HOMESTAKE
Grants Office

Alan D. Cox
Project Manager

30 March 2009

Via UPS Overnight

Mr. John Buckley, Site Manager
c/o Document Control Desk
Fuel Cycle Facilities Branch (Mailstop T8-A33)
Division of Fuel Cycle Safety and Safeguards
Office of Nuclear Materials Safety and Safeguards
U. S. Nuclear Regulatory Commission
11545 Rockville Pike
Two White Flint North
Rockville, MD 20852-2738

RE: **Grants Reclamation Project**
Docket No. 40-8903
License No. SUA-1471
2008 Annual Irrigation Program Report

Dear Mr. Buckley:

Pursuant to our recent conversations with yourself, members of the NRC staff, the Environmental Protection Agency – Region VI Dallas, and the New Mexico Environment Department, enclosed please find two (2) copies of the report entitled "Grants Reclamation Project – Evaluation of Years 2000 through 2008 Irrigation with Alluvial Ground Water, March 2009". As you know, this report is prepared annually for the Grants project, and provides monitoring data and related discussion/evaluation related to the application of irrigation water on approximately 400 acres of cropland. Crop irrigation at the Grants project is an integral part of ongoing ground water cleanup and restoration program efforts at the site.

We believe that the attached report, which includes cumulative data and analysis since the inception of land application / irrigation at the Grants site, addresses a number of the questions that have been raised with regard to this aspect of site ground water remediation efforts.

Thank you for your time and attention on this matter. If you have any questions or require additional information, please contact me in our Grants office at (505) 287-4456 Ext. 25 or via cell phone at (505) 400-2794.

Sincerely yours,

HOMESTAKE MINING COMPANY OF CALIFORNIA
Alan D. Cox

Enclosures (2 copies Irrigation Annual Report)

xc: S. Appaji, Region VI EPA, Dallas (w/encl.)
B. Olsen – NMED, Santa Fe (w/encl.)
D. Bahar – NMED, SOS, Santa Fe (w/encl.)

R. Chase – SLC office (w/encl.)
B. Ferdinand – SLC office
T. Grandy – SLC office
G. Hoffman – Hydro Engineering, Casper

NMSS01

P.O. Box 98 / Hwy. 605 Grants, NM 87020 Tele: (505) 287-4456 Fax: (505) 287-9289

Addl copy has been sent to PM

Grants Reclamation Project
Evaluation of Years 2000 Through 2008
Irrigation with Alluvial Ground Water

For:

Homestake Mining Company
P. O. Box 98
Grants, New Mexico 87020

By:

Environmental Restoration Group, Inc.
and
Hydro-Engineering, L.L.C.
March 2009

George L. Hoffman

George L. Hoffman, P.E.
Hydrologist
Hydro-Engineering, L.L.C
3/4/09

Ryan Stokes

Ryan Stokes, E.I.T
Engineer
Hydro-Engineering, L.L.C

Kenneth R Baker

Kenneth R. Baker, Ph.D.
Health Physicist
Environmental Restoration Group, Inc.

TABLE OF CONTENTS

Page Number

ES. Executive Summary ES-1

1.0 Introduction 1

2.0 Source Constituents in Irrigation Water 1

2.1 Sections 33 and 34 Irrigation 2

2.2 Section 28 Irrigation 4

2.3 Irrigation Water Usage 6

3.0 Soil Concentrations 7

3.1 Background Soil Concentrations 7
3.1.1 1998 Investigation 7
3.1.2 Background Determinations during Ongoing Investigation 8
3.1.3 Mean Background Soil Concentrations 8

3.2 Constituents in Treated Soil 14
3.2.1 Section 33 Center Pivot 18
3.2.2 Sections 33 and 34 Flood Areas 20
3.2.3 Section 28 Center Pivot 23
3.2.4 Comparison of Applied and Measured Soil Concentrations 27
3.2.4.1 Uranium 27
3.2.4.2 Selenium 28
3.2.5 Summary of Soil Concentration Comparison 30

4.0 Hay Concentrations and Constituent Uptakes 31

4.1 Measured Hay Concentrations 31
4.1.1 Section 33 Center Pivot 31
4.1.2 Sections 33 and 34 Flood Areas 32
4.1.3 Section 28 Center Pivot 32
4.1.4 Background Concentrations in Hay and Special Study 32
4.1.5 Summary of Hay Concentrations 33

4.2 Measured Uranium Uptake in Hay 34

5.0 Radiation Dose from Eating Beef 35

5.1 Vegetation to Livestock Uptake 35

5.2 Beef to Human Uptake 36

6.0 Conclusion 37

7.0 References 38

Figures

1. Location of Irrigation Areas with Soil Sample Locations From The 1998 Investigation 39

2. 1999 and 2000 Irrigation Areas with Irrigation Wells and Soil Sample Locations 40

3. 2001 Irrigation Areas with Irrigation Wells and Soil Sample Locations 41

4. 2002 Sections 33 and 34 Irrigation Areas with Irrigation Wells and Soil Sample Locations 42

5. 2003 Sections 33 and 34 Irrigation Areas with Irrigation Wells and Soil Sample Locations 43

6. 2004 Sections 33 and 34 Irrigation Areas with Irrigation Wells and Soil Sample Locations 44

7. 2005 Sections 33 and 34 Irrigation Areas with Irrigation Wells and Soil Sample Locations 45

8. 2006 Sections 33 and 34 Irrigation Areas with Irrigation Wells and Soil Sample Locations 46

9. 2007 Section 33 and 34 Irrigation Areas with Irrigation Wells And Soil Sample Locations 47

10. 2008 Section 33 and 34 Irrigation Areas with Irrigation Wells And Soil Sample Locations 48

11. 2002 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations 49

12. 2003 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations 50

13. 2004 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations 51

14. 2005 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations 52

15. 2006 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations 53

TABLE OF CONTENTS
(continued)

Page Number

Figures (continued)

16. 2007 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations....54
17. 2008 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations....55
18. Uranium Concentrations Versus Time for Section 33 Center Pivot Soil Samples....56
19. Uranium Concentrations Versus Time for Sections 33 and 34 Flood Soil Samples...57
20. Uranium Concentrations Versus Time for Section 28 Center Pivot Soil Samples....58
21. Selenium Concentrations Versus Time for Section 33 Center Pivot Soil Samples....59
22. Selenium Concentrations Versus Time for Sections 33 and 34 Flood Soil Samples..60
23. Selenium Concentrations Versus Time for Section 28 Center Pivot Soil Samples....61

Tables

1. 2000 through 2008 Sections 33/34 Irrigation Supply Concentrations....3
2. 2002 through 2008 Section 28 Irrigation Supply Concentrations....6
3. Pre-Operations and Background Soil Sample Results for Section 33....10
4. Pre-Operations and Background Soil Sample Results for Section 34....11
5. Pre-Operations and Background Soil Sample Results for Section 28....13
6. Irrigation Soil Analyses, 2000 through 2008....15
7. Summary of Irrigation Soil Analyses, 2000 through 2008....25
8. Uranium Applied in Irrigation Water....28
9. Measured Uranium in Soil at the End of 2008 Growing Season for Treated Soils, Mean Background Concentrations....28
10. Selenium Applied in Irrigation Water....29
11. Comparison of Measured Versus Applied Selenium....30
12. Summary of Hay Analyses....33
13. Average Uranium Concentrations in Soil and Hay....34
14. Transfer Coefficient from Soil to Hay (mg/kg-hay/mg/kg-soil)....35

Appendix

Appendix A 1999 and 2000 Irrigation Soil Analyses A-1
Appendix B Hay Analyses B-1

Executive Summary

This report characterizes changes in uranium and selenium concentrations in four hay fields supplied with irrigation water from groundwater with elevated levels of uranium and selenium. From 2000 through 2008, 270 to 394 acres were irrigated with this water. Uranium and selenium concentrations have been measured in the applied irrigation water and affected soils each year and hay crop since 2000.

The irrigation project is being conducted by Homestake Mining Corporation (HMC) as part of the Homestake Grants Reclamation Project. The project plan established an upper limit for the uranium concentration in irrigation water at the U.S. Nuclear Regulatory Commission effluent standard of 0.44 milligrams per liter (mg/l). Selenium was set at a site-specific State of New Mexico Water Quality Control Commission standard of 0.12 mg/l.

The fields subject to irrigation are located in Sections 28, 33, and 34 in Township 12 North, Range 10 West near Grants, New Mexico. Fields in Sections 28 and 33 were irrigated using a center pivot irrigation system. The field in Section 34 and an additional portion of Section 33 was irrigated by flooding. The total amount of irrigation water applied to the fields is 8100 acre feet (ac-ft), ranging from 695 to 1058 ac-ft annually.

The background concentrations of uranium and selenium in the soil are averages of these constituents in samples collected prior to the irrigation program and outside of the irrigated area each year. The background concentrations are compared to the concentration in each 1-foot (ft) interval of the upper three feet of soil in treated areas. The difference between the treated soil and background concentration is the amount of constituent added from the irrigation. The amount of a constituent in the upper three feet of soil is then compared to the total amount of the constituent added over the course of irrigation.

The mean background concentrations of uranium and selenium are similar in Sections 28 and 33 (center pivot areas). The concentrations in Section 34 are generally higher than in other fields, presumably because of their association with clay soils.

Mean background concentrations of uranium, in descending 1-ft layers (0-1 ft, 1-2 ft, 2-3 ft) are:

- Section 28: 0.56, 0.52, and 0.52, averaging 0.53 milligrams per kilogram (mg/kg).
- Section 33: 0.77, 0.69, and 0.72, averaging 0.73 mg/kg.
- Section 34: 1.96, 1.47, and 1.14, averaging 1.53 mg/kg

The data collected in the flooded area of Section 33 are insufficient to show trends and are not presented further in this summary, although they are presented in the report. On a mass basis, the percentages of uranium applied to the irrigated fields -excluding the Section 33 Flood area- that remain in the upper three feet ranges from 47 to 95 percent.

The percentage of selenium applied to the fields -excluding the Section 33 Flood area- that remains in the upper three feet of the soil varies from 54 to 90 percent.

Uranium application to the fields is discussed by the section below.

Uranium concentrations in the treated soils of Section 28 were essentially constant and similar to background concentrations from 2003 through 2005. The most recent (2008) concentrations exceeded mean background by factors of 2.09 (0-1 ft), 1.94 (1-2 ft), and 1.94 (2-3 ft). The Section 28 soil concentrations have been steady for the last three years.

Uranium concentrations in the treated soils of Section 33 started to exceed background concentrations in 2003. The most recent (2008) concentrations exceeded the mean background by factors of 1.83 (0-1 ft), 1.99 (1-2 ft) and 1.76 (2-3 ft). Uranium accumulated in the upper two feet of soil at an approximate constant rate until 2004, when concentrations appear to have achieved a steady state. In 2004, a steady state was apparent in the lower interval, but the 2007 and 2008 values are at a higher steady state.

Uranium is accumulating in the upper two feet of the treated areas of Section 34. No trend is apparent in the lower layer. The data are summarized as follows:

- The 2008 results exceed background by factors of 2.23 (0-1 ft at 4.38 mg/kg), 1.84 (1-2 ft at 2.70 mg/kg), and 1.50 (2-3 ft at 1.71 mg/kg).
- The concentration in the upper interval appears to have been increasing at a relatively constant rate since 2000, with a decline indicated in 2008.
- The concentration in the middle interval appeared to have been in a steady state since 2000 until an increase was observed in 2007.
- The concentration in the lower interval appears not to have stabilized. The most recent measurements are 1.75 (2007) and 1.71 (2008) mg/kg, which indicate a small amount of the uranium has migrated to the third interval.

The percentage of the mass of uranium and selenium applied to the fields that exists in the hay is less than one percent.

Nearly all of the uranium is being retained in the upper layers of the Section 34 flood treated soil while roughly one-half of the uranium has been retained in the upper three feet of soil in the Section 28 and Section 33 center pivots. In terms of risk to human health, uranium levels are currently acceptable. The dose to man by way of the ingestion of beef is negligible, as indicated by food web uptake calculations.

Selenium uptakes in hay are below the recommended upper limit for animal feed.
Selenium retention in soils had appeared to be independent of time and application, but the 2007 and 2008 data indicate retained percentages similar to the uranium percentages. Selenium

retention in the upper three feet of soil has not been similar to chloride, which is a conservative constituent in terms of fate and transport, for the last two years.

The monitoring of concentrations of uranium and selenium will continue as part of the ongoing irrigation program.

1.0 Introduction

This report characterizes changes in uranium and selenium concentrations in hay fields supplied with irrigation water from impacted groundwater sources near the Homestake Grants Reclamation Project. The irrigation project is being conducted by Homestake Mining Corporation (HMC).

Four hay fields have been irrigated with water containing elevated concentrations of uranium and selenium. Groundwater from wells adjacent to the Grants Reclamation Project was applied to hay fields situated in portions of Section 33 Pivot (150 acres) and Section 34 Flood (120 acres) during the 2000 through 2008 growing seasons and to a field in Section 28 (60 acres) during the 2002, 2003 and 2004 growing seasons. The field in Section 28 was expanded to 100 acres prior to the 2005 season and irrigated from 2005 to 2008. Fields in Sections 33 and 28 were irrigated using a center pivot irrigation system, whereas the field in Section 34 was irrigated by flooding. An additional 24 acres were flood irrigated in Section 33 in 2004, 2005 and 2008 but not in 2006 and 2007. All sections discussed in this report are located in Township 12 North, Range 10 West.

Uranium and selenium concentrations were measured in the applied irrigation water, affected soils and hay to determine constituent source terms and transfer to soils and hay. The measured results for the first growing season (2000) were compared to predictions made in 1999, which were based on published media transfer factors and other assumptions (ERG and HYDRO, 1999). The results from the first year of operation were reported previously (ERG and HYDRO, 2001). The report was updated for the 2001-2003 growing seasons in ERG and HYDRO, 2004 and updated again to include the 2004 through 2007 growing seasons (see ERG and HYDRO, 2005, 2006, 2007 and 2008).

The remainder of this report is organized as follows. Section 2 presents concentration data for several constituents in the irrigation water. Section 3 presents data on these same constituents in soil for background and irrigated areas. Section 4 addresses the constituent uptake in alfalfa hay. In Section 5, quantities of uranium and selenium ingested by beef-cattle and the resulting radiation dose to humans consuming this beef are calculated. The report ends with conclusions and references.

2.0 Source Constituents in Irrigation Water

The project plan (ERG and HYDRO, 1999) established an upper limit for the uranium concentration in irrigation water at the NRC effluent standard of 0.44 milligrams per liter (mg/l). The maximum allowable concentration of selenium in the irrigation supply was set at a State of New Mexico Water Quality Control Commission standard of 0.12 mg/l. With four exceptions, measured uranium and selenium concentrations have been below these limits since inception of the irrigation program through 2008. The exceptions occurred with two early 2005 uranium concentrations in Section 28, one early 2008 uranium concentration and one late 2001 selenium concentration in Section 33/34. In early 2005, adjustments were made by incorporating groundwater from new irrigation supply wells. The average 2008 uranium and selenium

concentrations for Section 33/34 water were 0.24 mg/l and 0.05 mg/l, respectively. The average concentrations for Section 28 were 0.36 mg/l and 0.07 mg/l.

2.1 Sections 33 and 34 Irrigation

A common pipe connecting 13 wells supplied the irrigation water for Sections 33 and 34 from 2000 through 2002. Three wells were added and one dropped in 2003, while five wells were added in 2004. Four wells were added and three dropped in 2005. Eight additional wells added in 2006 bringing the total active wells to 29. One additional well was added in 2007 and the use of a previous supply well was discontinued. In 2008 two wells were added and one well was dropped. The pipeline supplied water to one of the two major fields at a time. In the 2004 and 2005 growing seasons, irrigation of the 24 flooded acres in Section 33 occurred only in conjunction with the irrigation of the Section 34 field and at a limited rate to maintain concentrations below the limits described in Section 2.0. The Section 34 field was irrigated in 2008, with all of the water being supplied to this field during its irrigation. Figures 2 through 10 show the Sections 33 and 34 irrigation supply well locations and supply lines for years 2000 to 2008.

