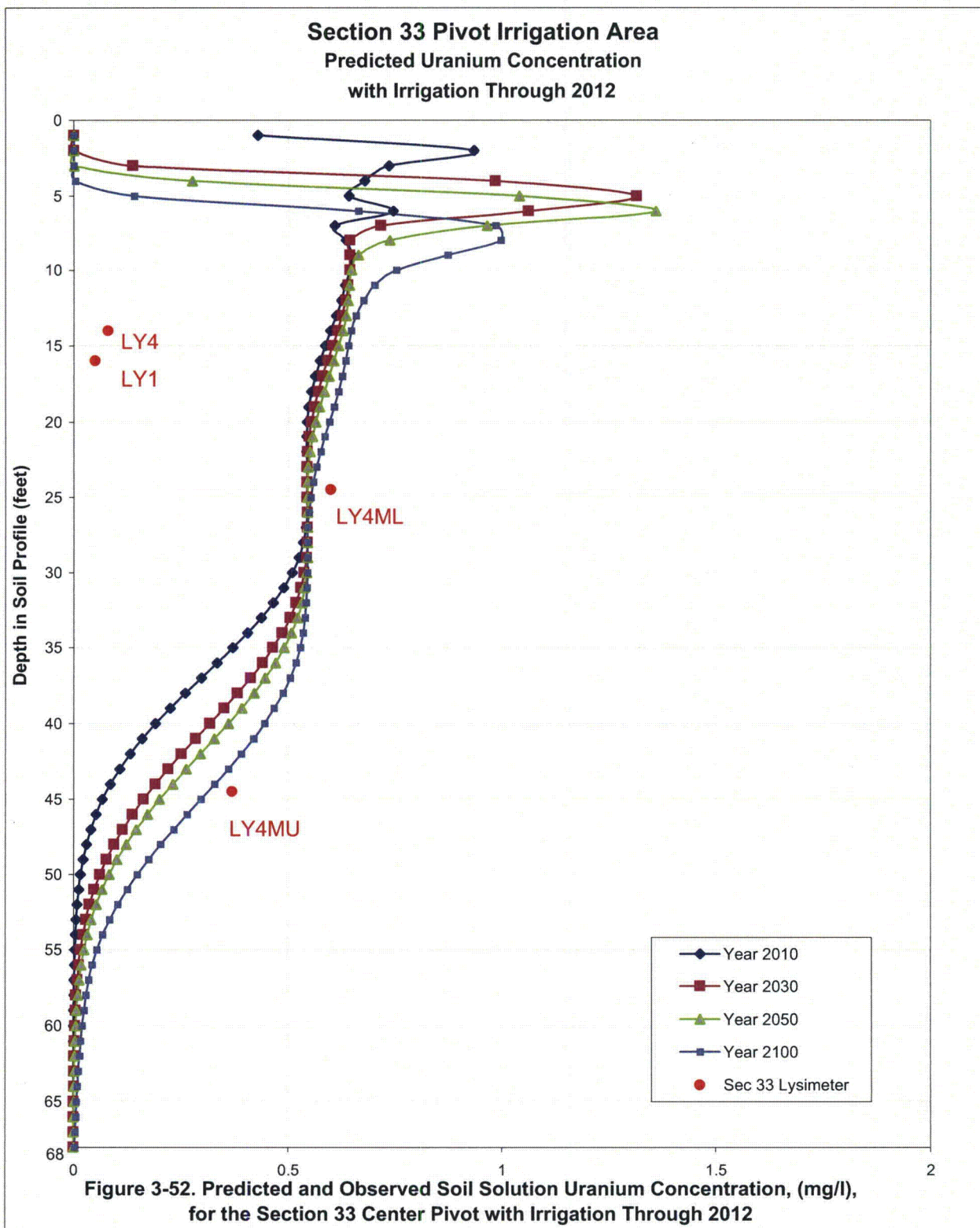


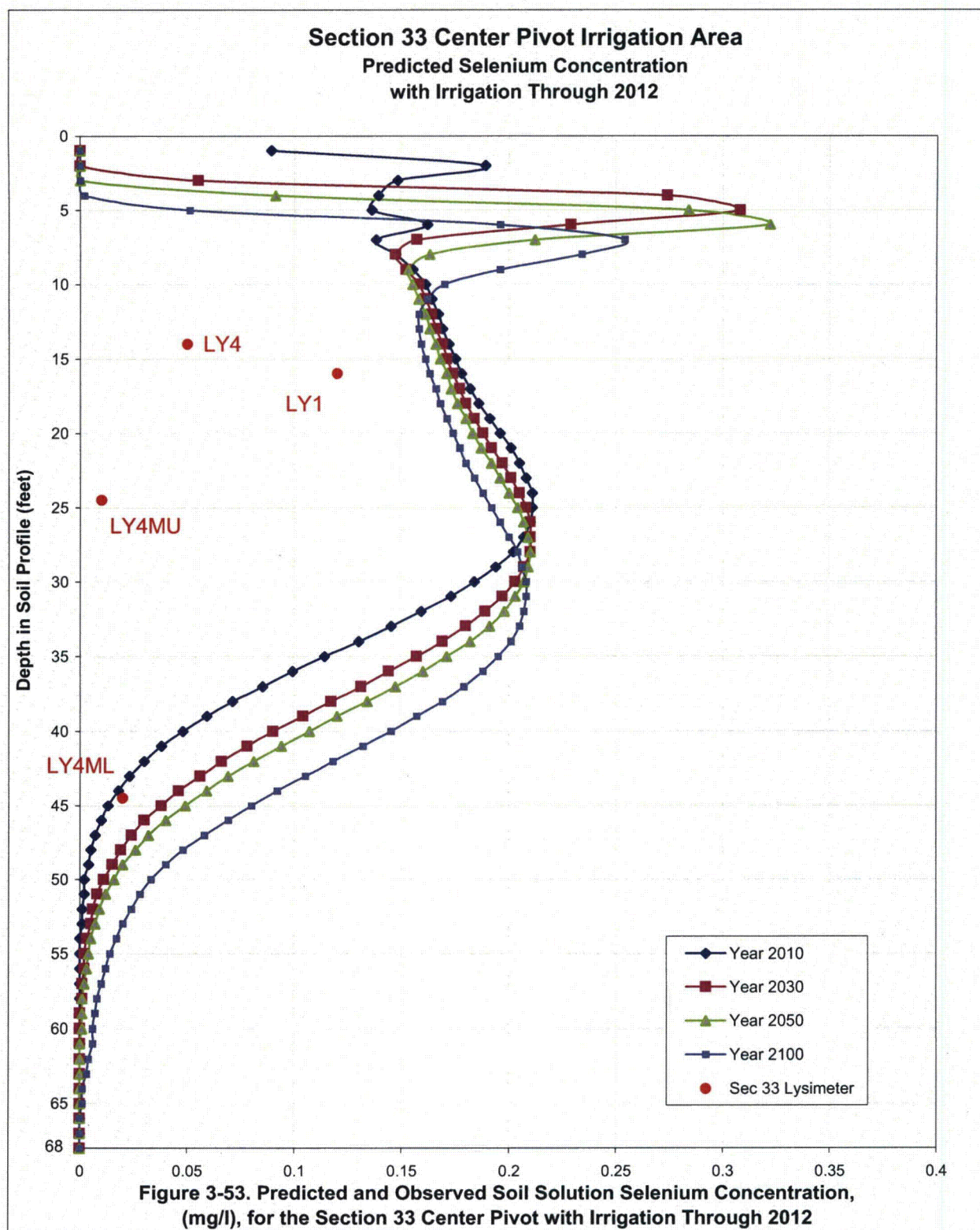




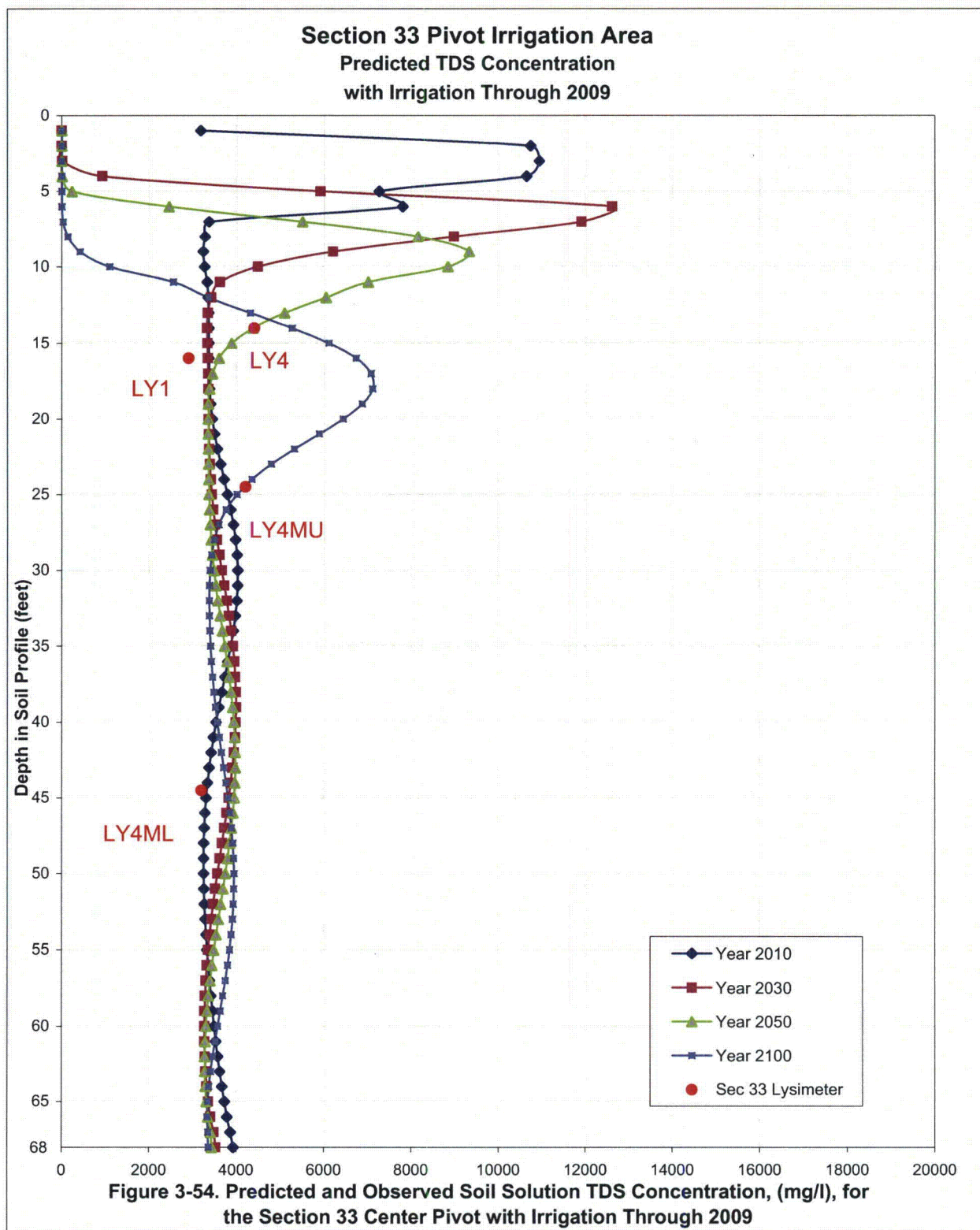




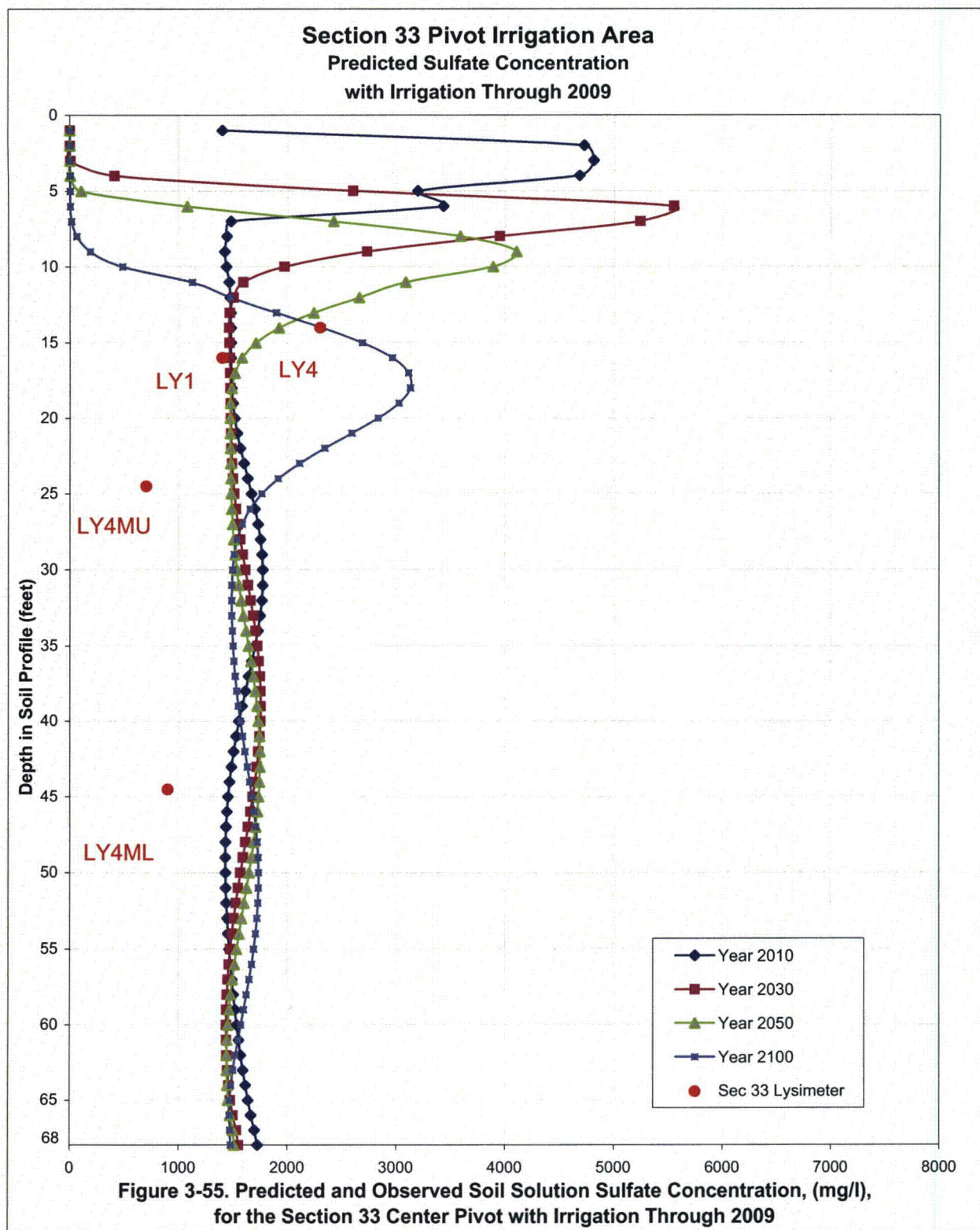


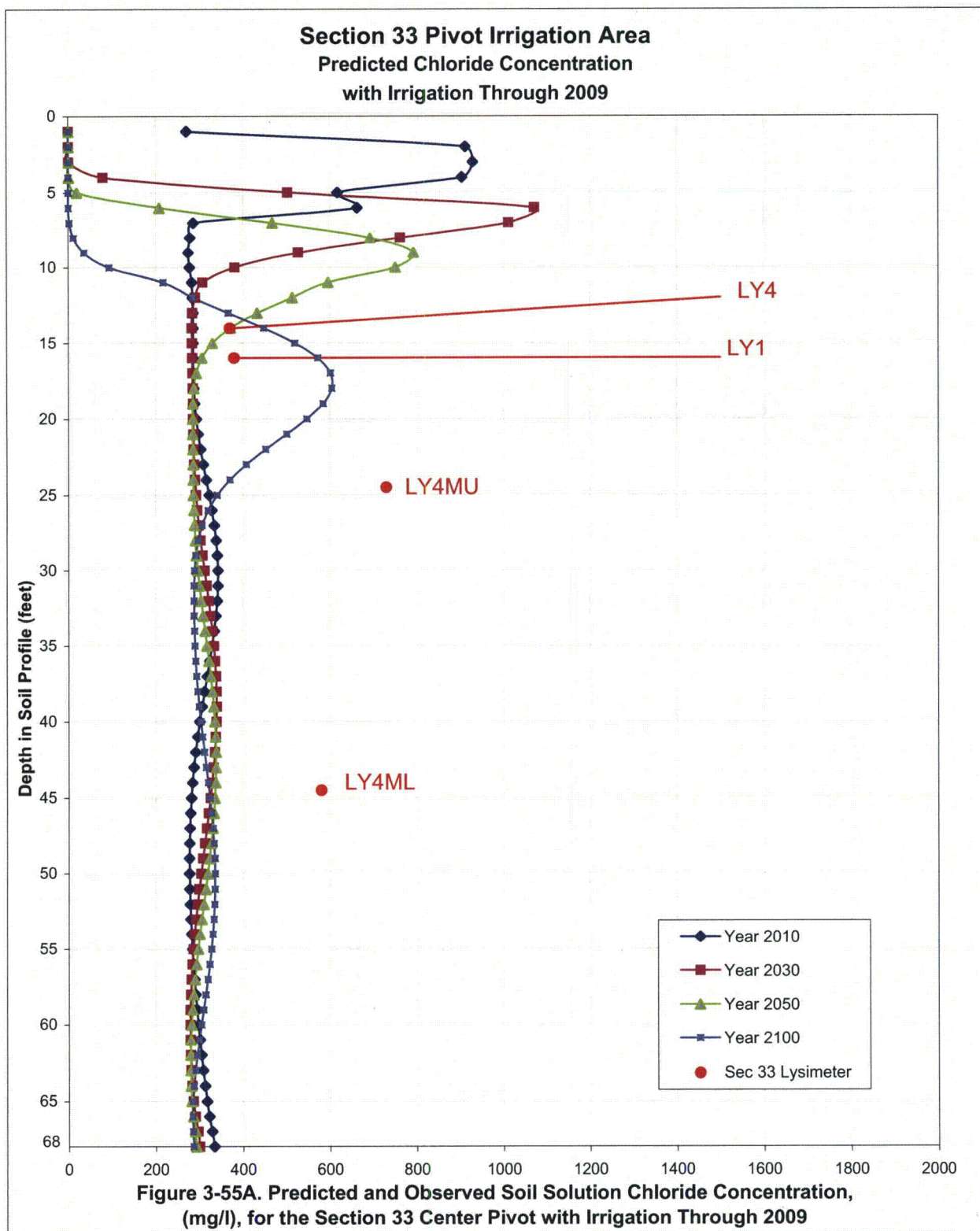


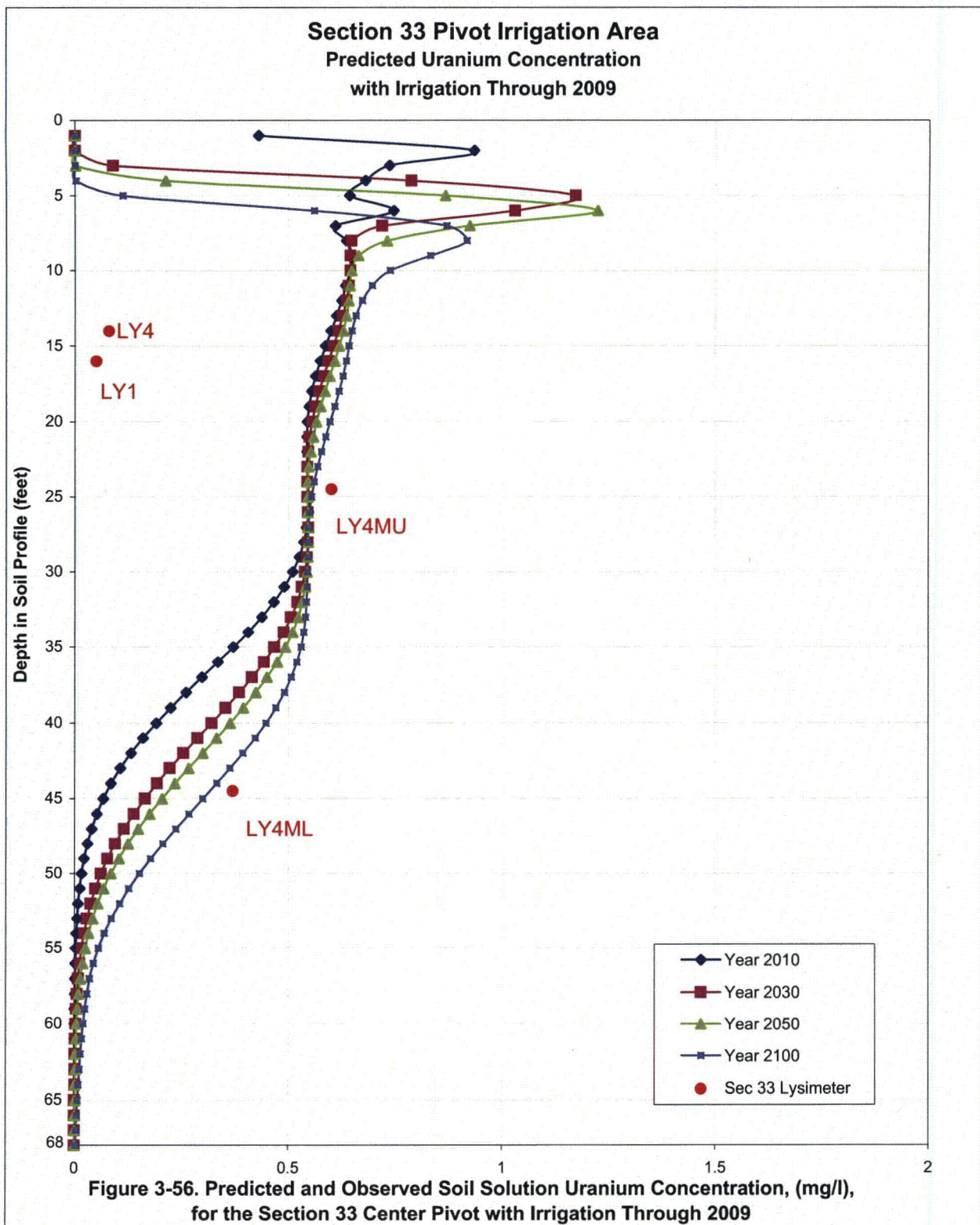