Water samples collected at the end of the pipeline at the flood outlet or center pivot are composite samples from the group of supply wells. Table 1 presents the concentrations of uranium, selenium, total dissolved solids (TDS), sulfate, molybdenum and chloride observed in the 2000-2008 irrigation water. Yearly averages are also presented in the table.

Average uranium and selenium concentrations were approximately 0.26 and 0.08 mg/l, respectively, over the nine growing seasons. The May 14, 2003 and the May 7, 2008 results for uranium (0.03 and 0.05 mg/l) are not included in the uranium average, because they are one order of magnitude lower than all other observations. Thus, they are assumed to be laboratory artifacts.

With one exception, the average concentrations of TDS and molybdenum were essentially constant from 2000 to 2008. The 2008 average concentrations were similar to previous averages. With the exception of the June 2006 measurement, TDS concentrations have ranged from 1390 to 1630 mg/l. Molybdenum concentrations were less than the 0.03 or 0.05 mg/l Method Detection Limits (MDLs), with the exception of four samples. Concentrations in these four samples (0.06, 0.05, 0.07 and 0.41 mg/l) exceeded MDLs. The result of 0.41 mg/l is one order of magnitude higher than all other molybdenum results and attributed to laboratory error. The sulfate concentrations ranged from 561 to 1020 mg/l. Chloride levels have been increasing slowly, and in 2008 were approximately 22 percent greater than initial measurements. Chloride concentrations have ranged from 94 to 247 mg/l in the nine years of monitoring.

Table 1. 2000 through 2008 Sections 33/34 Irrigation Supply Concentrations

Year	Date	Parameter (mg/l) Uranium	Selenium	TDS	Sulfate	Chloride	Molybdenum
2000	8/6/2000	0.26	0.12	1530	650	105	<0.03
	8/15/2000	0.26	0.12	1550	660	106	<0.03
	8/18/2000	0.28	0.12	1570	623	115	<0.03
	8/19/2000	0.27	0.12	1550	612	109	<0.03
	8/24/2000	0.27	0.11	1530	608	106	<0.03
	8/27/2000	0.26	0.11	1530	601	103	<0.03
	8/29/2000	0.3	0.11	1580	624	109	<0.03
	9/2/2000	0.28	0.11	1550	615	104	<0.03
	Average	0.27	0.12	1549	624	107	<0.03
2001	4/20/2001	0.28	0.11	1620	693	120	<0.03
	4/27/2001	0.27	0.12	1590	688	120	<0.03
	5/6/2001	0.3	0.11	1630	597	108	0.06
	5/10/2001	0.25	0.09	1590	580	103	<0.03
	5/19/2001	0.28	0.1	1590	660	118	<0.03
	5/24/2001	0.24	0.11	1500	664	116	<0.03
	6/3/2001	0.27	0.1	1610	665	118	<0.03
	6/10/2001	0.27	0.1	1570	659	113	<0.03
	6/28/2001	0.27	0.11	1530	661	104	<0.03
	7/5/2001	0.22	0.1	1480	655	94	<0.03
	7/24/2001	0.21	0.09	1460	650	120	<0.03
	8/29/2001	0.28	0.1	1600	693	114	0.41
	9/1/2001	0.27	0.1	1610	573	128	<0.03
	9/1/2001	0.21	0.1	1570	561	121	<0.03
	9/17/2001	0.29	0.13	1600	634	100	<0.03
	Average	0.26	0.1	1570	642	113	0.04
2002	4/15/2002	0.21	0.09	1510	708	125	<0.03
	4/16/2002	0.25	0.1	1580	704	129	<0.03
	5/8/2002	0.25	0.11	1600	678	----	----
	5/8/2002	0.26	0.1	1580	737	----	----
	5/14/2002	0.25	0.09	1560	741	120	<0.03
	7/3/2002	0.23	0.1	1560	694	135	0.05
	7/31/2002	0.23	0.1	1580	678	123	<0.05
	10/2/2002	0.21	0.1	1570	703	----	----
	Average	0.23	0.1	1564	705	126	<0.03
2003	5/14/2003	*0.03	0.05	1390	663	98.5	<0.03
	9/18/2003	0.22	0.08	1600	732	----	----
	Average	0.22	0.08	1600	732	----	----

Table 1. 2000 through 2008 Sections 33/34 Irrigation Supply Concentrations (concluded)

Year	Date	Parameter (mg/l) Uranium	Selenium	TDS	Sulfate	Chloride	Molybdenum
2004	5/4/2004	0.28	0.11	1550	703	130	<0.03
	5/27/2004	0.25	0.08	1570	690	130	<0.03
	8/18/2004	0.27	0.08	1530	693	----	----
	10/6/2004	0.23	0.08	1560	629	133	<0.03
	Average	0.26	0.09	1553	679	131	<0.03
2005	4/19/2005	0.25	0.06	1520	1020	247	<0.03
	4/20/2005	0.25	0.06	1510	996	235	<0.03
	5/25/2005	0.23	0.06	1580	603	131	<0.03
	6/1/2005	0.24	0.06	1520	661	129	<0.03
	8/8/2005	0.27	0.06	1500	621	----	----
	9/26/2005	0.3	0.07	1550	659	124	<0.03
	10/11/2005	0.29	0.07	1580	612	125	<0.03
	10/24/2005	0.35	0.08	1610	683	144	<0.03
	Average	0.27	0.06	1546	732	162	<0.03
2006	4/10/2006	0.24	0.05	1520	654	134	<0.03
	6/26/2006	0.37	0.1	2000	875	192	0.07
	8/14/2006	0.27	0.07	1580	696	----	----
	10/10/2006	0.29	0.07	1500	639	128	<0.03
	Average	0.29	0.07	1650	716	151	0.04
2007	4/12/2007	0.28	0.06	1630	668	136	<0.03
	4/30/2007	0.27	0.06	1580	670	132	<0.03
	6/4/2007	0.23	0.06	1540	654	125	<0.03
	8/21/2007	0.3	0.05	1600	678	----	----
	10/22/2007	0.31	0.06	1570	661	143	<0.03
	Average	0.28	0.06	1584	666	134	<0.03
2008	4/7/2008	*0.0521	0.073	1430	687	160	<0.03
	4/21/2008	0.262	0.042	1560	728	99	<0.03
	6/2/2008	0.254	0.048	1550	683	142	<0.03
	9/24/2008	0.213	0.049	1660	710	148	<0.03
	Average	0.24	0.05	1550	702	137	<0.03

Notes:
* Indicates datum not used.

2.2 Section 28 Irrigation

Section 28 was irrigated from 2002 through 2008. Figures 11 and 12 show the locations of the four wells installed to supply water to the center pivot system in the first two years. Figures 13, 14 and 15 show that well 886 was added in 2004 and wells M9, MO, MQ, MR, and MS were added in 2005 and 2006. Alluvial well M16 was added in 2007 and wells M9 and MQ were not used in 2007 and 2008 (see Figures 16 and 17). Table 2 presents TDS, sulfate, chloride, molybdenum, uranium, and selenium concentrations obtained in the Section 28 irrigation water. One sample of irrigation water was collected during the first two irrigation seasons. Four and eight samples were collected in 2004 and 2005, respectively. Five samples were collected in both 2006 and 2007 and three samples were collected in 2008. Chloride and molybdenum were omitted as analytes in 2002 and from one sample in 2004, 2006 and 2007.

The concentrations of TDS and sulfate were essentially constant from 2002 through 2008. The TDS concentration was 2,070 mg/l in 2002 and 2003 and averaged 2115, 2109, 1986, 2122 and 1917 mg/l in 2004, 2005, 2006, 2007 and 2008, respectively. The annual average sulfate concentrations ranged from 881 to 936 mg/l. The annual average concentrations of chloride and molybdenum ranged from 133 to 185 mg/l and less than 0.03 to 0.04 mg/l, respectively.

Uranium concentrations have increased gradually in Section 28 irrigation water: 0.23 mg/l in 2002, 0.24 mg/l in 2003, 0.27 mg/l in 2004, and stabilized in 2005 through 2008 at 0.35 to 0.36 mg/l.

The seven-year average uranium concentration of 0.31 mg/l is assumed to be the average of the reported mean concentrations for the seven years, 2002 through 2008 (0.23, 0.24, 0.27, 0.35, 0.35, 0.36 and 0.36 mg/l).

Selenium concentrations were 0.08 mg/l in 2002 and less than 0.005 mg/l in 2003. The latter result is questionable because the concentration in each of the four supply wells was measured at 0.04 or 0.05 mg/l and no other water was introduced to the supply line (see HMC's 2003 Annual Report for individual well results). The average 2004 through 2008 selenium concentrations were similar to the 2002 value. Thus, the six-year average selenium concentration of 0.08 mg/l is assumed to be an average of the mean concentration reported from 2002 through 2008.

Table 2. 2002 through 2008 Section 28 Irrigation Supply Concentrations

Year	Sampling Date	Parameter					
		Uranium	Selenium	TDS	Sulfate	Chloride	Molybdenum
2002	10/2/2002	0.23	0.08	2070	881	----	----
2003	5/14/2003	0.24	<0.005	2070	936	184	<0.03
2004	5/4/2004	0.23	0.07	2120	933	190	<0.03
	5/27/2004	0.29	0.07	2110	950	170	<0.03
	8/18/2004	0.27	0.06	2140	956	----	----
	10/6/2004	0.27	0.06	2090	838	194	<0.03
	Average	0.27	0.07	2115	919	185	<0.03
2005	4/12/2005	0.48	0.11	2220	955	176	0.09
	5/6/2005	0.51	0.12	2230	1010	192	0.11
	5/20/2005	0.33	0.08	2120	916	194	<0.03
	5/27/2005	0.26	0.06	2050	907	176	<0.03
	6/3/2005	0.33	0.08	2040	926	182	<0.03
	6/10/2005	0.33	0.07	2000	943	186	<0.03
	6/17/2005	0.31	0.08	2100	899	167	<0.03
	10/11/2005	0.28	0.06	2110	863	170	<0.03
	Average	0.35	0.08	2109	927	180	0.04
2006	3/1/2006	0.35	0.08	2230	926	197	0.04
	4/10/2006	0.35	0.09	2150	985	185	0.05
	6/26/2006	0.3	0.07	1550	645	158	<0.03
	8/14/2006	0.36	0.09	1980	928	----	----
	10/2/2006	0.38	0.09	2020	925	161	0.07
	Average	0.35	0.08	1986	882	175	0.04
2007	4/1/2007	0.32	0.08	2130	904	173	<0.03
	4/30/2007	0.41	0.09	2240	980	164	0.04
	6/26/2007	0.32	0.08	2010	856	163	<0.03
	8/17/2007	0.38	0.08	2130	978	----	----
	10/10/2007	0.39	0.09	2100	885	184	0.04
	Average	0.36	0.08	2122	921	171	0.04
2008	4/1/2008	0.465	0.083	2050	1020	90	0.05
	6/2/2008	0.285	0.059	1750	893	152	<0.03
	9/24/2008	0.318	0.056	1950	867	157	<0.03
	Average	0.36	0.07	1917	927	133	0.04

2.3 Irrigation Water Usage

Water usage was 715 (in 2000) and 695 (in 2001) acre-feet (ac-ft) on the 270 acres (Sections 33 and 34); 995 (in 2002) and 949 (in 2003) ac-ft on the 330 acres (Sections 33, 34 and 28); 1028 ac-ft in 2004 on the 354 acres; 1034 ac-ft in 2005 on the 394 acres; and 837 and 789 ac-ft in 2006 and 2007 respectively on 370 acres as the flood area in Section 33 was not irrigated. In 2008, 1054 ac-ft were used on 394 acres to irrigate all four areas.

3.0 Soil Concentrations

Samples have been collected from irrigated and non-irrigated soils and analyzed for uranium, selenium, and chloride to observe the effects of irrigation on their deposition over time. The incremental deposition of uranium and selenium constituents in soil was then used to calculate transfer coefficients from soil to hay. Chloride was tracked as a conservative constituent and used to verify observations of selenium deposition in soil.

Investigators labeled the first samples collected from irrigated areas as pre-operations samples. Samples collected from adjacent, fallow areas were labeled as background samples. Areas slated for irrigation that were sampled prior to irrigation (pre-operations) were essentially background areas until they were irrigated with impacted groundwater. Thus, to assist the reader, sampling areas are hereafter referred to as treated (irrigated areas) and untreated (non-irrigated areas) areas.

ACZ Laboratories, Inc. performed the analyses on the soil samples. When testing for chloride and sulfate, ACZ consistently returned qualifiers for those two constituents stating "analysis exceeded method hold time."

3.1 Background Soil Concentrations

Naturally-occurring uranium and selenium concentrations in untreated soils were determined in two studies. In 1998, HMC characterized uranium and selenium concentrations in soils, prior to selecting fields for the irrigation study. In 1999, HMC investigated chloride concentrations in Sections 33 and 34 prior to the start of irrigation. HMC has also collected and analyzed soil samples immediately prior to and during the irrigation program.

3.1.1 1998 Investigation

The first investigation (RIMCON and Hydro-Engineering, 1998) was completed prior to the selection of treatment areas. Surface and near-surface soil samples were collected inside and outside the fields slated for irrigation. The samples were analyzed for uranium and selenium concentrations and parameters to define soil types.

At the time of sampling, surface soils in Sections 28, 33, and 34 were placed in three general categories: loamy sand, sandy loam, and sandy clay loam, respectively. The percentage of clay in these soils appeared to increase from Section 28 to 33 to 34, in ascending order (RIMCON and Hydro-Engineering, 1998).

The 1998 results are listed in Tables 3, 4 and 5 for Section 33, 34 and 28, respectively, along with recent "untreated area" background analyses. A "1998" in the comment column in the tables indicate the sample was taken during the 1998 background investigation.

Figure 1 shows the location of the soil samples collected in Sections 33, 34, and Section 28. Seven soil samples collected from Section 33 were analyzed for uranium and selenium. The two eastern Section 33 soil results are included with the Section 34 results in Table 4 because the soil in eastern Section 33 is similar to the clay soils in Section 34. This figure also shows nine samples in Section 34 and one in the northern portion of Section 3 that are considered to be representative of the area for Section 34. Figure 1 also shows the location of seven samples in Section 28 and one along the western edge of Section 27 that were used to define the background concentrations in Section 28 in the 1998 investigation.

3.1.2 Background Determinations during Ongoing Investigation

Additional background samples were collected in treated (pre-operational) and untreated areas, starting in 1999. HMC continued to collect samples from the treated (post-treatment) and untreated areas in subsequent years.

The background soil samples were analyzed by ACZ Laboratories, Inc. Uranium concentrations were determined using U.S. Environmental Protection Agency (EPA) Method 6020 ICP-MS, with an MDL of 0.03 mg/kg for all samples collected in 2000, 2002, 2003 and 2004; 0.01 mg/kg in 2001; 0.06 mg/kg in 2005; and 0.05 mg/kg in 1999, 2006, 2007 and 2008.

Selenium concentrations in samples collected from 1999-2001 were determined using EPA Method 7742 Modified AA-Hydride, with an MDL of 0.1 mg/kg. The 2002 selenium analyses were determined using three methods. The samples were first analyzed using EPA Method 6020 ICP-MS, with an MDL of 0.8 mg/kg. The samples were then re-analyzed twice: first by way of EPA Method 7742 modified AA-Hydride, followed by EPA Method 6020 ICP-MS. The latter analysis was performed because selenium concentrations reported by way of EPA Method 7742 were below the relatively high MDL of 0.6 mg/kg. A lower MDL (0.05 mg/kg) was then obtained in subsequent years, using EPA Method 6020. The EPA M6020 ICP-MS method was used for 2003, 2004, 2005, 2006, 2007 and 2008. All selenium concentrations reported in 2002 were below the MDL of 0.60 mg/kg, limiting the usefulness of the data. The 2002 results were not considered in evaluating trends in selenium concentrations, because selenium concentrations prior to and after 2002 exceeded the lowest MDL observed in 2002 by a factor of two.

3.1.3 Mean Background Soil Concentrations

Mean background is defined as the average of the untreated, pre-irrigation-treated and background concentrations of constituents in all such samples collected to date (see Tables 3 through 5 for updated mean background values). This value is designated by section and layer(s) and is updated with new data as they are obtained. Thus, it changes annually. The importance in having this value defined in this manner is to supplement and improve the background data set, as warranted. These mean background values are used to calculate uptake of a constituent in the treated areas. Figures 18, 19 and 20 show the data used to calculate the mean uranium

background concentrations for Section 33, 34 and 28 respectively. Figures 21, 22 and 23 depict the mean background plots for selenium.