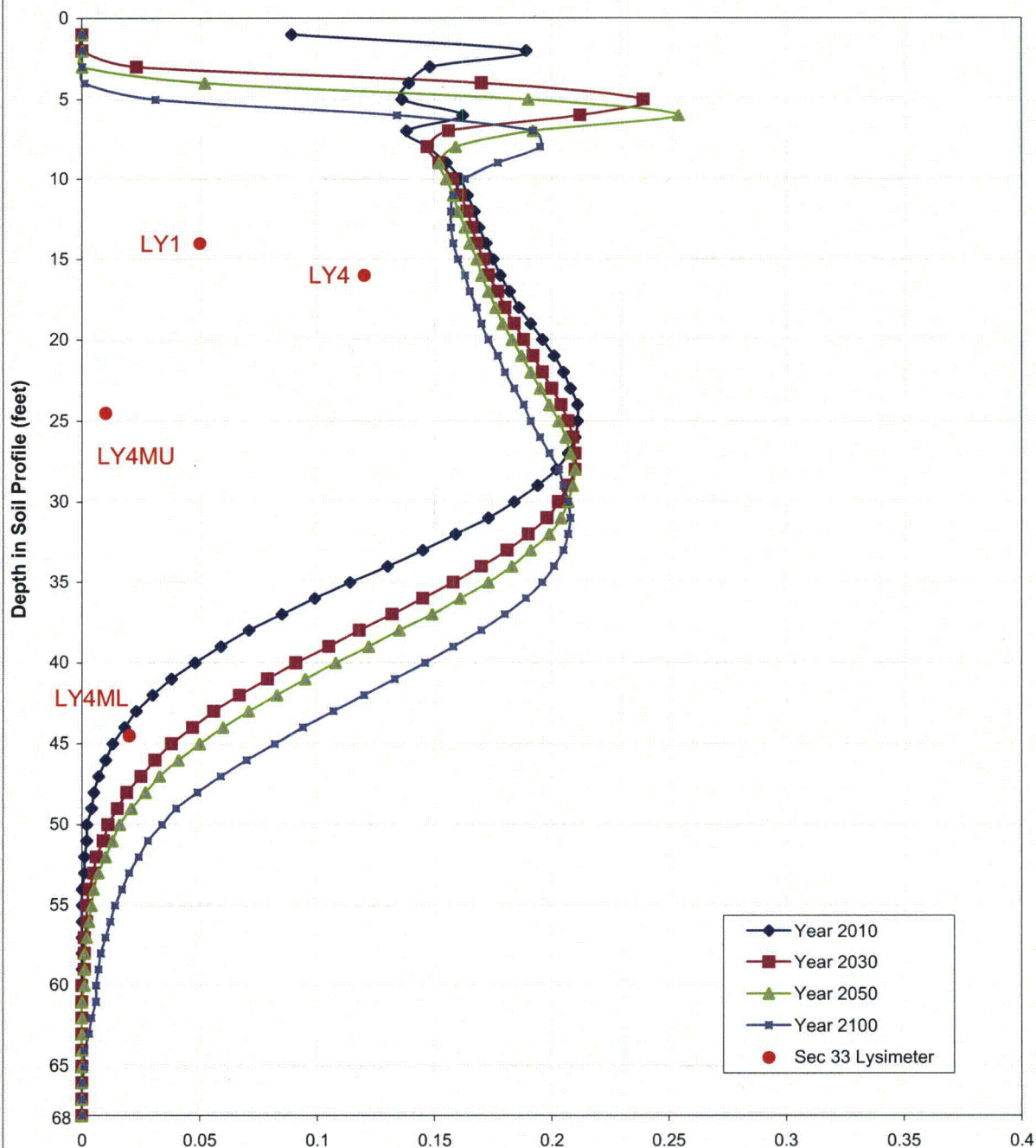








**Section 33 Pivot Irrigation Area  
Predicted Selenium Concentration  
with Irrigation Through 2009**



**Figure 3-57. Predicted and Observed Soil Solution Selenium Concentration, (mg/l),  
for the Section 33 Center Pivot with Irrigation Through 2009**



## 4.0 Ground-Water Quality

Monitoring ground-water quality in the irrigated area is a very important part of assessing the effects of the irrigation program. Additional monitoring wells have been added to the Section 33 and Section 34 areas for additional ground-water monitoring. The present ground-water monitoring program in Section 28 is adequate. This ground-water monitoring is being used to determine if the irrigation program has any measurable impact on the ground-water system.

### 4.1 Section 34

The Section 34 irrigation consists of 120 acres of flood irrigation in the northeastern portion in Section 34. This irrigation extends slightly into the other 3 quarters of Section 34 as shown in Figure 4-1. New ground-water monitoring wells 555, 556 and 557 were added in 2010. Existing monitoring wells 844, 845 and 846 have been used to monitor the ground-water quality in this area (see Table 4-1 for well data). Figure 4-1 shows that a zero saturation zone for the alluvial aquifer exists to the south of the Section 34 irrigation area, and alluvial ground-water in this area is forced to move toward the west. The alluvial aquifer exists in the northern portion of Section 3 to the south of the Section 34 irrigation but these two areas are only connected around the zero saturation boundary to the east of Felice Acres.

**Table 4-1. Existing and New Section 34 Well Data**

WELL NAME	NORTH. COORD.	EAST COORD.	WELL DEPTH (FT-MSP)	CASING DIAM. (IN)	WATER LEVEL			MP ABOVE LSD	MP ELEV. (FT-MSL)	DEPTH TO BASE OF ALLUVIUM	ELEV. TO BASE OF ALLUVIUM	CASING PERFORA TIONS	SATURATED THICKNESS
					DATE	DEPTH (FT-MSP)	ELEV. (FT-MSL)						
EXISTING ALLUVIAL WELLS													
844	1538376	487002	75	4	8/13/2008	35.28	6520.85	1.2	6556.13	70	6484.9	A 35-75	35.9
845	1537280	487833	65	4	12/1/2008	36.54	6520.51	1.7	6557.05	55	6500.4	A 45-65	20.2
846	1537219	484730	75	4	12/3/2008	45.58	6503.34	0.8	6548.92	65	6483.1	A 40-65	20.2
NEW ALLUVIAL WELLS													
555	1538575	486249	80	5	--	44	6513	2	6557	80	6477	A 60-80	36
556	1537722	485957	80	5	--	45	6511	2	6556	78	6478	A 60-80	33
557	1537235	485729	70	5	--	47	6509	2	6556	70	6486	A 50-70	23

#### 4.1.1 Sulfate Concentrations

The sulfate concentrations for 1999 and 2010 for the alluvial aquifer in Section 34 are presented in Figure 4-1. The red contour shows the 1999 sulfate concentrations with concentrations exceeding 1000 mg/l in the western portion of the Section 34 Flood area. The 2010 sulfate concentrations are listed adjacent to each of the monitoring wells. The 1000 contour exists in the area near alluvial monitoring wells 844 and 845 and extends to the western edge of section 34.

The sulfate concentrations in alluvial wells 844 and 845 prior to the start of the irrigation in 2000 were gradually declining with time while sulfate concentrations in monitoring well 846 were gradually increasing with time prior to the start of the irrigation program (see Figure 4-2).

Sulfate concentrations in well 844 and 845 have since exhibited a general increase during the period of irrigation, but their concentrations are significantly less than concentrations that were observed prior to the mid-1990s. Overall sulfate concentrations in monitoring well 846 have increased during the operation of the irrigation program. Sulfate concentrations in monitoring wells 844 and 845, which are adjacent to the flood irrigation area were approximately 1,000 mg/l in 2010. The sulfate concentrations are not likely to be affected by the Section 34 flood irrigation but more likely to have been affected by the changes in the restoration program to the east of this area. The higher sulfate concentrations in well 846 are not thought have been influenced at all by the irrigation in Section 34.

#### **4.1.2 TDS Concentrations**

The TDS concentrations for 1999 and 2010 are shown on the alluvial aquifer in Section 34. The red contour shows the TDS concentrations in 1999 and the blue contour shows the TDS concentrations in Section 34 in 2010. The width of the zone where the TDS concentrations exceed 2000 mg/l has increased from 1999 to 2010. A light green pattern is shown on Figure 4-3 where concentrations exceed the site standard of 2,734 mg/l. The TDS patterns versus time have shown fairly similar patterns to those of sulfate concentrations (see Figure 4-4). The TDS concentrations of monitoring wells 844 and 845 were 2610 and 2180 mg/l in late 2010. It is difficult to say whether these TDS concentrations have been affected by the Section 34 irrigation. It is more likely the changes in TDS concentrations in these two wells are due to changes in concentrations to the east of these wells. TDS concentrations in monitoring well 846 have become fairly steady over the last few years, which indicates the irrigation in Section 34 has not affected well 846.

#### **4.1.3 Chloride Concentrations**

The chloride concentrations for 1999 and 2010 are presented in Figure 4-5 for the alluvial aquifer in this area. The chloride concentration in alluvial well 844 exceeded 200 in 1999 and still exceeds that level in 2010. Additional areas of chloride concentrations to the east and upgradient of this area had values above 200 mg/l in 1999 also. The 200 mg/l TDS contour in 2010 now extends from monitoring wells F, GH, 844 and 845 over to west of monitoring well 846.

Figure 4-6 shows the chloride concentrations for monitoring wells 555, 556, 557, 844, 845 and 846. This figure shows chloride concentrations in 2010 for each of these wells. These chloride concentrations are similar to the freshwater injection concentration and are thought to be due to the freshwater injection that occurred to the east of this area. The chloride concentrations in monitoring wells 844 and 845 have been relatively steady during the operation of the Section 34 flood irrigation. Chloride concentrations have increased since 2000 in monitoring well 846. This increase is thought to be due to the alluvial ground-water moving to the west and not a function of the irrigation program.

#### **4.1.4 Uranium Concentrations**

Figure 4-7 presents the 1999 and 2010 uranium concentrations in the alluvial aquifer. This figure shows the concentrations are fairly similar in 1999 and 2010 in the Section 34 irrigation area. Changes in uranium concentration have been small during the irrigation period.

Figure 4-8 presents the uranium concentrations versus time for wells 844, 845 and 846. This shows fairly small uranium concentrations changes with a slight increase in 2004 in well 844. This small increase could be due to higher levels moving into this area or it could be due to the Section 34 irrigation. The fact that uranium concentrations in well 844 have been relatively steady since 2004 likely indicates that the increase in 2004 resulted from ground-water movement caused by the restoration program rather than an ongoing contribution from the irrigation program.