As of 2008, mean background uranium concentrations for the three Section 33 intervals are 0.77 (0-1 ft), 0.69 (1-2 ft), and 0.72 mg/kg (2-3 ft). The corresponding mean background concentrations for selenium and chloride are 0.14, 0.15, and 0.13 mg/kg; and 24, 37, and 30 mg/kg, respectively. Table 3 lists uranium, selenium, and chloride concentrations in the 1998 and 1999 background samples and those collected near the Section 33 irrigation area from 2000 through 2008. This table is broken into three depth intervals: 0-1, 1-2, and 2-3 ft. Results from a sample are listed in the depth interval if at least 6 inches (in) of the sample is from the interval.

In Section 34, the mean background uranium concentrations were 1.96 (0-1 ft), 1.47 (1-2 ft), and 1.14 (2-3 ft) mg/kg. Table 4 presents the constituents in Section 34 background soils. As in Section 33, the Section 34 soils generally show a decrease in mean uranium concentrations with increasing depth, but the difference between concentrations for each depth interval is greater in Section 34. A few results appeared to be outliers and were not used to calculate concentrations. Note that the six eastern samples from Section 33 are included in the Section 34 table because the soils from these two samples are primarily clays. The Sections 33 and 34 clay soils are combined in Table 4 to define the background concentrations for the two flood irrigated areas.

In Section 28, the mean background uranium concentrations were 0.56 (0-1 ft), 0.52 (1-2 ft), and 0.52 (2-3 ft) mg/kg. Table 5 presents the results for Section 28.

The mean background concentrations of selenium are similar in Sections 28 and 33. Selenium concentrations in Section 34 are generally higher, presumably because of their association with clay soils.

Measurements for uranium, selenium, and chloride showed a high degree of variability between and within fields, with coefficients of variation (100 x standard deviation/mean) ranging between 22 and 80 percent.

Table 3. Pre-Operations and Background Soil Sample Results for Section 33

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
0-1	S33-4	Treated	0-6	0.37	0.55	0.03	----	*1998
	S33-4	Treated	6-48	0.36	0.53	0.03	----	*1998
	S33-7	Treated	0-24	0.30	0.44	0.03	----	*1998
	S33-8	Treated	0-20	0.58	0.86	0.07	----	1998
	S33-9	Untreated	0-24	0.56	0.83	0.15	----	1998
	S33-10	Untreated	0-12	0.70	1.03	0.05	----	1998
	33A	Treated	0-6	0.24	0.36	0.10	13	1999
	33B	Treated	0-6	0.56	0.82	0.20	7	1999
	33C	Treated	0-6	0.44	0.65	0.05	35	**1999
	33D	Untreated	0-6	0.49	0.73	0.20	22	1999
	33D1	Untreated	0-6	0.77	1.14	0.20	18	2000
	BG-1	Untreated	0-12	0.66	0.98	0.10	32	2001
	BG-1	Untreated	0-12	0.58	0.85	----	2	&#2002
	BG-1	Untreated	0-12	0.53	0.78	0.12	21	2003
	BG-1	Untreated	0-12	0.60	0.88	0.27	28	2004
	BG-1	Untreated	0-12	0.53	0.78	0.18	27	2005
	BG-1	Untreated	0-12	0.60	0.88	0.18	18	2006
	BG-1	Untreated	0-12	0.60	0.89	0.39	68	2007
	BG-1	Untreated	0-12	0.49	0.72	0.21	@170	2008
			Mean	0.52	0.77	0.14	24	
			SDV	0.13	0.20	0.10	17	
			CV	25.66	25.65	69.20	69	

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
1-2	S33-4	Treated	6-48	0.36	0.53	0.03	----	*1998
	S33-7	Treated	0-24	0.30	0.44	0.03	----	*1998
	S33-8	Treated	0-20	0.58	0.86	0.07	----	1998
	S33-9	Untreated	0-24	0.56	0.83	0.15	----	1998
	S33-10	Untreated	12-30	0.38	0.56	0.03	----	*1998
	BG-2	Untreated	12-24	0.51	0.76	0.20	29	2001
	BG-2	Untreated	12-24	0.40	0.59		8	#2002
	BG-2	Untreated	12-24	0.35	0.52	0.12	25	2003
	BG-2	Untreated	12-24	0.53	0.79	0.24	32	2004
	BG-2	Untreated	12-24	0.47	0.69	0.15	71	2005
	BG-2	Untreated	12-24	0.60	0.88	0.16	21	2006
	BG-2	Untreated	12-24	0.60	0.89	0.44	73	2007
	BG-2	Untreated	12-24	0.41	0.61	0.23	@160	2008
			Mean	0.47	0.69	0.15	37	
			SDV	0.10	0.15	0.12	25	
			CV	22.42	22.42	77.70	68	

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
2-3	S33-4	Treated	6-48	0.36	0.53	0.03	----	*1998
	S33-7	Treated	24-48	0.24	0.35	0.03	----	*1998
	S33-8	Treated	20-48	0.35	0.52	0.03	----	*1998
	S33-9	Untreated	24-48	0.70	1.03	0.10	----	1998
	S33-10	Untreated	12-30	0.38	0.56	0.03	----	*1998
	S33-10	Untreated	30-60	0.40	0.59	0.03	----	*1998
	BG-3	Untreated	24-36	0.56	0.83	0.30	41	2001
	BG-3	Untreated	24-36	0.45	0.66		8	#2002
	BG-3	Untreated	24-36	0.45	0.67	0.12	22	2003
	BG-3	Untreated	24-36	0.55	0.81	0.26	31	2004
	BG-3	Untreated	24-36	0.53	0.79	0.15	@222	2005
	BG-3	Untreated	24-36	0.74	1.09	0.15	16	2006
	BG-3	Untreated	24-36	0.58	0.86	0.27	63	2007
	BG-3	Untreated	24-36	0.49	0.72	0.20	@180	2008
			Mean	0.48	0.72	0.13	30	
			SDV	0.14	0.20	0.10	20	
			CV	28.46	28.48	79.91	66	

@ = considered an outlier, did not use
* = 1998 Se Reported as less than LLD of 0.05 mg/kg, used 0.025
** = 1999 Se MDL= 0.1 Reported as less than MDL, used 0.05 mg/kg
# = 2002 Se MDL= 0.8 All data reported as < MDL, did not use
CV = coefficient of variation
SDV = standard deviation

Table 4. Pre-Operations and Background Soil Sample Results for Section 34

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
0-1	S33-1	Untreated	0-6	0.96	1.42	0.13	----	1998
	S33-1	Untreated	6-24	1.23	1.82	0.19	----	1998
	S33-2	Untreated	0-6	1.12	1.65	0.18	----	1998
	S33-2	Untreated	6-24	1.02	1.51	0.19	----	1998
	S3-1	Untreated	0-14	0.70	1.03	0.11	----	1998
	S34-1	Untreated	3-24	@5.85	@8.77	0.10	----	1998
	S34-3	Treated	4-26	1.03	1.52	0.11	----	1998
	S34-5	Untreated	3-40	0.84	1.24	0.14	----	1998
	S34-7	Untreated	3-28	0.78	1.15	0.06	----	1998
	S34-8	Untreated	2-30	1.26	1.86	0.31	----	1998
	S34-10	Untreated	3-28	1.01	1.49	0.13	----	1998
	S34-11	Untreated	3-15	1.36	2.01	0.03	----	*1998
	S34-13	Untreated	4-18	@3.93	@5.81	0.11	----	1998
	S34-14	Treated	4-24	0.79	1.17	0.19	----	1998
	34A	Treated	0-6	1.84	2.72	0.40	36	1999
	34B	Treated	0-6	1.60	2.36	0.40	54	1999
	34C	Treated	0-6	1.18	1.75	0.30	79	1999
	34D	Treated	0-6	2.44	3.60	0.60	36	1999
	34E	Treated	0-6	1.56	2.31	0.40	25	1999
	34F	Treated	0-6	2.05	3.03	0.80	68	1999
	34G	Treated	0-6	1.25	1.85	0.30	13	1999
	34H	Treated	0-6	2.29	3.38	0.70	43	1999
	341	Treated	0-6	0.67	0.99	0.10	42	1999
	BG-1-34	Untreated	0-12	1.67	2.47	0.30	100	2001
	BG-1-34	Untreated	0-12	0.30	0.45		7	#2002
	BG-1-34	Untreated	0-12	1.58	2.33	0.42	83	2003
	BG-1-34	Untreated	0-12	1.89	2.79	0.75	151	2004
	BG-1-34	Untreated	0-12	1.63	2.41	0.53	@400	2005
	BG-1-33F	Untreated	0-12	1.06	1.56	0.47	30	2004
	BG-1-33F	Untreated	0-12	0.76	1.12	0.25	76	2005
	BG-1-33F	Untreated	0-12	1.05	1.55	0.56	24	2006
	BG-1-34	Untreated	0-12	2.07	3.06	0.69	@253	2006
	BG-1-33F	Untreated	0-12	1.21	1.79	0.38	64	2007
	BG-1-34	Untreated	0-12	2.23	3.30	0.74	@267	2007
	BG-1-33F	Untreated	0-12	0.97	1.44	0.32	@220	2008
	BG-1-34	Untreated	0-12	1.71	2.52	0.57	@289	2008
			Mean	1.33	1.96	0.34	55	
			SDV	0.52	0.77	0.22	36	
			CV	39.31	39.34	65.71	66	

Table 4. Pre-Operations and Background Soil Sample Results for Section 34 (concluded)

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium (pCi/g)	Natural Uranium mg/kg	Selenium (mg/kg)	Chloride (mg/kg)	Comment
1-2	S33-1	Untreated	6-24	1.23	1.82	0.19	----	1998
	S33-2	Untreated	6-24	1.02	1.51	0.19	----	1998
	S3-1	Untreated	14-38	0.71	1.05	0.09	----	1998
	S34-1	Untreated	3-24	@5.85	@8.77	0.10	----	1998
	S34-3	Treated	4-26	1.03	1.52	0.11	----	1998
	S34-5	Untreated	3-40	0.84	1.24	0.14	----	1998
	S34-7	Untreated	3-28	0.78	1.15	0.06	----	1998
	S34-8	Untreated	2-30	1.26	1.86	0.31	----	1998
	S34-10	Untreated	3-28	1.01	1.49	0.13	----	1998
	S34-11	Untreated	15-60	0.58	0.86	0.03	----	*1998
	S34-13	Untreated	4-18	@3.93	@5.81	0.11	----	1998
	S34-13	Untreated	18-30	0.68	1.00	0.14	----	1998
	S34-14	Treated	4-24	0.79	1.17	0.19	----	1998
	BG-2	Untreated	12-24	1.30	1.92	0.20	120	2001
	BG-2	Untreated	12-24	0.36	0.53		4	#2002
	BG-2	Untreated	12-24	0.99	1.46	0.35	131	2003
	BG-2-34	Untreated	12-24	1.38	2.04	0.68	----	2004
	BG-2-34	Untreated	12-24	1.65	2.44	0.69	----	2005
	BG-2-33F	Untreated	12-24	0.88	1.30	0.39	35	2004
	BG-2-33F	Untreated	12-24	0.62	0.92	0.20	103	2005
	BG-2-33F	Untreated	12-24	0.78	1.15	0.35	20	2006
	BG-2-34	Untreated	12-24	@2.66	@3.93	@0.87	@219	2006
	BG-2-33F	Untreated	12-24	0.87	1.29	0.31	57	2007
	BG-2-34	Untreated	12-24	1.87	2.67	0.78	@271	2007
	BG-2-33F	Untreated	12-24	0.80	1.18	0.31	90	2008
	BG-2-34	Untreated	12-24	1.48	2.19	0.48	@257	2008
			Mean	1.00	1.47	0.27	70	
			SDV	0.36	0.53	0.21	48	
			CV	36.61	36.03	75.69	68	

2-3	S33-1	Untreated	24-48	1.32	1.95	0.23	----	1998
	S33-2	Untreated	24-48	0.40	0.59	0.09	----	1998
	S3-1	Untreated	14-38	0.71	1.05	0.09	----	1998
	S34-1	Untreated	24-36	0.43	0.64	0.13	----	1998
	S34-5	Untreated	3-40	0.84	1.24	0.14	----	1998
	S34-7	Untreated	28-40	0.43	0.64	0.41	----	1998
	S34-8	Untreated	30-60	0.69	1.02	0.34	----	1998
	S34-11	Untreated	15-60	0.58	0.86	0.03	----	*1998
	S34-13	Untreated	18-30	0.68	1.00	0.14	----	1998
	S34-14	Treated	30-90	0.20	0.30	0.03	----	*1998
	BG-3	Untreated	24-36	0.53	0.79	0.20	120	2001
	BG-3	Untreated	24-36	0.27	0.40		4	#2002
	BG-3	Untreated	24-36	1.12	1.66	0.36	141	2003
	BG-3-34	Untreated	24-36	0.93	1.38	0.40	@169	2004
	BG-3-34	Untreated	24-36	1.44	2.13	0.51	@354	2005
	BG-3-33F	Untreated	24-36	0.90	1.33	0.42	30	2004
	BG-3-33F	Untreated	24-36	0.61	0.90	0.19	81	2005
	BG-3-33F	Untreated	24-36	0.71	1.05	0.34	14	2006
	BG-3-34	Untreated	24-36	1.55	2.29	0.54	@259	2006
	BG-3-33F	Untreated	24-36	0.84	1.24	0.35	43	2007
	BG-3-34	Untreated	24-36	1.11	1.64	0.53	@246	2007
	BG-3-33F	Untreated	24-36	0.66	0.97	0.25	@170	2008
	BG-3-34	Untreated	24-36	0.85	1.26	0.27	@210	2008
			Mean	0.77	1.14	0.27	62	
			SDV	0.35	0.52	0.16	53	
			CV	45.69	45.62	58.56	86	

@ = considered an outlier, did not use
* = 1998 Se Reported as less than LLD of 0.05 mg/kg, used 0.025
# = 2002 Se MDL= 0.8 All data reported as < MDL, did not use
CV = coefficient of variation
SDV = standard deviation