#### **4.1.5 Selenium Concentrations**

The selenium concentrations for 2010 are presented in Figure 4-9 for the alluvial aquifer in the area of the Section 34 irrigation. Selenium concentrations were all less than 0.1 mg/l in 1999 in the irrigation area and are presently 0.1 mg/l or less. Figure 4-10 presents the selenium concentrations showing an increase in selenium concentrations in 2001 and 2003 in wells 844 and 845, respectively. An increase in selenium concentrations was observed in well 846 starting in 1996. The selenium concentrations are thought to be caused by variations in water coming into this area but the small increases in wells 844 and 845 could plausibly be a result of the irrigation program.

#### **4.1.6 Molybdenum Concentrations**

The molybdenum concentrations for 2010 are presented in Figure 4-11 for the Section 34 area. All of these concentrations are less than 0.03 mg/l. Concentrations in 1999 were similar in this area. Figure 4-12 shows the molybdenum concentrations versus time and shows that these concentrations have been low since the start of irrigation in 2000.

#### **4.1.7 Nitrate Concentrations**

The nitrate concentrations are presented in Figures 4-13 and 4-14. Nitrate concentrations have stayed fairly steady and low in wells 844 and 845 during the irrigation operation. The nitrate concentrations in well 846 were on a significant increasing trend prior to irrigation and this trend has continued. Because the increasing trend predates irrigation, these changes are not thought to be a function of the irrigation program.

### **4.2 Section 28**

The Section 28 area has consisted of 60 acres of center pivot irrigation from 2002 through 2004, and, after expansion of the center pivot area, 100 irrigated acres from 2005 through 2009. Figure

4-15 shows the location of the 100 acre center pivot. Numerous monitoring wells exist in this area and have been used to define the water quality changes with time (see Table 4-2).

**Table 4-2. Section 28 Monitoring Well Data**

WELL NAME	NORTH. COORD.	EAST COORD.	WELL DEPTH (FT-MSP)	CASING DIAM. (IN)	WATER LEVEL		MP ABOVE LSD	MP ELEV. (FT-MSL)	DEPTH TO BASE OF ALLUVIUM	ELEV. TO BASE OF ALLUVIUM	CASING PERFORA TIONS	SATURATED THICKNESS	
					DATE	DEPTH (FT-MSP)							ELEV. (FT-MSL)
EXISTING ALLUVIAL WELLS													
633	1541467	479642	83	8	12/10/2009	73.33	6484.23	0	6557.56	95	6462.6	A Nov-83	21.7
634	1541652	480362	103	4.5	12/10/2009	70.21	6489.86	2.8	6560.07	95	6462.3	A 80-100	27.6
654	1541994	478636	120	4.5	12/10/2009	72.78	6477.72	1.4	6550.5	106	6443.1	A 60-120	34.6
655	1541620	479830	96	8	12/14/2009	72.61	6485.57	---	6558.18	88	---	A 21-84	---
656	1542578	478333	88	8	10/23/2007	75.1	6478.97	---	6554.07	88	---	A 6-88	---
659	1541689	480772	101	4.5	12/10/2009	69.58	6490.59	2	6560.17	97	6461.2	A 61-101	29.4
680	1543850	478746	80	4.5	10/25/1996	77.39	6481.48	2	6558.87	75	6481.9	A 50-80	0
681	1540676	482734	117	6	9/24/1998	64.18	6496.34	2.1	6560.52	111	6447.4	A 67-117	48.9
684	1540273	478499	143	6	10/20/2009	87.34	6465.94	2	6553.28	118	6433.3	A 83-143	32.7
688	1541257	483955	105	5	12/14/2009	60.92	6501.7	2.9	6562.62	95	6464.7	A 65-105	37
881	1542034	481478	96	4.5	12/10/2009	73.26	6491.78	2.0	6565.04	103	6460	A 76-96	31.7
882	1541404	482396	110	4.5	11/18/2008	68.21	6492.95	2.0	6561.16	95	6461.2	A 70-110	31.7
883	1540097	483039	100	5	12/14/2009	62	6495.13	1.9	6557.13	96	6459.3	A 60-90	35.9
884	1542677	481498	90	5	6/22/2009	74.66	6491.44	1.0	6566.1	85	6480.2	A 58-88	11.3
885	1541919	483474	100	5	12/10/2009	65.25	6499.39	1.5	6564.64	95	6468.1	A 70-100	31.3
886	1542327	482487	90	5	12/10/2009	68.78	6495.77	1.5	6564.55	87	6476.1	A 60-90	19.7
887	1543063	482469	67	5	6/16/2009	57.54	6510.19	1.5	6567.73	60	6506.2	A 42-67	4
888	1542285	479335	105	5	12/10/2009	75.7	6481.63	1.1	6557.33	90	6466.2	A 75-105	15.4
889	1540047	480222	65	5	10/24/1996	63.31	6486.32	1.5	6549.63	60	6488.2	A 35-65	0
890	1541365	480088	101	5	12/10/2009	72.87	6485.56	1.7	6558.43	93	6463.7	A 81-101	21.8
893	1541934	482244	98	4.5	12/8/2008	70.1	6493.87	2.1	6563.97	93	6468.9	A 78-98	25
M16	1543252	485112	93.3	5	12/10/2009	61.54	6509.05	1.4	6570.59	100	6469.2	A 60-100	39.9
MO	1543620	485518	88	4.5	12/10/2009	63.48	6509.41	2	6572.89	80	6490.9	A 45-85	18.5
MR	1542609	483574	100	5	12/10/2009	65.97	6500.29	1.8	6566.26	100	6464.5	A 54-94	35.8
MS	1542607	485570	82	5	12/10/2009	61.25	6509.42	1.5	6570.67	89	6480.2	A 52-82	29.3
MT	1543221	483531	98	4.5	10/14/2009	55.04	6512.39	2.3	6567.43	87	6478.1	A 34-94	34.3
MV	1542618	484418	105	4.5	12/8/2008	67.55	6502.23	1.3	6569.78	95	6473.5	A 75-105	28.7



#### **4.2.1 Sulfate Concentrations**

Figure 4-15 shows the sulfate concentrations for 1999 and 2010. The 1000 mg/l contour exists along the central portion of Section 28 during 1999. The 1000 sulfate contour does not exist in this area of Section 28 in 2010 and has retreated to the western edge of Section 27 in 2010.

The sulfate concentration plots for wells 654, 659, 881, 886, 888 and 890 are shown on Figure 4-16. This figure shows that the sulfate concentrations were decreased significantly in monitoring wells 654 and 888 in 2004 and 2005. These two wells are located in the western portion of Section 28 and show the reduction of the western edge of the sulfate concentrations in Section 28. Sulfate concentrations have steadily declined in 2007 through 2009 in irrigation supply well 886 near the center of the Section 28 Pivot with a small increase in 2010. Sulfate concentrations overall have been fairly steady in wells 659, 881 and 890.