Table 5. Pre-Operations and Background Soil Sample Results for Section 28

Interval (ft)	Location ID	Area	Depth (in)	U-nat (pCi/g)	U-nat mg/kg	Selenium mg/kg	Chloride (mg/kg)	Comment
0-1	S28-2	Untreated	0-40	@1.06	@1.57	0.14	----	1998
	S28-3	Untreated	4-22	0.23	0.34	0.18	----	1998
	S28-9	Treated	0-40	0.33	0.49	0.06	----	1998
	NE27-1	Untreated	0-6	0.34	0.50	0.03	----	*1998
	NE28-2	Untreated	0-6	0.24	0.35	0.03	----	*1998
	NE28-4	Untreated	0-8	0.13	0.19	0.16	----	1998
	NE28-5	Untreated	0-12	0.50	0.74	0.10	----	1998
	NE28-7	Untreated	0-8	0.51	0.75	0.12	----	1998
	BG-1	Untreated	0-12	2.02	@2.99		14	#2002
	BG-1	Untreated	0-12	0.35	0.51	0.15	6	2003
	BG-1	Untreated	0-12	0.60	0.88	0.22	12	2004
	BG-1	Untreated	0-12	0.32	0.47	0.12	@283	2005
	BG-1	Untreated	0-12	0.42	0.62	0.10	19	2006
	BG-1	Untreated	0-12	0.53	0.78	0.23	32	2007
	BG-1	Untreated	0-12	0.40	0.59	0.15	@220	2008
			Mean	0.38	0.56	0.13	17	
			SDV	0.13	0.20	0.06	9.79	
			CV	35.63	35.65	49.57	59	
1-2	S28-2	Untreated	0-40	@1.06	@1.57	0.14	----	1998
	S28-3	Untreated	4-22	0.23	0.34	0.18	----	1998
	S28-9	Treated	0-40	0.33	0.49	0.06	----	1998
	NE28-4	Untreated	8-28	0.23	0.34	0.03	----	*1998
	NE28-7	Untreated	8-24	0.23	0.34	0.05	----	1998
	BG-2	Untreated	12-24	@1.10	@1.62		13	#2002
	BG-2	Untreated	12-24	0.41	0.61	0.10	6	2003
	BG-2	Untreated	12-24	0.52	0.77	0.22	14	2004
	BG-2	Untreated	12-24	0.32	0.47	0.07	----	2005
	BG-2	Untreated	12-24	0.35	0.51	0.03	14	2006
	BG-2	Untreated	12-24	0.62	0.91	0.24	26	2007
	BG-2	Untreated	12-24	0.31	0.46	0.15	@240	2008
			Mean	0.36	0.52	0.11	15	
			SDV	0.13	0.19	0.08	7.20	
			CV	36.05	36.66	68.30	49	
2-3	S28-2	Untreated	0-40	@1.06	@1.57	0.14	----	1998
	S28-9	Treated	0-40	0.33	0.49	0.06	----	1998
	NE27-1	Untreated	24-80	0.14	0.21	0.03	----	*1998
	NE28-4	Untreated	28-84	0.22	0.32	0.03	----	*1998
	NE28-5	Untreated	25-84	0.44	0.65	0.03	----	*1998
	NE28-7	Untreated	24-48	0.14	0.21	0.03	----	*1998
	BG-3	Untreated	24-36	@0.98	@1.45		13	#2002
	BG-3	Untreated	24-36	0.36	0.53	0.12	11	2003
	BG-3	Untreated	24-36	0.55	0.81	0.19	10	2004
	BG-3	Untreated	24-36	0.37	0.55	0.07	@290	2005
	BG-3	Untreated	24-36	0.39	0.58	0.06	16	2006
	BG-3	Untreated	24-36	0.54	0.80	0.25	30	2007
	BG-3	Untreated	24-36	0.36	0.53	0.15	@270	2008
			Mean	0.35	0.52	0.09	16	
			SDV	0.14	0.20	0.07	8.15	
			CV	39.64	39.57	78.80	51	

@ = considered an outlier, did not use

* = 1998 Se Reported as less than LLD of 0.05 mg/kg, used 0.025

= 2002 Se MDL= 0.8 All data reported as < MDL, did not use

CV = coefficient of variation

SDV = standard deviation

3.2 Constituents in Treated Soil

Uranium, selenium, molybdenum, calcium, magnesium, sodium, chloride, and sulfate levels were measured in soil samples from Sections 33 and 34 in 1999 (prior to irrigation) and after each of the 2000 through 2008 irrigation seasons. The pH, conductivity and sodium absorption ratio (SAR) were also measured or calculated for the samples.

Changes in soil chemistry between pre-irrigation samples and those collected after the first irrigation season in 2000 are described in ERG and HYDRO, 2001, 2004, 2005, 2006, 2007, 2008 and in this report.

Figures 2 through 10 show the sampling locations in Sections 33 and 34 for 2000 through 2008. Figures 11 through 17 present the soil sampling locations in Section 28 for 2002 through 2008. Figures 18 through 23 present uranium and selenium soil concentrations for each of the irrigation areas.

Composite samples were prepared from locations indicated within each irrigation area and associated background locations. In 2000, the suffixes -1, -2, or -3 on sample labels indicate samples collected from 0-6 (-1), 6-18 (-2), or 18-36-in (-3) depth intervals. The ranges of sampling depths were changed in 2001, to better assess the impacts of irrigation. In 2001 to 2008, suffixes -1, -2, and -3 indicate composites from 0-1 ft, 1-2 ft and 2-3 ft, respectively. Comparisons between data acquired in 2000 and data from subsequent years must be qualified by the change in sampling depths.

An example of compositing conducted in 2001 at Section 33 is as follows: the grab samples collected from 0-1 ft at soil sample locations EW2, EW4, EW6, WW2, WW4, WW6, NW2, NW4, NW6, SW2, SW4 and SW6 (see Figure 3 for sample locations) were composited into one sample labeled P-1. Grab samples from 1-2 ft at these locations were composited into one sample labeled P-2.

Table 6 presents the results for composite samples collected at each of the areas in 2000 through 2008. Appendix A gives the 1999 and 2000 individual sample results that were used to calculate the 2000 average values presented in Table 6. No samples were collected at Section 28 in 2001; irrigation in this area began in 2002. Composite samples collected at treated areas are labeled P (Section 33), F (Section 34) or N (Section 28). They are further subdivided by P-, F-, or N-1 (0-1 ft), P-, F-, or N-2, (1-2 ft) and P-, F-, or N-3 (2-3 ft). Thus, constituents in the composite samples represent an average condition in layers across the center pivot area, at 0-1 ft, 1-2 ft and 2-3 ft depth intervals.

Table 6. Irrigation Soil Analyses, 2000-2008

Sample Site	Date	U (mg/kg)	Se (mg/kg)	Mo (mg/kg)	pH (units)	Cond. (mmhos/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR (ratio)	Cl (mg/kg)	SO4 (mg/kg)
					SECTION 33 CENTER PIVOT							
P-1	12/7/2000	0.93	0.37	<1	7.9	0.987	4.00	1.27	5.67	3.40	26	98
	6/15/2001	0.94	0.30	<1	8.0	1.230	3.77	1.48	7.48	4.84	123	500
	11/20/2002	0.98	<0.6	<1	7.8	1.610	7.71	2.80	8.10	3.53	13	300
	11/18/2003	1.36	0.28	<1	7.8	2.200	7.99	3.25	13.50	5.69	55	590
	11/9/2004	1.78	0.45	<1	7.6	3.780	19.70	8.73	21.40	5.67	101	190
	11/5/2005	1.45	0.31	<1	8.1	2.060	9.35	4.02	11.20	4.33	51	460
	10/21/2006	1.87	0.36	<1	7.8	3.560	15.80	6.36	20.40	6.13	109	1020
	11/10/2007	1.67	0.44	<1	7.7	3.280	12.40	5.91	19.10	6.31	85	600
	11/22/2008	1.41	0.41	1	8.0	2.630	10.70	5.07	17.10	6.09	80	500
P-2	12/7/2000	0.81	0.45	<1	7.8	1.480	6.30	1.88	7.77	3.84	46	290
	6/15/2001	0.60	0.30	<1	7.9	1.120	4.32	1.45	6.11	3.60	109	500
	11/20/2002	0.89	<0.6	<1	7.8	2.190	10.10	3.78	13.10	4.97	14	600
	11/18/2003	1.14	0.19	<1	7.9	2.690	10.30	3.86	16.10	6.05	82	710
	11/9/2004	1.52	0.39	<1	7.6	4.300	19.40	10.80	27.50	7.07	155	200
	11/5/2005	1.15	0.21	2	8.1	3.940	15.10	7.68	27.30	8.09	94	420
	10/21/2006	1.62	0.15	<1	7.7	3.320	14.20	5.93	17.90	5.64	142	900
	11/10/2007	1.34	0.30	<1	7.7	5.300	19.60	11.00	37.00	9.46	187	900
	11/22/2008	1.37	0.35	1	8.0	3.600	13.40	6.30	25.80	8.22	114	1130
P-3	12/7/2000	1.03	0.25	<1	7.6	1.720	8.35	2.29	8.33	3.71	36	210
	6/15/2001	0.54	0.10	<1	7.8	1.020	4.74	2.18	4.27	2.30	67	400
	11/20/2002	0.68	<0.6	<1	7.7	2.400	11.70	5.34	11.60	3.97	34	1000
	11/18/2003	1.00	0.18	<1	7.8	2.970	15.50	5.67	17.30	5.32	106	570
	11/9/2004	1.15	0.38	<1	7.6	3.440	15.90	9.31	19.30	5.43	137	220
	11/5/2005	1.00	0.30	1	8.0	4.500	18.70	10.50	147.00	38.50	197	580
	10/21/2006	1.05	0.14	<1	7.8	3.500	13.90	6.17	19.70	6.22	126	780
	11/10/2007	1.30	0.39	<1	7.6	4.670	20.30	10.60	26.40	6.72	174	670
	11/22/2008	1.27	0.33	3	7.9	3.600	14.80	7.10	23.10	6.98	184	1220
BG-1	12/7/2000	1.14	0.20	<1	7.6	1.240	9.07	2.64	0.64	0.26	18	<50
	6/20/2001	0.98	0.10	1	7.9	0.231	1.51	0.48	0.43	0.43	32	<300
	11/20/2002	0.85	<0.6	<1	7.8	0.450	3.51	0.98	0.69	0.46	<4	<100
	11/18/2003	0.78	0.12	<1	7.8	0.700	4.13	1.15	0.60	0.36	21	160
	11/8/2004	0.88	0.27	<1	7.7	0.980	6.22	1.94	1.83	0.91	28	60
	11/5/2005	0.78	0.18	<1	8.1	0.835	5.20	1.54	1.60	0.87	27	570
	10/21/2006	0.88	0.18	<1	7.9	1.060	6.04	1.69	1.87	0.95	18	160
	11/10/2007	0.89	0.39	<1	7.7	1.510	7.57	2.80	2.03	0.89	68	280
	11/22/2008	0.72	0.21	1	8.0	0.883	6.13	2.12	1.81	0.89	170	820
BG-2	6/20/2001	0.76	0.20	<1	7.9	0.321	1.83	0.92	0.57	0.48	29	<300
	11/20/2002	0.59	<0.6	<1	7.7	1.250	7.58	3.04	3.56	1.54	8	<100
	11/18/2003	0.52	0.12	<1	7.7	0.670	4.27	1.28	0.70	0.42	25	90
	11/8/2004	0.79	0.24	<1	7.8	0.690	4.05	1.45	1.22	0.74	32	70
	11/5/2005	0.69	0.15	<1	8.1	0.745	4.24	1.45	1.41	0.83	71	2140
	10/21/2006	0.88	0.16	<1	8.0	0.757	3.63	1.60	1.47	0.90	21	120
	11/10/2007	0.89	0.44	<1	7.7	1.550	9.46	3.44	2.42	0.95	73	350
	11/22/2008	0.61	0.23	2	8.0	0.809	5.05	2.21	1.73	0.90	160	680
BG-3	6/20/2001	0.83	0.30	<1	7.9	0.385	2.41	1.12	0.48	0.36	41	300
	11/20/2002	0.66	<0.6	<1	7.9	0.580	3.39	1.32	1.79	1.17	8	300
	11/18/2003	0.67	0.12	<1	7.7	0.620	3.77	1.39	0.70	0.43	22	70
	11/8/2004	0.81	0.26	<1	7.8	0.720	4.13	1.54	1.50	0.89	31	80
	11/5/2005	0.79	0.15	2	8.3	0.607	3.39	1.26	1.23	0.80	222	6770
	10/21/2006	1.09	0.15	<1	8.0	1.080	5.54	2.55	2.20	1.09	16	200
	11/10/2007	0.86	0.27	<1	7.7	1.740	10.60	3.73	2.81	1.05	63	300
	11/22/2008	0.72	0.20	3	8.0	0.877	5.06	2.27	2.37	1.24	180	870

Table 6. Irrigation Soil Analyses, 2000-2008 (continued)

Sample Site	Date	U (mg/kg)	Se (mg/kg)	Mo (mg/kg)	pH (units)	Cond. (mmhos/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR (ratio)	Cl (mg/kg)	SO4 (mg/kg)
						SECTION 33 FLOOD						
F-1	11/5/2004	1.78	0.56	<1	7.6	2.810	19.10	7.21	11.30	3.11	114	190
	11/8/2005	1.35	0.31	1	7.8	2.690	16.80	6.23	10.20	3.01	66	1210
	10/28/2006	1.76	0.41	<1	7.8	1.480	8.25	2.91	4.79	2.03	72	1070
	11/10/2007	1.69	0.45	<1	7.8	2.000	9.35	3.6	8.85	3.48	98	450
	12/3/2008	1.70	0.43	2	8.0	1.780	7.42	2.68	11.2	4.98	89	910
F-2	11/5/2004	1.67	0.47	1	7.7	2.360	13.70	5.09	10.40	3.39	115	150
	11/8/2005	1.14	0.24	<1	7.8	2.260	13.30	4.68	9.22	3.08	57	620
	10/28/2006	1.24	0.26	<1	7.7	2.320	16.00	5.15	8.33	2.56	46	970
	11/10/2007	1.55	0.40	<1	7.8	3.070	16.90	6.58	13.00	3.79	63	390
	12/3/2008	1.53	0.39	<1	7.7	2.650	21.70	7.48	13.70	3.59	46	1670
F-3	11/5/2004	1.68	0.49	<1	7.7	2.400	18.40	6.52	11.60	3.28	115	150
	11/8/2005	1.00	0.20	<1	7.8	2.670	17.80	5.91	10.70	3.11	41	350
	10/28/2006	1.62	0.21	<1	7.7	1.840	10.90	3.38	5.93	2.22	52	970
	11/10/2007	1.51	0.40	<1	7.7	2.010	11.50	4.06	7.97	2.86	52	470
	12/3/2008	0.96	0.23	<1	7.7	2.890	19.90	6.91	12.00	3.28	50	860
BG-1	11/5/2004	1.56	0.47	1	7.8	0.770	3.49	1.40	2.51	1.60	30	110
	11/8/2005	1.12	0.25	<1	7.8	0.962	5.16	1.84	2.29	1.22	76	2720
	10/28/2006	1.55	0.56	<1	7.9	0.702	2.93	1.04	1.98	1.41	24	100
	11/10/2007	1.79	0.38	<1	7.8	0.800	4.30	1.55	1.96	1.15	64	140
	12/3/2008	1.44	0.32	<1	7.9	1.150	6.04	2.29	4.20	2.06	220	1200
BG-2	11/5/2004	1.30	0.39	<1	7.8	0.820	4.42	1.70	2.28	1.30	35	120
	11/8/2005	0.92	0.20	<1	7.8	0.829	4.13	1.52	2.41	1.43	103	1960
	10/28/2006	1.15	0.35	<1	7.8	0.470	1.94	0.71	1.37	1.19	20	210
	11/10/2007	1.29	0.31	<1	7.8	0.810	4.24	1.65	1.79	1.04	57	160
	12/3/2008	1.18	0.32	<1	7.8	0.840	4.92	1.90	2.58	1.40	90	660
BG-3	11/5/2004	1.33	0.42	<1	7.8	0.940	5.13	2.06	2.79	1.47	30	160
	11/8/2005	0.90	0.19	<1	7.8	1.110	5.74	2.20	3.55	1.78	81	3200
	10/28/2006	1.05	0.34	<1	7.9	0.677	2.88	1.05	1.84	1.31	14	190
	11/10/2007	1.24	0.35	<1	7.8	0.710	3.80	1.41	1.96	1.21	43	260
	12/3/2008	0.97	0.25	<1	7.8	0.840	4.66	1.85	3.09	1.71	170	900

Table 6. Irrigation Soil Analyses, 2000-2008 (continued)

Sample Site	Date	U (mg/kg)	Se (mg/kg)	Mo (mg/kg)	pH (units)	Cond. (mmhos/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR (ratio)	Cl (mg/kg)	SO4 (mg/kg)
						SECTION 34 FLOOD						
F-1	12/7/2000	3.35	0.68	<1	7.7	2.594	11.95	4.66	14.58	5.03	56	767
	8/8/2001	2.72	0.50	2	7.8	5.090	10.90	3.17	13.50	5.09	182	900
	11/22/2002	0.69	<0.6	<1	7.9	1.050	4.73	1.47	5.26	2.99	18	800
	11/26/2003	3.72	0.82	1	7.8	4.570	22.50	9.62	31.60	7.89	284	2620
	11/4/2004	4.43	1.15	2	7.7	5.220	20.50	8.98	40.40	10.52	398	680
	11/19/2005	3.94	1.10	2	8.0	5.420	20.80	8.64	37.60	9.80	416	5190
	10/28/2006	4.88	0.95	<1	7.9	3.500	12.20	5.72	22.90	7.65	445	5210
	11/10/2007	5.02	1.32	2	7.8	4.910	17.50	8.05	35.00	9.79	429	4400
	12/3/2008	4.38	1.14	1	7.7	4.430	19.40	9.10	33.40	8.85	392	7700
F-2	12/7/2000	2.22	0.37	<1	7.6	3.237	14.42	6.01	18.58	5.85	78	1497
	8/8/2001	1.88	0.40	2	7.6	4.970	8.20	2.25	8.57	3.75	139	1400
	11/22/2002	0.46	<0.6	<1	8.0	1.030	3.85	1.12	6.06	3.84	10	200
	11/26/2003	1.90	0.40	<1	7.8	5.020	25.20	8.01	33.60	8.25	396	2480
	11/4/2004	2.27	0.63	<1	7.6	5.370	23.80	7.90	40.50	10.17	390	370
	11/19/2005	1.41	0.38	1	7.9	4.890	20.50	5.55	32.60	9.03	352	3980
	10/28/2006	2.25	0.45	<1	7.6	3.610	12.90	4.34	23.30	7.94	478	4230
	11/10/2007	3.05	0.94	<1	7.7	5.770	21.20	8.24	40.60	10.60	560	4000
	12/3/2008	2.70	0.68	1	7.8	4.240	21.60	8.16	30.00	7.78	406	4900
F-3	12/7/2000	1.62	0.03	<1	7.6	3.397	13.63	5.02	22.21	6.75	56	980
	8/8/2001	1.15	0.30	<1	7.6	5.960	10.10	3.25	9.83	3.80	170	1800
	11/22/2002	0.42	<0.6	<1	8.0	0.930	3.63	1.53	4.90	3.05	3	<100
	11/26/2003	1.08	0.19	<1	7.8	4.420	23.90	6.53	25.80	6.61	302	1550
	11/4/2004	1.40	0.37	<1	7.6	4.800	25.30	7.39	34.90	8.63	166	210
	11/19/2005	2.62	0.68	2	8.0	4.550	17.40	5.78	32.90	9.66	560	5840
	10/28/2006	1.21	0.28	<1	7.5	3.860	18.50	5.18	23.20	6.74	302	2340
	11/10/2007	1.75	0.64	<1	7.6	5.280	24.20	6.25	32.70	8.38	337	1700
	12/3/2008	1.71	0.37	<1	7.8	4.410	23.00	8.99	32.50	8.13	227	1810
BG-1	8/8/2001	2.47	0.30	2	7.6	4.160	5.86	1.75	2.87	1.47	100	800
	11/22/2002	0.45	<0.6	<1	7.8	0.460	3.52	0.79	0.37	0.25	7	<100
	11/26/2003	2.33	0.42	<1	7.8	1.680	5.70	2.22	9.60	4.82	83	850
	11/3/2004	2.79	0.75	<1	7.8	2.320	8.67	2.05	13.30	5.74	151	490
	11/19/2005	2.41	0.53	2	7.7	3.230	12.80	3.50	15.40	5.39	400	1360
	10/28/2006	3.06	0.69	<1	7.8	2.200	9.53	2.22	10.60	4.37	253	810
	11/10/2007	3.30	0.74	2	7.7	3.650	19.10	4.81	19.60	5.67	267	800
	12/3/2008	2.52	0.57	1	7.8	2.740	13.70	3.37	15.00	5.13	289	810
BG-2	8/8/2001	1.92	0.20	2	7.5	4.730	7.94	2.60	4.53	1.97	120	300
	12/4/2002	0.53	<0.6	<1	7.8	0.410	3.03	1.06	0.32	0.22	4	<100
	11/26/2003	1.46	0.35	1	7.8	3.290	18.70	8.07	16.90	4.62	131	670
	11/3/2004	2.04	0.68	<1	7.7	4.040	19.70	4.51	26.10	7.50	220	280
	11/19/2005	2.44	0.39	2	7.9	4.460	20.80	4.99	23.90	6.66	349	1040
	10/28/2006	3.93	0.87	<1	7.7	2.400	12.30	2.59	10.90	3.99	219	810
	11/10/2007	2.67	0.78	2	7.7	4.280	21.00	5.02	25.80	7.15	271	1240
	12/3/2008	2.19	0.48	2	7.8	3.260	17.90	4.59	18.50	5.52	257	1040
BG-3	8/8/2001	0.79	0.20	<1	7.6	8.200	6.35	2.12	2.77	1.35	120	100
	11/22/2002	0.40	<0.6	<1	7.9	0.360	2.51	1.14	0.35	0.25	4	<100
	11/26/2003	1.66	0.36	<1	7.7	2.460	12.80	5.95	10.70	3.49	141	370
	11/3/2004	2.04	0.40	<1	7.5	4.200	25.90	5.95	24.50	6.14	169	230
	11/19/2005	2.13	0.51	2	7.9	4.160	20.50	5.74	19.00	5.25	354	1280
	10/28/2006	2.29	0.54	<1	7.8	3.000	15.00	3.17	15.40	5.11	259	1040
	11/10/2007	1.64	0.53	<1	7.6	4.420	19.80	5.26	27.60	7.80	246	950
	12/3/2008	1.26	0.27	<1	7.7	3.990	22.30	6.24	24.60	6.51	210	1480

Table 6. Irrigation Soil Analyses, 2000-2008 (concluded)

Sample Site	Date	U (mg/kg)	Se (mg/kg)	Mo (mg/kg)	pH (units)	Cond. (mmhos/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR (ratio)	Cl (mg/kg)	SO4 (mg/kg)
						SECTION 28 CENTER PIVOT						
N-1	11/19/2002	2.99	<0.6	2	7.7	4.27	20.80	9.40	26.90	6.92	48	3700
	11/24/2003	0.81	0.18	<1	7.8	1.95	8.47	3.94	10.00	4.01	24	400
	11/11/2004	0.89	0.37	<1	7.6	2.67	14.60	6.38	14.00	4.32	28	70
	11/15/2005	0.68	0.17	<1	7.9	2.65	13.90	6.55	11.40	3.57	42	430
	10/21/2006	1.11	0.16	2	7.6	2.37	12.70	6.20	9.35	3.04	57	280
	11/10/2007	1.14	0.47	<1	7.7	2.50	14.00	6.18	10.90	3.43	34	490
	11/22/2008	1.17	0.39	1	7.9	2.90	16.90	8.44	13.40	3.73	48	760
N-2	11/19/2002	1.47	<0.6	<1	7.7	4.51	20.60	7.60	29.00	7.72	68	3400
	11/24/2003	0.70	0.16	<1	7.9	2.42	9.47	3.73	15.70	6.11	49	450
	11/11/2004	0.80	0.23	<1	7.7	2.63	11.50	4.60	16.20	5.71	61	70
	11/15/2005	0.74	0.15	<1	7.9	4.09	15.70	7.75	26.60	7.77	87	330
	10/21/2006	1.14	0.09	2	7.7	2.56	12.50	6.43	12.90	4.16	18	610
	11/10/2007	1.01	0.34	<1	7.6	3.11	17.60	8.91	15.00	4.12	37	500
	11/22/2008	1.01	0.24	1	7.8	3.27	18.40	9.17	16.40	4.42	35	870
N-3	11/19/2002	0.74	<0.6	<1	7.6	4.51	22.90	7.57	26.40	6.76	39	1300
	11/24/2003	0.57	0.13	<1	7.8	2.55	13.20	5.28	13.40	4.41	74	380
	11/11/2004	0.70	0.23	<1	7.6	3.30	17.00	7.29	17.40	4.99	134	70
	11/15/2005	0.58	0.12	<1	7.9	4.29	14.90	7.44	6.00	1.80	118	420
	10/21/2006	1.06	0.08	2	7.8	3.58	15.20	8.21	26.00	7.60	37	670
	11/10/2007	0.92	0.25	<1	7.8	3.46	16.30	8.70	20.60	5.83	37	540
	11/22/2008	1.01	0.25	1	8.0	3.11	15.20	8.55	17.50	5.08	60	910
BG-1	11/19/2002	2.99	<0.6	2	8.0	0.82	3.33	0.91	4.20	2.88	14	700
	11/24/2003	0.51	0.15	<1	7.9	0.33	1.94	0.61	0.30	0.26	6	60
	11/11/2004	0.88	0.22	<1	7.4	1.16	6.93	1.99	3.91	1.85	12	20
	11/15/2005	0.47	0.12	<1	7.8	1.01	6.37	2.00	2.32	1.13	283	4380
	10/21/2006	0.62	0.10	2	7.7	0.46	2.41	0.71	0.57	0.45	19	80
	11/10/2007	0.78	0.23	<1	7.7	0.71	4.19	1.35	0.95	0.57	32	118
	11/22/2008	0.59	0.15	1	7.8	0.44	2.56	0.77	0.88	0.68	220	1390
BG-2	11/19/2002	1.62	<0.6	<1	7.7	2.00	14.90	3.27	6.88	2.28	13	500
	11/24/2003	0.61	0.10	<1	8.0	0.35	1.69	0.81	0.60	0.53	6	120
	11/11/2004	0.77	0.22	<1	7.4	0.66	4.22	1.42	1.01	0.60	14	<10
	11/15/2005	0.47	0.07	<1	8.0	0.73	3.71	1.58	1.50	0.92	405	5350
	10/21/2006	0.51	<.05	1	7.8	0.53	2.22	0.95	0.89	0.70	14	<50
	11/10/2007	0.91	0.24	<1	7.6	0.95	5.95	2.18	1.45	0.71	26	99
	11/22/2008	0.46	0.15	1	8.0	0.40	2.11	0.89	0.88	0.71	240	1300
BG-3	11/19/2002	1.45	<0.6	<1	7.8	1.51	9.24	1.95	6.29	2.66	13	500
	11/24/2003	0.53	0.12	<1	8.0	0.53	2.10	1.26	1.80	1.39	11	120
	11/11/2004	0.81	0.19	<1	7.5	0.80	4.74	2.03	1.60	0.86	10	10
	11/15/2005	0.55	0.07	<1	7.9	1.05	5.09	2.43	3.03	1.56	290	4340
	10/21/2006	0.58	0.06	1	7.9	0.44	1.33	0.68	1.25	1.25	16	70
	11/10/2007	0.80	0.25	<1	7.7	0.88	4.99	1.84	1.76	1.95	30	120
	11/22/2008	0.53	0.15	<1	8.1	0.493	1.96	0.95	1.95	1.62	270	1500

NOTE: 2000 Sample: 1 = 0 - 6 inches, 2 = 6 - 18 inches and 3 = 18 - 36 inches
2001 through 2008 Sample: 1 = 0 - 1 ft, 2 = 1 - 2 ft and 3 = 2 - 3 ft; BG samples are background.

Composite samples collected from untreated (background) areas are labeled BG-1, BG-2, or BG-3, representing the same three layers.

Table 7 lists concentrations of uranium and selenium in 1999 (background surface samples only), 2000 at 0-6, 6-18, and 18-36 in; and 2001 to 2008 at 0-1, 1-2 and 2-3 ft.

3.2.1 Section 33 Center Pivot

Twelve locations were sampled in the treated area of Section 33 in each of the eight latter years (2001 to 2008) and at the three depths described above. Fewer samples were collected in 2000. Corresponding depths were sampled at each of four background locations for the three analyzed

depths (BG-1, BG-2, and BG-3) in untreated areas of Section 33 for the 2002 and 2003 samples. Ten background samples were composited together for the Section 33 soils in 2004 to 2008.

As stated in Section 3.1.3, the term "mean background" is defined as the average of all of the untreated, composite concentrations of a constituent determined from initial testing results to the most current. As defined, the mean background uranium concentration for Section 33 for all three layers is 0.73 mg/kg.

Generalized findings for uranium are as follows:

- Uranium concentrations in composite samples collected from the treated area in 2001 were slightly below associated background samples. The treated area results were 0.94 (0-1 ft), 0.60 (1-2 ft) and 0.54 (2-3 ft). The untreated area results were 0.98 (0-1 ft), 0.76 (1-2 ft) and 0.83 mg/kg (2-3 ft).

- Uranium concentrations in the treated area started to exceed those in background samples in 2002. The most recent (2008) concentrations observed in the treated area were 1.41 (0-1 ft), 1.37 (1-2 ft) and 1.27 (2-3 ft); this compares to the corresponding mean background values of 0.77 (0-1 ft), 0.69 (1-2 ft) and 0.72 mg/kg (2-3 ft). The concentrations of uranium in the upper three feet of treated soil exceeded the mean background by factors of 1.83 (0-1 ft), 1.99 (1-2 ft) and 1.76 (2-3 ft). Uranium accumulated in the upper two feet of soil at an approximate constant rate until 2004, when concentrations achieved a steady state (see Figure 18).

Generalized findings for selenium are as follows:

- Selenium concentrations in composite samples collected from the treated area have generally exceeded those in associated background samples. In addition, selenium concentrations are similar at 1-2 ft and 2-3 ft in the treated areas.

- The most recent (2008) concentrations observed in the treated area are 0.41 (0-1 ft), 0.35 (1-2 ft), and 0.33 (2-3 ft) mg/kg; and in the mean background are 0.14 (0-1 ft), 0.15 (1-2 ft) and 0.13 (2-3 ft) mg/kg.

- Selenium concentrations in the top three feet of treated soil exceeded the mean background by factors of 2.93 (0-1 ft), 2.33 (1-2 ft) and 2.54 (2-3 ft). The 2008 selenium data from the treated area were similar to the higher treated values measured in the past while the untreated measurements were slightly above the mean background values (see Figure 21).

Generalized findings for other parameters are as follows:

- The data in Table 6 show general increases in conductivity, SAR, calcium, magnesium and sodium concentrations in both treated and untreated soils in Section 33 until they decreased in 2008. The concentrations of sulfate and chloride have varied over time in the treated and background areas (e.g., concentrations of chloride in treated areas have generally increased, while in background areas, they have varied at generally low levels). The SAR for the treated areas has a discernable rising trend but there have been dramatic swings over the period of record.

- Increasing amounts of salts and alkalinity (inferred from increases in calcium and magnesium) in the background areas cannot be explained using the current sampling program. The increase is not likely due to movement of contaminated groundwater from the irrigated fields because uranium concentrations in all intervals in the untreated area have been similar over the course of the irrigating. The rise in salt and alkalinity levels in background samples may be due to a reduction in local precipitation.

3.2.2 Sections 33 and 34 Flood Areas

Composite soil samples were collected from three soil layers in the Section 34 flood irrigation area after the 2000 (15 samples from 3 depths at up to 9 locations), 2001 (30 samples from 3 depths at 10 locations), 2002 (36 samples from 3 depths at 12 locations), 2003 (33 samples from 3 depths at 11 locations); 2004, 2005, 2006, 2007 and 2008 (each with 36 samples from 3 depths at 12 locations) irrigation seasons. Two background samples were combined for each of the 2001 and 2002 background soil analyses for Section 34, one background sample was collected in 2003 and ten background samples were combined in 2004, 2005, 2006, 2007 and 2008 (see Figures 2 through 10 for sample locations). Uranium and selenium concentrations observed in the Sections 33 and 34 flood irrigation areas are presented in Figures 19 and 22, respectively. A comparison with background was not made for Section 33 Flood, because there are insufficient data to analyze.

Generalized findings for uranium concentrations in Section 34 relative to the 2008 mean background are as follows:

- 2000: Average uranium concentrations in the treated areas are appreciably higher than those in the untreated areas when compared to those for subsequent years. However, this may reflect the difference in the sampling interval and calls this comparison into question.

- 2001: Uranium concentrations in the treated area at 0-1 ft (2.72 mg/kg) are a factor of 1.39 greater than the 2008 mean background (1.96 mg/kg). The value of treated soil at 1-2 ft (1.88 mg/kg) exceeds the mean background (1.47 mg/kg) by a factor of 1.28.

- 2002: Uranium concentrations in both treated and background areas were consistently lower than those observed in 2001, 2003, 2004, 2005, 2006, 2007 and 2008. This anomaly is likely due to a systemic analytical bias and not representative of actual concentrations.

- 2003: Uranium concentration in the treated area at 0-1 ft (3.72 mg/kg) exceeded the mean background (1.96 mg/kg) by a factor of 1.90. The uranium concentration at 1-2 ft (1.90 mg/kg) exceeded the mean background by a factor of 1.29. The 2-3 ft interval treated uranium value was essentially the same as the mean background.

- 2004: Uranium concentration in the treated area at 0-1 ft (4.43 mg/kg) exceeded the 2008 mean background (1.96 mg/kg) by a factor of 2.26. The 1-2 ft of treated soil (2.27 mg/kg) exceeded the mean background (1.47 mg/kg) by a factor of 1.54, whereas the bottom interval was similar to mean background.