#### **4.2.2 TDS Concentrations**

TDS concentrations for the alluvial aquifer in Section 28 are presented in Figure 4-17 and show a reduction within the 2000 mg/l contour area which extended west of Section 28 in 1999, and extends only a short distance into Section 28 in 2010. Figure 4-18 shows similar declines in TDS concentrations in wells 654, 886 and 888 as those observed for sulfate concentrations. A small decline has been observed in wells 659, 881 and 890 during the operation of irrigation in Section 28.

#### **4.2.3 Chloride Concentrations**

The chloride concentrations in Section 28 are presented in Figure 4-19 for 1999 and 2010. The chloride concentrations have been fairly similar between these two periods except for the declines that have occurred in wells 654, 886 and 888 due to the freshwater injection in this area (see Figure 4-20).

#### **4.2.4 Uranium Concentrations**

The uranium concentrations for the alluvial aquifer in Section 28 are presented in Figure 4-21. This figure shows a green pattern which is the area where concentrations exceed the site standard of 0.16 mg/l in 2010. The 1999 0.1 mg/l contour extends further to the north and south of the area than in the more recent 2010 contour which reflects the eleven-year period of off-site operation. Figure 4-22 shows the decrease in concentrations that have been observed in monitoring wells 654, 886 and 888. A small increase in uranium concentrations in irrigation supply well 881 has been observed in the last four years. This increase is thought to be due to ongoing ground-water migration rather than being a function of the irrigation program because the concentration trends in other wells indicate no measurable impacts.

#### **4.2.5 Selenium Concentrations**

Figure 4-23 presents the 1999 and 2010 selenium concentrations for the Section 28 area. The selenium concentration contour of 0.1 mg/l extended to the western edge of Section 28 in 1999 and has retreated to the point where it does not extend to the eastern edge of Section 28 in 2010.

Figure 4-24 presents the selenium concentration time plot for the Section 28 monitoring wells. This plot shows a decline in the selenium concentrations in wells 654, 886 and 888. Some increase in selenium concentrations has also been observed in the last four years in well 881. Selenium concentrations in irrigation wells 659 and 890 are presently fairly similar to those observed prior to the start of the irrigation.

#### **4.2.6 Molybdenum Concentrations**

The molybdenum concentrations for the alluvial aquifer are presented in Figure 4-25. This area shows very low molybdenum concentrations except for small values in irrigation supply wells 634, 659, 881 and 886. Figure 4-26 shows that these molybdenum concentrations have been small in the past with a small increase in 2009 and 2010 in well 881. These small molybdenum concentrations in Section 28 are likely from the movement of alluvial water from Section 27 into this area. Figure 5-26 shows the molybdenum concentration in 2010 exceeded 0.1 mg/l to the east of Section 28 in Section 27. This higher molybdenum concentration likely caused the increase in the molybdenum concentration in the alluvial aquifer in the Section 28 Center Pivot area. It is very unlikely that the molybdenum concentrations in the Section 28 area have been affected by the application of water to the irrigation area.

#### **4.2.7 Nitrate Concentrations**

The nitrate concentrations in 1999 exceeded 10 mg/l in the northern portion of the Section 28 Center Pivot area adjacent to the zero saturation boundary (see Figure 4-27). The nitrate concentrations exceeded 10 mg/l into the western half of Section 27 in 2010. Figure 4-28 presents the nitrate concentrations with time and shows very small changes in nitrate concentrations except for the decrease in wells 888 and 886.

### **4.3 Section 33**

Section 33 has the 150 acre center pivot and 24 acres of flood area. The 24 acre flood area is typically included in the Section 34 analysis because the soil properties in the Section 33 flood area are similar to those in the Section 34 flood area. However, the ground-water evaluation for the Section 33 flood is included in the Section 33 ground-water evaluation. Figure 4-29 shows the location of the 3 new monitoring wells; 551, 553 and 554. These wells were added in 2009 to further define the ground-water concentrations in this area. Wells 551, 553, 554, 647, 649, 657 and 658 are used in evaluating the ground-water concentrations adjacent to the 150 acre center pivot while alluvial well 650 is used to monitor the Section 33 flood area (see Table 4-3 for well completion information). Well 648 has not had enough water in it the last few years to collect a sample.

**Table 4-3. Existing and New Section 33 Well Data**

WELL NAME	NORTH. COORD.	EAST COORD.	WELL DEPTH (FT-MSP)	CASING DIAM. (IN)	WATER LEVEL			MP ABOVE LSD	MP ELEV. (FT-MSL)	DEPTH TO BASE OF ALLUVIUM	ELEV. TO BASE OF ALLUVIUM	CASING		
					DATE	DEPTH (FT-MSP)	ELEV. (FT-MSL)					PERFORATIONS	SATURATED THICKNESS	
EXISTING ALLUVIAL WELLS														
541	1539831	477236	120	5	12/4/2008	93.6	6462.02	2	6555.62	---	---	A	78-118	---
647	1536623	478308	140	4.5	12/4/2008	106.65	6445.26	1.4	6551.91	132	6418.5	A	80-140	26.7
648	1534730	478343	120	4.5	12/4/2008	115.7	6432.09	2	6547.79	120	6425.8	A	80-120	6.3
649	1534730	479798	124	4.5	12/4/2008	102.82	6440.47	0.3	6543.29	115	6428	A	84-124	12.5
650	1536779	482135	109	4.5	12/4/2008	83.9	6463.21	2.2	6547.11	103	6441.9	A	89-109	21.3
657	1537497	478392	128	6	12/4/2008	2.2	6446.93	2.2	6551.81	120	6429.6	A	87-128	17.3
658	1535922	478436	130	6	12/4/2008	0.4	6441.68	0.4	6550.18	129	6420.8	A	89-130	20.9
685	1539098	478170	100	4.5	12/4/2008	100.17	6456.4	1.7	6556.57	116	6438.9	A	60-100	17.5
687	1539011	477276	102	6	12/4/2008	99.05	6456.91	2.2	6555.96	120	6433.8	A	62-102	23.1
996	1537621	477989	138	5	12/4/2008	105	6447.52	1.7	6552.52	136	6414.8	A	126-136	32.7
NOTE: Wells 635, 657A and 658A do not penetrate the water table.														
NEW ALLUVIAL WELLS														
551	1536280	479800	130	5	---	105	6450	2	6547.3	120	6433	A	90-130	18
553	1534840	480510	120	5	---	97	6448	2	6547.48	110	6433	A	80-120	15
554	1534840	479110	140	5	---	103	6440	2	6547.17	130	6411	A	100-140	29

NOTE: Wells 635, 657A and 658A do not penetrate the water table.