- 2005: Uranium concentration in the treated area at 0-1 ft (3.94 mg/kg) exceeded the mean background (1.96 mg/kg) by a factor of 2.01, while the concentration of the middle interval indicated no increase and the bottom interval indicated an anomalous increase.

- 2006: Uranium concentrations in the treated area at 0-1 ft (4.88 mg/kg) exceed the mean background (1.96 mg/kg) by a factor of 2.49. The concentration from 1-2 ft (2.25) is 1.53 times the mean background of 1.47 mg/kg, indicating that less uranium has moved into the 1-2 ft interval than is retained in the upper interval. Essentially no increase was observed in the third interval, which is typical for the lower sampled interval.

- 2007: Uranium concentration in the treated area at 0-1 ft was similar to the 2006 value, indicating that uranium removal concentration has reached a maximum in the upper level. The concentration in the middle level increased to 2.07 times the mean background while the third level showed a small increase.

- 2008: Uranium concentrations gradually declined or were steady in all three layers relative to the 2007 values, indicating no additional removal of uranium. Additional removal is expected in the second and third layers.

- From 2001 to 2008, uranium concentrations in Section 34 Flood increased in the 0-1 ft layer from 2.72 to 4.38 mg/kg, a factor of 1.89. The average uranium concentration in the first 3 feet of soil increased from 1.91 to 2.93 mg/kg, a factor of 1.53.

- Average uranium concentrations in deeper layers of treated soils were generally lower than those in the surface samples.

A comparison of the results obtained in 2001, 2003, 2004, 2005, 2006, 2007 and 2008 indicates that uranium is accumulating in the treated areas of Section 34, primarily in the upper and middle intervals. In Section 33 Flood, little accumulation of uranium has occurred due to the limited amount of irrigation on this area.

Generalized findings for selenium are as follows:

- 2001: Selenium concentration in the treated area at 0-1 ft (0.50 mg/kg) exceeded the mean background (0.34 mg/kg) by a factor of 1.47. The average of the first 3 feet of treated soil (0.40 mg/kg) exceeded the mean background (0.29 mg/kg) by a factor of 1.38.

- 2002: Selenium concentrations at all depths in the treated and mean background area were reported as less than 0.60 mg/kg. As stated in Section 3.1.2, the MDL was too high to be useful in determining trends.

- 2003: Selenium concentration in the treated area at 0-1 ft (0.82 mg/kg) exceeded the mean background (0.34 mg/kg) by a factor of 2.41. The average of the first 3 feet of treated soil (0.47 mg/kg) exceeded the mean background (0.29 mg/kg) by a factor of 1.62.

- 2004: Selenium concentration in the treated area at 0-1 ft (1.15 mg/kg) exceeded the mean background (0.34 mg/kg) by a factor of 3.38. The average of the first 3 feet of treated soil (0.72 mg/kg) exceeded the mean background (0.29 mg/kg) by a factor of 2.48.

- 2005: Selenium concentration in the treated area at 0-1 ft (1.10 mg/kg) exceeded the mean background (0.34 mg/kg) by a factor of 3.24. The average of the first 3 feet of soil (0.72 mg/kg) exceeded the mean background (0.29 mg/kg) by a factor of 2.48.

- 2006: Selenium concentration in the treated area of Section 34 Flood at 0-1 ft (0.95 mg/kg) exceeds the mean background (0.34 mg/kg) by a factor of 2.79. The average of the first 3 feet of soil (0.56 mg/kg) exceeds the mean background (0.29 mg/kg) by a factor of 1.93.

- 2007: Selenium concentration in the treated area of Section 34 Flood at 0-1 ft (1.32 mg/kg) exceeds the mean background (0.34 mg/kg) by a factor of 3.88 while at 1-2 ft (0.94 mg/kg) exceeds the mean background (0.27 mg/kg) by a factor of 3.48. The increased selenium in 2007 should be used with caution because the background selenium values also increased.

- 2008: Selenium concentration in the treated area of Section 34 Flood at 0-1 ft (1.14 mg/kg) exceeds the mean background (0.34 mg/kg) by a factor of 3.35. A decrease in the selenium levels in each of the three intervals was observed compared to the 2007 values.

A comparison of the results obtained in 2001, 2003, 2004, 2005, 2006, 2007 and 2008 indicates that selenium has accumulated in the treated areas of Section 34. The concentration of selenium peaked in the upper layer in 2004, gradually declined in 2005, rose slightly in 2006 and 2007, and decreased again in 2008. The selenium concentration at 1-2 ft was 60% of those in the upper layer in 2008. The deepest interval (2-3) shows a small amount of selenium accumulation in the soil.

Generalized findings for other parameters are as follows:

- In the Section 34 Flood area, there have been increases in sodium, SAR, conductivity, magnesium and chloride to generally steady levels for the past few years, whereas levels of sulfate have generally continued to increase in the treated soils. Calcium levels have fluctuated.

3.2.3 Section 28 Center Pivot

Twelve locations were sampled in the treated area of Section 28 in 2002, 2003, 2004, 2005, 2006, 2007 and 2008 at the three, 1-ft depth intervals described above. Corresponding depths were sampled at each of the background locations in untreated areas of Section 28 (See Figure 11 for the five background locations that were composited for the three depths for 2002 and Figures 12 through 17 for the 2003 through 2008 locations). Graphical presentations of uranium and selenium concentrations are included in Figures 20 and 23, respectively.

Generalized findings for uranium are as follows:

- Uranium concentrations in composite samples collected from the treated and background areas in 2002 were, with one exception, at levels significantly above pre-operational and 2003 through 2008 treated levels. The 2002 data are likely elevated because of laboratory error and do not represent uranium concentrations in Section 28 soils. These data are not considered further.

- Uranium concentrations in the treated area slightly exceed those in the background area in 2003 to 2008. The most recent (2008) concentrations of uranium observed in the treated area were 1.17 (0-1 ft), 1.01 (1-2 ft) and 1.01 (2-3 ft); and 0.56 (0-1 ft), 0.52 (1-2 ft) and 0.52 mg/kg (2-3 ft) for the mean background. The treated intervals exceed the mean background by factors of 2.09 (0-1 ft), 1.94 (1-2 ft) and 1.94 (2-3 ft). All three interval concentrations of uranium in the treated area currently exceed background by an

average factor of 1.99. Thus, uranium concentrations are essentially twice that of background and appear to have reached a steady state..

Generalized findings for selenium are as follows:

- Selenium concentrations in composite samples collected from the treated and background areas in 2002 were all below the relatively high MDA of 0.6 mg/kg and are not useful in trend analysis.

- In 2008, selenium concentrations observed in the treated area were 0.39 (0-1 ft), 0.24 (1-2 ft) and 0.25 mg/kg (2-3 ft); mean background concentrations were 0.13 (0-1 ft), 0.11 (1-2 ft), and 0.09 mg/kg (2-3 ft). When comparing the intervals, the three treated intervals exceeded mean background by 3.00 (0-1 ft), 2.18 (1-2 ft) and 2.78 (2-3 ft). In 2008, the average concentration of selenium in the treated area exceeded the mean background by a factor of 2.65, indicating that selenium was retained in the Section 28 soils in 2008. This is thought to be caused by a smaller amount of water moving beyond the 3 foot soil interval.

Generalized findings for other parameters are as follows:

- As indicated in Table 6, there are general decreases in conductivity, SAR and calcium, magnesium, sodium and sulfate concentrations in both treated and background soils for Section 28 from 2003 to 2006 with slight increases in 2007 and 2008. The chloride and sulfate results in the untreated area are more variable.

Table 7. Summary of Irrigation Soil Analyses, 2000-2008

		Uranium (mg/kg)		Selenium (mg/kg)	
Section	Yearly Data	Treated Area	Background	Treated Area	Background
33 Center Pivot	1999 AVG:	----	0.61	----	0.12
	2000-1 AVG:	0.93	1.14	0.37	0.20
	2000-2 AVG:	0.81	----	0.45	----
	2000-3 AVG	1.03	----	0.25	----
	2001-1	0.94	0.98	0.30	0.10
	2001-2	0.60	0.76	0.30	0.20
	2001-3	0.54	0.83	0.10	0.30
	2002-1	0.98	0.85	<0.60	<0.60
	2002-2	0.89	0.59	<0.60	<0.60
	2002-3	0.68	0.66	<0.60	<0.60
	2003-1	1.36	0.78	0.28	0.12
	2003-2	1.14	0.52	0.19	0.12
	2003-3	1.00	0.67	0.18	0.12
	2004-1	1.78	0.88	0.45	0.27
	2004-2	1.52	0.79	0.39	0.24
	2004-3	1.15	0.81	0.38	0.26
	2005-1	1.45	0.78	0.31	0.18
	2005-2	1.15	0.69	0.21	0.15
	2005-3	1.00	0.79	0.30	0.15
	2006-1	1.87	0.88	0.36	0.18
	2006-2	1.62	0.88	0.15	0.16
	2006-3	1.05	1.09	0.14	0.15
	2007-1	1.67	0.89	0.44	0.39
	2007-2	1.34	0.89	0.30	0.44
	2007-3	1.30	0.86	0.39	0.27
	2008-1	1.41	0.72	0.41	0.21
	2008-2	1.37	0.61	0.35	0.23
	2008-3	1.27	0.72	0.33	0.20
28 Center Pivot	2002-1	2.99	2.99	<0.60	<0.60
	2002-2	1.47	1.62	<0.60	<0.60
	2002-3	0.74	1.45	<0.60	<0.60
	2003-1	0.81	0.51	0.18	0.15
	2003-2	0.70	0.61	0.16	0.10
	2003-3	0.57	0.53	0.13	0.15
	2004-1	0.89	0.88	0.37	0.22
	2004-2	0.80	0.77	0.23	0.22
	2004-3	0.70	0.81	0.23	0.19
	2005-1	0.68	0.47	0.17	0.12
	2005-2	0.74	0.47	0.15	0.07
	2005-3	0.58	0.55	0.12	0.07
	2006-1	1.11	0.62	0.16	0.10
	2006-2	1.14	0.51	0.09	<0.05
	2006-3	1.06	0.58	0.08	0.06
	2007-1	1.14	0.78	0.47	0.23
	2007-2	1.01	0.91	0.34	0.24
	2007-3	0.92	0.80	0.25	0.25
	2008-1	1.17	0.59	0.39	0.15
	2008-2	1.01	0.46	0.24	0.15
	2008-3	1.01	0.52	0.25	0.15

Table 7. Summary of Irrigation Soil Analyses, 2000-2008 (concluded)

		Uranium (mg/kg)		Selenium (mg/kg)	
Section	Yearly Data	Treated Area	Background	Treated Area	Background
34 Flood	1999 AVG:	----	2.44	----	0.44
	2000-1 AVG:	3.35	----	0.68	----
	2000-2 AVG:	2.22	----	0.37	----
	2000-3 AVG	1.62	----	0.30	----
	2001-1	2.72	2.47	0.50	0.30
	2001-2	1.88	1.92	0.40	0.20
	2001-3	1.15	0.79	0.30	0.20
	2002-1	0.69	0.45	<0.60	<0.60
	2002-2	0.46	0.53	<0.60	<0.60
	2002-3	0.42	0.40	<0.60	<0.60
	2003-1	3.72	2.33	0.82	0.42
	2003-2	1.90	1.46	0.40	0.35
	2003-3	1.08	1.66	0.19	0.36
	2004-1	4.43	2.79	1.15	0.75
	2004-2	2.27	2.04	0.63	0.68
	2004-3	1.40	1.38	0.37	0.40
	2005-1	3.94	2.41	1.10	0.53
	2005-2	1.41	2.44	0.38	0.69
	2005-3	2.62	2.13	0.68	0.51
	2006-1	4.88	3.06	0.95	0.69
	2006-2	2.25	3.93	0.45	0.87
	2006-3	1.21	2.29	0.28	0.54
	2007-1	5.02	3.30	1.32	0.74
	2007-2	3.05	2.67	0.44	0.78
	2007-3	1.75	1.64	0.64	0.53
	2008-1	4.38	2.52	1.14	0.57
	2008-2	2.70	2.19	0.68	0.48
	2008-3	1.71	1.26	0.37	0.27
33 Flood	2004-1	1.78	1.56	0.56	0.47
	2004-2	1.67	1.30	0.47	0.39
	2004-3	1.68	1.33	0.49	0.42
	2005-1	1.35	1.12	0.31	0.25
	2005-2	1.14	0.92	0.24	0.20
	2005-3	1.00	0.90	0.20	0.19
	2006-1	1.76	1.62	0.41	0.21
	2006-2	1.24	1.55	0.26	0.56
	2006-3	1.62	1.05	0.21	0.35
	2007-1	1.69	1.79	0.45	0.38
	2007-2	1.55	1.29	0.40	0.31
	2007-3	1.51	1.24	0.40	0.35
	2008-1	1.70	1.44	0.43	0.32
	2008-2	1.53	1.18	0.39	0.32
	2008-3	0.96	0.97	0.23	0.25

Notes:
2000 Sample: 1 = 0 - 6 inches, 2 = 6 - 18 inches and 3 = 18 - 36 inches
2001 through 2008 Sample: 1 = 0 - 1 ft, 2 = 1 - 2 ft and 3 = 2 - 3 ft

3.2.4 Comparison of Applied and Measured Soil Concentrations

3.2.4.1 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 supplement 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 application rates have been above and below 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 throughout the upper three feet of the soil profile.

It is reasonable to adopt a mass balance approach to track the fate of the applied uranium. Actual applied uranium concentrations, application rates of irrigation water, and calculated increases in soil are presented in Tables 8 and 9.

The calculated data in Tables 8 and 9 are determined as follows:

a = cumulative masses of uranium applied per irrigation area, mg = $\Sigma_{2000\text{-}2008}$[(average concentration in water, mg/l) (volume of water in ac-ft) (28.3 l/ft^3) (43,560 ft^2/ac)]

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

c = measured concentration of uranium, mg/kg = (sum of measured concentrations of uranium or selenium in three 1-ft layers minus background concentrations)

d = measured mass of uranium, mg = (b)(c)/3

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, soil density is assumed at 90 pounds per cubic foot (lb/ft^3).

The above-background concentrations of uranium in each section, in mg/kg, are: Section 33 Center Pivot (1.87); Section 33 Flood (-0.38); Section 34 (4.22); and Section 28 (1.59). Based on this series of calculations, the ratios of measured to applied masses of uranium in the three feet of soil are: Sections 33 Pivot (0.47), 33 Flood (-0.54), 34 (0.95), and 28 (0.49). An error was found in Table 8 for the 2007 ratios. Correction of this error indicates that 0.60, 0.49, 1.31

and 0.58 ratios were observed for Section 33 Center Pivot, Section 33 Flood, Section 34 Flood and Section 28 Center Pivot, respectively, in 2007.

In Sections 33 Pivot and Section 28, 53 and 51 percent of the applied uranium is unaccounted for, respectively. The loss of uranium 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 three feet and this is attributed to the presence of clay soils. The measured concentrations in Section 33 Flood are less than background and therefore do not produce a reliable retention value.

Accumulating uranium concentrations for each layer in each irrigation area are shown in Figures 18 (Section 33 Center Pivot), 19 (Sections 33 and 34 Flood), and 20 (Section 28 Center Pivot). Each figure is subdivided into upper, middle, and lower intervals. The horizontal line on each figure represents the mean background concentration.

Table 8. Uranium Applied in Irrigation Water

	Uranium Concentration (mg/l)		Acreages				Volume of Irrigation Water Applied (ft)			
Year	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

Notes:
NA = not irrigated

Table 9. Comparison of Measured Versus Applied Uranium

	Section			
2008	28 Pivot	33 Flood	33 Pivot	34 Flood
Applied Mass of Uranium (mg), a	576,859,496	30,277,967	1,068,727,797	952,914,697
Sum of 3-ft Measured Concentrations Minus Background (mg/kg), c	3.19-1.60= 1.59	4.19-4.57= -0.38	4.05-2.18= 1.87	8.79-4.57= 4.22
Mass of Soil (kg), b	533,958,480	128,150,035	800,937,720	640,750,176
Measured Mass of Uranium (mg), d	282,997,994	-16,232,338	499,251,179	901,321,914
Ratio of Measured to Applied Masses, e	0.49	-0.54	0.47	0.95

3.2.4.2 Selenium

The applied and measured selenium concentrations in the upper 3-ft layer of soil were calculated in a similar manner and are presented in Tables 10 and 11.