#### 4.3.1 Sulfate Concentrations

The sulfate concentrations for the alluvial aquifer are presented in Figure 4-29 for the Section 33 area. This figure shows the 1999 and 2010 alluvial sulfate concentrations in Section 33. The 1999 contour is presented in red while the blue contour presents the 2010 sulfate concentrations. Sulfate concentration data (2010) is also posted on the figure adjacent to each of the wells. The Section 33 center pivot is located in the Rio San Jose alluvial system. The Rio San Jose alluvial system receives water from the San Mateo alluvial system in the western portion of Section 28 and also to the southeast of Section 33 into the eastern edge of Section 4. The Rio San Jose alluvial system typically has a concentration gradient from the west-southwest to the east-northeast. The location of the 500 mg/l sulfate concentration in 1999 was generally slightly further east in Sections 32 and 33 than the present 2010 contour. The movement of the concentration contour line to the east varies due to the amount of natural recharge to the Rio San Jose alluvial system on the west side. The San Andres aquifer also has a direct connection with the alluvial aquifer in the southeast portion of Section 32 and therefore has caused a sink to develop in the alluvial aquifer in this area due to the movement of alluvial ground-water into the San Andres aquifer. This would also tend to shift the sulfate contour to the west.

Figure 4-30 shows the sulfate concentrations for alluvial wells 551, 553, 554, 647, 649 and 658. Three samples were collected from the new alluvial wells 551 and 553 while two additional samples were collected from well 554 in 2010. A small increase in concentration in alluvial well

658 was observed in 2009 followed by a small decrease in sulfate in 2010. Sulfate concentration in alluvial well 649, which is on the south side of the center pivot, has gradually increased from 2006 through 2010. Sulfate concentrations prior to the irrigation in 2000 were higher in well 649 and fairly similar to those that have been observed the last three years.

It is difficult to determine whether any increase in sulfate concentrations has occurred due to the Section 33 irrigation. A very small increase in sulfate concentration could exist in some of these wells due to the Section 33 irrigation but it could also easily be from the slightly higher sulfate concentrations that exist to the northwest in the Rio San Jose alluvial system, or also the shifting of higher concentrations to the west in Section 33. Fairly steady concentrations had been observed in alluvial well 650 until an increase was observed in 2010 which is located on the southwest side of Section 33 flood area.

#### **4.3.2 TDS Concentrations**

The TDS concentrations have been monitored in Section 33 since 1997 when the original monitoring wells were drilled. Figure 4-31 presents the TDS concentrations for 1999 and 2010. The data values adjacent to the wells are 2010 concentrations. The 1,000 mg/l contour for TDS in 2010 is slightly west of its location in 1999. This indicates that the higher concentrations in the eastern side of the Rio San Jose have shifted slightly to the west in this area. The TDS concentrations to the north of Section 33 irrigation in the Rio San Jose alluvial system are generally higher than those in the Section 33 Center Pivot area. This shows that the area to the north has a potential to increase the alluvial TDS concentrations in the Section 33 Center Pivot area as this water moves to the south.

Figure 4-32 presents the TDS concentrations for wells 551, 553, 554, 647, 649, 650 and 658. This data shows that, in general, the TDS concentrations for the first few years in wells 647 and 649 gradually decrease, but there has been an overall increase in wells 647, 649 and 658 over the last three years. This very small increase could possibly be showing an effect on TDS in the alluvial aquifer from the Section 33 Center Pivot, but it could also easily result from movement of the slightly higher concentrations to the north or the westerly movement of ground water. Therefore, it is difficult to determine from the TDS concentrations whether the Section 33 irrigation has had a measurable impact on the ground-water quality in this area. TDS concentrations were fairly steady in well 650 until a small increase in 2010.

#### **4.3.3 Chloride Concentrations**

The alluvial chloride concentrations are presented in Figure 4-33 for 1999 and 2010. This plot shows that the 1999 chloride concentrations of >100 mg/l extended to the northwest side of the Section 33 Center Pivot. The 2010 chloride concentrations extend down to the southern edge of the center pivot. The movement of the 100 mg/l contour from 1999 to 2010 could possibly be attributed to irrigation in Section 33, but as with other constituents, it could also be a result of movement of the chloride concentrations from the north of the site into the Section 33 Center Pivot area.

Figure 4-34 presents the chloride concentrations for the monitoring wells in the Section 33 area. This figure shows fairly steady chloride concentrations but does show a small increase in



chloride concentrations for the last five years in wells 649 and 658. A small increase was also observed in 2009 and 2010 in wells 647 and 649. Present chloride concentrations in well 647 are less than those that were observed in 1997. It is difficult to determine whether the changes in the chloride concentrations in the alluvial aquifer in the area of Section 33 Center Pivot are due to the operation of the center pivot. The chloride concentrations in alluvial well 650 could possibly be showing the effects on the ground water from the Section 33 flood irrigation but the value is well within natural range of this constituent.

#### **4.3.4 Uranium Concentrations**

The uranium concentrations are an important parameter because it is the main hazardous constituent of concern in the irrigation water. Figure 4-35 presents the 1999 and 2010 uranium concentrations for the alluvial aquifer in the Section 33 area. The red contour shows that the uranium concentrations of 0.05 mg/l extended down to the southern edge of Section 33 in 1999. These concentrations extend down to alluvial well 657 which is approximately  $\frac{3}{4}$  of a mile north of well 648 in 2010. A decrease in the area of significant uranium concentrations has occurred in the Section 33 center pivot irrigation area from 1999 to 2010.

Figure 4-36 presents the uranium concentrations versus time for the Section 33 alluvial wells. This plot shows that the uranium concentrations for the last eleven years during the operation of the Section 33 Center Pivot have been relatively steady. These concentrations had declined by the start of the irrigation program to concentrations observed today. The observed uranium concentrations do not indicate any measurable effect on the ground-water quality that is attributable to the Section 33 Center Pivot irrigation. The small and steady concentrations from alluvial well 650 do not indicate any effects from the Section 33 flood system.

#### **4.3.5 Selenium Concentrations**

Figure 4-37 presents the 2010 selenium concentrations for the alluvial aquifer in the Section 33 area. No iso-concentration contours are shown on this figure for the 1999 or 2010 concentrations because the selenium concentrations are all very low. The 2010 concentrations are posted by each well.

Figure 4-38 presents the selenium concentrations for the Section 33 monitoring wells. The selenium concentrations in monitoring well 647 have gradually declined from 0.07 in 1997 to 0.04 in 2010. This small decline in selenium concentrations is likely due to the off-site restoration efforts that have been occurring for the last eleven years in this area. An overall very gradual increase in selenium concentrations has occurred in alluvial well 649 from 0.02 to 0.05 over this period of time. An apparent slight increase was also observed in alluvial well 658 during 2009 and selenium values were fairly steady in this well in 2010. These selenium concentration changes are not significant enough to determine if the Section 33 irrigation has had any effect on the selenium concentrations in the alluvial aquifer. Selenium concentrations had been steady in well 650 while a small increase was observed in 2010.