The above-background concentrations of selenium in each section for the three layers, in mg/kg, are: Section 33 Center Pivot (0.67); Section 33 Flood (0.17); Section 34 (1.31); and Section 28 (0.55). Based on the same series of calculations shown above in Section 3.2.4.1, the ratios of measured to applied masses of selenium in the three feet of soil are: Sections 33 Pivot (0.54), 33 Flood (0.94), 34 (0.90), and 28 (0.71).

In Section 33 Pivot, 46 percent of the applied selenium is unaccounted for. The 2008 selenium results indicate that more then one-half of the applied selenium is still within the upper three feet of soil.

Actual selenium measurements are also shown in Figures 21 (Section 33 Center Pivot), 22 (Sections 33 and 34 Flood), and 23 (Section 28 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, is parted to the dissolved phase, rather than absorbed in soils. A review of Figures 21 through 23 indicates that the retention of selenium appears to be independent of time, implying that absorption in soil is not retarding the movement of selenium through the soil. Only 4, 14 and 47 percent of the chloride concentration applied was measured in the soil in 2008 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 and 33 Center Pivot was not retained in the first three feet of soil. The higher percentage for selenium indicates some removal of this constituent.

Table 10. Selenium Applied in Irrigation Water

	Selenium Concentration (mg/l)a		Acreages				Volume of Irrigation Water Applied (ft)			
Year	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

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 11. Comparison of Measured Versus Applied Selenium

	Section			
2008	28 Pivot	33 Flood	33 Pivot	34 Flood
Applied Mass of Selenium (mg), a	138,097,362	7,701,223	331,547,575	311,939,485
Sum of 3-ft Measured Concentrations Minus Background (mg/kg), c	0.88-0.33= 0.55	1.05-0.88= 0.17	1.09-0.42= 0.67	2.19-0.88= 1.31
Mass of Soil (kg), b	533,958,480	128,150,035	800,937,720	640,750,176
Measured Mass of Selenium (mg), d	97,892,388	7,261,835	178,876,091	279,794,244
Ratio of Measured to Applied Masses, e	0.71	0.94	0.54	0.90

3.2.5 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, 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. 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 2008 results indicate that uranium is being retained in all three intervals in Sections 28 and 33, whereas uranium is only being retained in the upper two intervals in Section 34. The 2008 results also indicate selenium is being retained but these results need to be confirmed with future measurements.

In 2008, the uranium concentrations in the irrigated areas ranged from 0.96 to 4.38 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 2008. The selenium concentrations in the irrigated areas for 2008 ranged from 0.23 to 1.14 mg/kg. The laboratory reported selenium MDL and PQL for the soil analysis were 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.

4.0 Hay Concentrations and Constituent Uptakes

Until 2008, alfalfa was used exclusively as hay crop in the irrigated areas, except for the outer 40 acres in Section 28, which is a grass. The following changes were made in the irrigated crops in 2008. The field in the western half of the Section 34 flood area was tilled and replanted with triticale. The eastern half also had triticale seeded with the current alfalfa crop, but was not tilled. The 24 acres in the eastern portion of the Section 33 flood area was tilled and replanted with triticale. No crop was obtained from this area in 2008 due to late season planting. The crop in the Section 33 center pivot area had 25 acres of canola and 25 acres of camelina crop seeded into the current alfalfa (see Appendix B).

Constituents in soil are known to be taken up by plants. The extent of plant uptake is dependent on many parameters, including the constituent and the plant species. The measured concentrations of uranium and selenium in each cutting of hay were measured and compared to the soil concentration measured at the end of the growing season. The ratio of the concentration in plants to that in the soil is defined as the transfer coefficient from soil to plant. The transfer coefficients have been calculated and compared to NRC values that are based on published studies. All hay data and transfer coefficients are based on concentrations calculated from dry weights of both soil and vegetation.

4.1 Measured Hay Concentrations

The vegetation samples were collected after the hay was cut and prior to the baling of hay. The samples are collected from a distribution similar to the soil sample site distribution. The hay samples were analyzed by an offsite vendor laboratory.

4.1.1 Section 33 Center Pivot

During the first and second cuttings in Section 33 in 2001, eight samples were taken from various portions of the field. Sixteen samples were collected from the third cutting. Eight samples were taken from each cutting in 2002. Twelve samples were taken from each cutting in 2003 through 2008, but in 2008 only two cuttings were taken. The individual results are reported in Appendix B where the concentrations are reported on a dry-weight basis. The uranium and selenium concentrations were generally slightly higher in the first cutting each year but were opposite this trend in 2007 and 2008. The highest uranium concentration occurred in the first cutting of 2004. Selenium concentrations were generally lower for the second and third cuttings but were essentially the same in 2005. The highest selenium and uranium concentrations

occurred in the third cutting of 2007 and the second cutting in 2008. Table 12 presents the summary of the uranium and selenium concentrations in the Section 33 cuttings.

4.1.2 Sections 33 and 34 Flood Areas

In Section 34, ten samples were collected from the first two cuttings in 2001 and eight samples were collected from the third cutting. Six samples were collected from each of four cuttings in 2002. In 2003, twelve, seven and twelve samples were collected from the first, second and third cuttings, respectively. In 2004 and 2005, twelve and six samples were analyzed for the first and second cuttings, while ten and six samples were collected for the first and second cuttings in 2006. Six samples were collected from the first cutting in 2007. Six and twelve samples were collected from the first and second cuttings in 2008. Higher uranium concentrations were observed in the second cutting in 2002 and third cuttings in 2001 and 2003. The highest selenium concentrations for each cutting were similar, and occurred in the first cuttings of 2001, 2003, 2004 and 2005; the second cutting of 2006, and in the fourth cutting in 2002. The hay was not cut on the Section 33 flood area in 2004, 2006, 2007 and 2008. Table 12 presents the summary of the uranium and selenium concentrations in the Section 34 cuttings.

4.1.3 Section 28 Center Pivot

Six samples were collected in 2002 from the first hay cutting in the Section 28 irrigation area. Only one cutting was obtained from Section 28 because a crop of millet was used to establish cover over the site prior to alfalfa seeding. Twelve samples were collected from each of the three cuttings in 2003 through 2007. In 2008, twelve samples were also collected, but only one cutting was preformed. Average uranium concentrations have varied from 0.29 to 1.83 mg/kg. Selenium concentrations varied from 0.79 to 1.62 mg/kg. In general, uranium concentrations in the 2008 hay from Section 28 were similar to those observed in 2005. Table 12 presents the summary of the uranium and selenium concentrations in the Section 28 cuttings.

4.1.4 Background Concentrations in Hay and Special Study

In 2000, a composite sample was prepared from ten samples collected from the second cutting in Section 33 (see Appendix B for data). The sample was split and one of the samples was washed with tap water prior to analysis. The results were 0.62 mg/kg and 0.58 mg/kg for uranium and 1.4 mg/kg and 1.5 mg/kg for selenium. These results indicate that uranium and selenium in the sample did not arise from material deposited on the exterior plant surfaces.

Two samples of baled hay collected from hay fields a few miles to the northwest of the Homestake Mining Company irrigation areas were taken in 2000 for comparison to that grown in this study. While it is not known what the constituent soil concentrations were, it is known that

water from the shallow alluvial aquifer near the Grants Project was not used as a source for irrigation. The uranium concentrations were reported as 0.19 and 0.05 mg/kg; the selenium concentrations were 0.2 and 0.1 mg/kg. These data indicate lower levels of uranium and selenium in what is assumed to be background hay.

Table 12. Summary of Hay Analyses

Irrigation Areas										
	Section 33			Section 34				Section 28		
Year	1st Cut	2nd Cut	3rd Cut	1st Cut	2nd Cut	3rd Cut	4th Cut	1st Cut	2nd Cut	3rd Cut
Average Uranium Concentrations (mg/kg)										
2000	1.12	0.62	----	0.73	----	----	----	----	----	----
2001	0.58	0.57	0.30	0.55	0.38	0.71	----	----	----	----
2002	1.32	0.37	0.77	0.92	1.52	0.54	0.88	0.29	----	----
2003	0.73	0.70	0.73	0.89	0.56	1.15	----	0.99	0.98	1.14
2004	1.62	0.51	0.90	1.02	0.88	----	----	1.09	1.17	0.86
2005	0.84	0.64	0.71	1.82	0.88	----	----	1.83	0.94	1.43
2006	0.80	0.62	0.45	0.79	0.78	----	----	1.21	0.77	0.62
2007	1.04	1.18	1.60	1.02	----	----	----	0.90	1.59	1.17
2008	0.47	0.83	----	0.49	0.43	----	----	1.68	----	----
Average Selenium Concentrations (mg/kg)										
2000	1.10	1.40	----	0.50	----	----	----	----	----	----
2001	1.41	1.05	0.87	1.05	0.82	0.78	----	----	----	----
2002	1.80	1.17	1.81	0.83	1.14	1.06	1.17	0.79	----	----
2003	1.70	1.46	1.54	1.62	0.80	1.11	----	1.62	1.28	1.00
2004	1.24	0.69	1.24	1.19	0.25	----	----	1.03	1.07	1.02
2005	1.25	1.29	1.27	1.90	0.80	----	----	1.50	1.24	1.48
2006	1.25	1.29	1.00	0.75	1.40	----	----	1.17	1.27	0.95
2007	1.30	1.40	1.50	1.43	----	----	----	0.90	1.20	1.33
2008	1.10	1.30	----	1.80	1.30	----	----	1.50	----	----

Notes:
No cuttings were obtained from the Section 33 Flood in 2004. This was a new field, with no hay production.

4.1.5 Summary of Hay Concentrations

Table 12 presents a summary of the concentrations observed in hay cuttings from 2000 to 2008. No trends are apparent for uranium or selenium during 2003 to 2008. The data indicate a slight decrease in uranium from the first to the third cutting. No trends are evident for selenium. The average uranium concentrations in the 2008 hay cuttings ranged from 0.47 to 1.68 mg/kg.

In 2008, the average selenium concentrations in hay ranged from 1.1 to 1.8 mg/kg. Prior years' results show a similar range for the upper limit. Recent studies have shown that selenium in cattle diets plays an important role in maintaining cattle health and nutrition. A minimum requirement for selenium in cattle feed appears to be about 0.1 mg/kg and in many regions of the country, selenium is added to feed. The National Research Council (NRC, 2000) has established 2 mg/kg as the Maximum Tolerable Concentration (MTC) for cattle feed. They note that toxicity

is possible at levels as low as 5 mg/kg. Since the measured levels are below the MTC, further analysis of selenium in this report is considered unnecessary.

4.2 Measured Uranium Uptake in Hay

The uptake of constituents from soil to plants is generally considered to be directly proportional to the concentration in soil. The ratio of the concentration in the plant to that in the soil is called the transfer coefficient. The transfer coefficient from NUREG/CR-5512 for uranium in vegetation is 1.7E-2 pCi/kg-plant/pCi/kg-soil. Since the quantity of uranium is proportional to the activity in units of picoCuries (pCi), the transfer coefficient can also be expressed as 0.017 mg/kg-plant/mg/kg-soil. An estimate of the plant uptake from the application of irrigation water is presented in ERG and HYDRO (1999). The average soil concentration for each field is tabulated in Table 13 and used to predict the hay uranium concentration.

To measure an uptake factor in plants, the average soil concentration of all three layers was used since alfalfa roots extend to a depth of three feet or more. Table 13 presents the data for the average uranium in soil and hay by section and year. The transfer coefficient from soil to hay is calculated and shown in Table 14 for each year.

Table 13. Average Uranium Concentrations in Soil and Hay

	Avg. Uranium Soil Concentration (mg/kg)			Avg. Uranium Hay Concentration (mg/kg)		
Year	Section 33	Section 34	Secton 28	Section 33	Section 34	Section 28
2000	0.92	2.4	----	0.87	0.73	----
2001	0.69	1.92	----	0.48	0.55	----
2002	0.85	0.52	1.64	0.82	0.97	0.29
2003	1.17	2.23	0.69	0.72	0.87	1.04
2004	1.48	2.7	0.8	1.01	0.95	1.04
2005	1.2	2.66	0.67	0.73	1.35	1.4
2006	1.51	2.78	1.1	0.62	0.79	0.87
2007	1.44	3.27	1.02	1.27	1.02	1.22
2008	1.35	2.93	1.06	0.65	0.46	1.68
				Average:	0.90	

The calculated uranium transfer coefficients have a mean of 0.78 and standard deviation of 0.54. This is one order of magnitude higher than the published transfer coefficient of 0.017. The fact that the uranium uptake is higher than predicted by the NRC published transfer coefficient might be explained by the fact that the uranium concentration in the soil moisture (and available to the plants) may be significantly higher in fields irrigated with contaminated water than for soil moisture within contaminated soil that is derived from clean groundwater or rain to support plant growth.

Table 14. Transfer Coefficient from Soil to Hay

Transfer Coefficients (mg/kg hay/mg/kg soil)			
Year	Section 33	Section 34	Section 28
2000	0.95	0.30	----
2001	0.70	0.29	----
2002	0.96	1.87	0.18
2003	0.62	0.39	1.51
2004	0.68	0.35	1.30
2005	0.61	0.51	2.09
2006	0.41	0.28	0.79
2007	0.88	0.32	1.20
2008	0.48	0.16	1.58
	Mean	0.78	
	SDV	0.54	

In 2002, 622 pounds (lbs) of uranium were applied to the sites, based on an average uranium concentration of 0.23 mg/l and 995 ac-ft of water. Slightly less was applied in 2003 and slightly more in 2004, 2005 and 2006. This is a small amount considering that it was applied over 330 acres. The amount of uranium removed by uptake into the hay can be estimated based on the typical observed uranium concentration of 1 mg/kg in the hay. The amount of uranium contained in the 480 tons of hay produced in 2002 is about one lb. Thus, less than 1% of the uranium that was supplied to the field in 2002 (622 lbs) was removed by the hay.

The amount of uranium and selenium being removed by the hay is insignificant. In 2002, for example, the amount of selenium contained in the 480 tons of hay produced is estimated at one pound. In 2002, less than one-half of one percent of the selenium applied to the field (243 pounds) is being removed by the hay. Similar calculated results for both uranium and selenium can be obtained for the other years.

5.0 Radiation Dose from Eating Beef

The dose to humans from eating beef initially requires a calculation of the uptake to beef from the vegetation followed by the transfer from beef to human. For dose calculation purposes, we have used the average uranium in hay measurements from 2000 through 2008 (Table 13 average concentration 0.90 mg/kg = 609 pCi/kg). The measured natural concentrations of uranium and selenium in hay grown in the region are presented in Section 4.1.4. The analysis that follows does not subtract the natural background concentrations in hay grown on untreated soils from the measured values in this study.

5.1 Vegetation to Livestock Uptake

The uranium concentration in meat (C_{bi}), as a result of cattle eating hay produced from the Grants site irrigation fields can be estimated by multiplying the rate of intake of vegetation by the transfer coefficient, then multiplying by the fraction of food supply and the concentration in the hay.

$$C_{bi} = QF_{bi}(F_{pg}C_{pgi} + F_hC_{hi})$$

Where the values of the parameters are discussed below:

Q	=	assumed feed ingestion rate, 27 kg(wet weight)/d, NUREG/CR-5512
F_{bi}	=	Transfer coefficient from vegetation to livestock, 2.0E-4, NUREG/CR-5512
F_{pg}	=	fraction of the total annual feed requirement (including pasture and other feed sources) from hay grown in irrigation area = 0.5
C_{pgi}	=	measured concentration in vegetation (pCi/kg) = 609 pCi/kg
F_h	=	fraction of the total annual feed requirement not from irrigated hay, = 0.5. Assumed 50% not grown on irrigated area.
C_{hi}	=	uranium concentration in the other fraction of feed not grown on the irrigated area = 0

C_{bi} = 27 kg/day (2.0E-4) {(0.5) (609) + (0.5) (0.0)} = 1.6 pCi/kg meat

5.2 Beef to Human Uptake

Total activity in the human body from eating only meat produced from the irrigated fields for a year can be calculated as follows:

$$I_i = U_{bk}C_{bi}$$

Where:

I_i	=	annual intake rate (pCi/y)
U_{bk}	=	ingestion rate of beef for an adult = (0.16 kg/d)(365d/y)
C_{bi}	=	concentration in meat (pCi/kg)

I_i = (1.6 pCi/kg meat) (0.16 kg/d) (365 day/y)

I_i = 93 pCi/y

The ingestion dose is calculated from the following equation:

$$I_{(ing)} = I_i DCF_{(ing)}$$

Where:

$I_{(ing)}$ = ingestion dose, millirem per year (mrem/y)

$DCF_{(ing)}$ = ingestion dose conversion factor (5 rem/10 μCi, from 10 CFR 20 Appendix B)

$$I_{(ing)} = (93\ pCi/y)\ (1E\text{-}6\ \mu Ci/pCi)\ (5\ rem/10\ \mu Ci)\ (1E3\ mrem/rem)$$

$$I_{(ing)} = 0.05\ mrem/y$$

While this scenario may be considered overly conservative, the projected radiation dose to humans is considered insignificant.

6.0 Conclusion

Uranium is being retained in the upper layers of treated soil. In terms of risk to human health, uranium levels are currently acceptable. The dose to man by way of food web uptake calculations is negligible, at 0.05 mrem/yr.

The average increase of uranium in soil appears to be similar to that predicted although distributed to greater depths. The increase in concentrations in the hay was approximately 50 times higher than that predicted using the NRC's soil to vegetation transfer coefficient. The NRC transfer coefficient may not take into account constituent uptake via water application in addition to soil/vegetation transfer mechanisms. This much larger observed transfer coefficient from water and soil contributions combined still results in negligible radiation doses to the public. Therefore, the use of alluvial water for irrigation of hay fields with slightly elevated concentrations of uranium is not a significant health concern.

Selenium uptakes in the hay are below the recommended upper limit for animal feed. Selenium retention in soils appears to be independent of time and application. The concentrations are not time-dependent, implying that absorption in soil is not retarding the movement of selenium through the soil.

The monitoring of concentrations of uranium and selenium will continue as part of the ongoing irrigation program.

7.0 References

RIMCON and Hydro-Engineering, 1998. Soil Characterization and Attenuation Studies. Prepared for Homestake Mining Company, Grants, New Mexico.

Environmental Restoration Group and Hydro-Engineering, February 1999, Evaluation of the Use of Alluvial Ground Water for Irrigation, Consulting Report for Homestake Mining Company, Grants, New Mexico.

Environmental Restoration Group and Hydro-Engineering, 2001, Evaluation of the Year 2000 Irrigation with Alluvial Ground Water, Consultants Report for Homestake Mining Company, Grants, New Mexico.

Environmental Restoration Group and Hydro-Engineering, 2004, Evaluation of the Year 2000 Through 2003 Irrigation with Alluvial Ground Water, Consultants Report for Homestake Mining Company, Grants, New Mexico.

Environmental Restoration Group and Hydro-Engineering, 2005, Evaluation of the Year 2000 Through 2004 Irrigation with Alluvial Ground Water, Consultants Report for Homestake Mining Company, Grants, New Mexico.

Environmental Restoration Group and Hydro-Engineering, 2006, Evaluation of the Year 2000 Through 2005 Irrigation with Alluvial Ground Water, Consultants Report for Homestake Mining Company, Grants, New Mexico.

Environmental Restoration Group and Hydro-Engineering, 2007, Evaluation of the Year 2000 Through 2006 Irrigation with Alluvial Ground Water, Consultants Report for Homestake Mining Company, Grants, New Mexico.

Environmental Restoration Group and Hydro-Engineering, 2008, Evaluation of the Year 2000 Through 2007 Irrigation with Alluvial Ground Water, Consultants Report for Homestake Mining Company, Grants, New Mexico.

NRC, 1992, NUREG/CR 5512: Residual Radioactive Contamination from Decommissioning, Final Report, U.S. Nuclear Regulatory commission, Washington, D.C.

NRC, 2000. National Research Council, 2000, "Nutrient Requirements for Beef Cattle." National Academy Press, Washington, D.C.

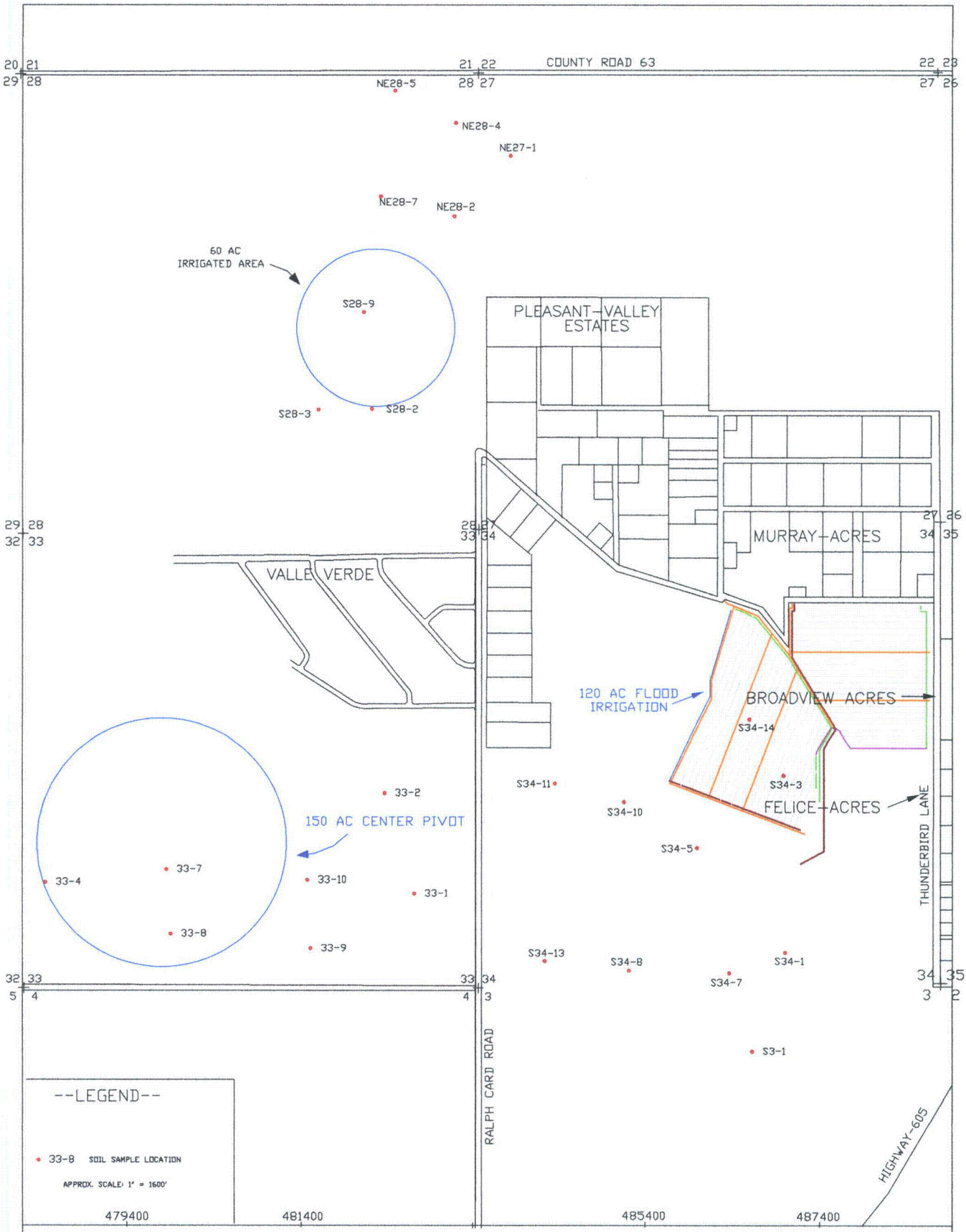

FIGURE 1. LOCATION OF IRRIGATION AREAS WITH SOIL SAMPLE LOCATIONS FROM THE 1998 INVESTIGATION

DATE: 02/13/09
(hmg) C:\PROJECTS\2009-06\IRRIGATION\98IRRI

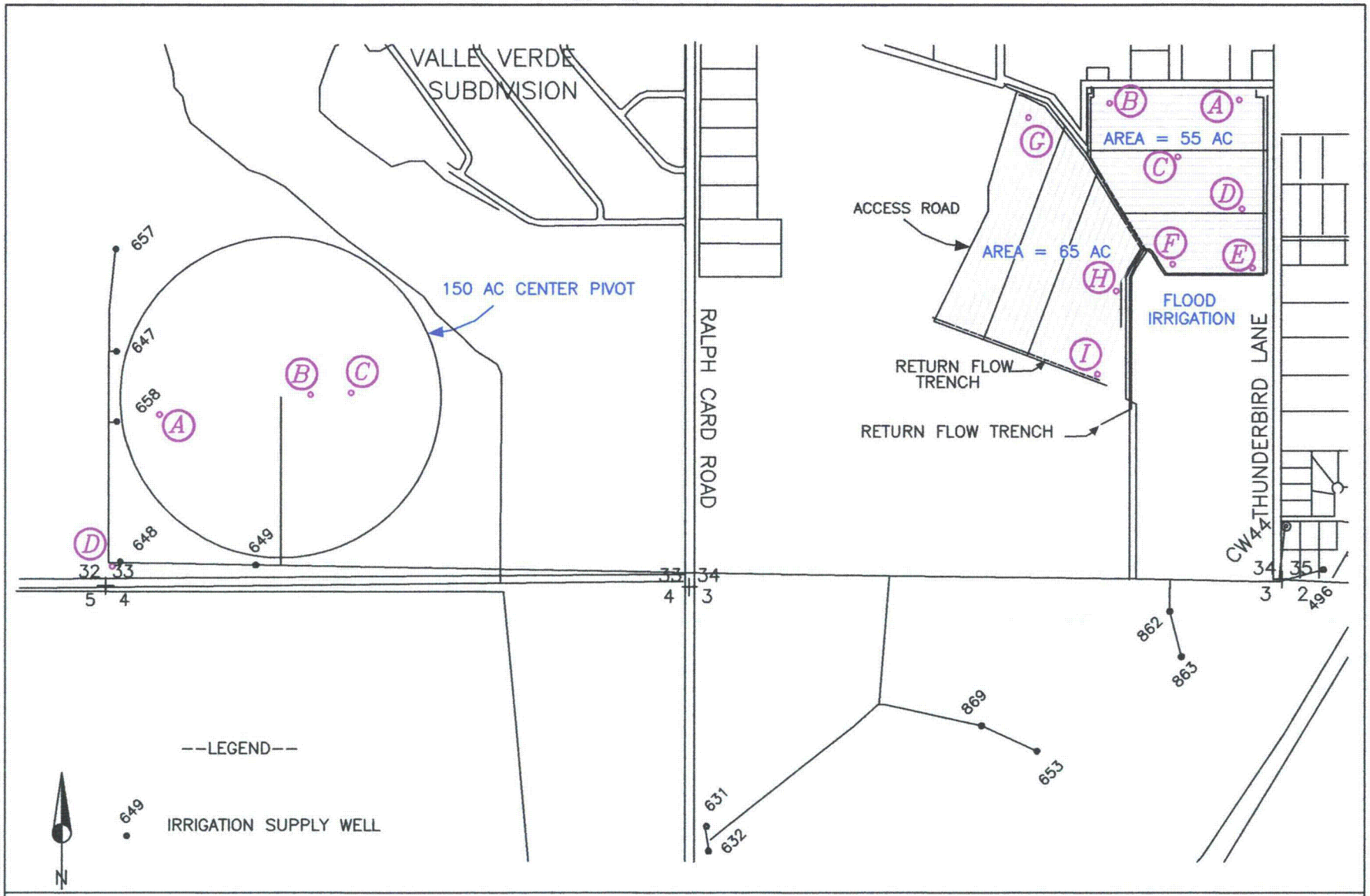

FIGURE 2. 1999 AND 2000 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

SCALE: 1" = 1200'

DATE: 02/13/09

C:\PROJECTS\2009-06\IRRIGATION\SOILSAMP2000.DWG

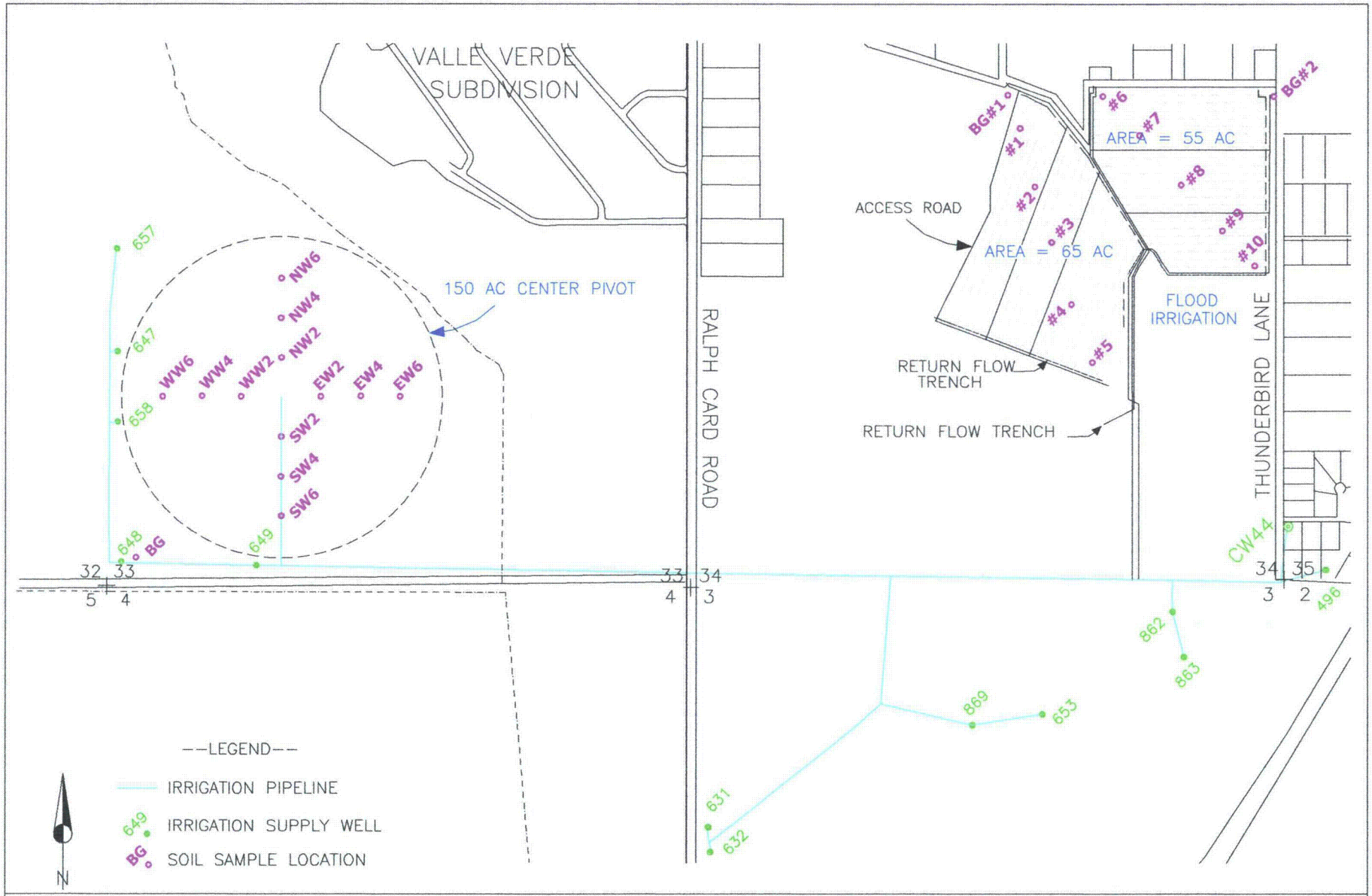

FIGURE 3. 2001 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

SCALE: 1" = 2400'

DATE: 02/13/200

C:\PROJECTS\2009-06\IRRIGATION\SOILSAMP2000.DWG

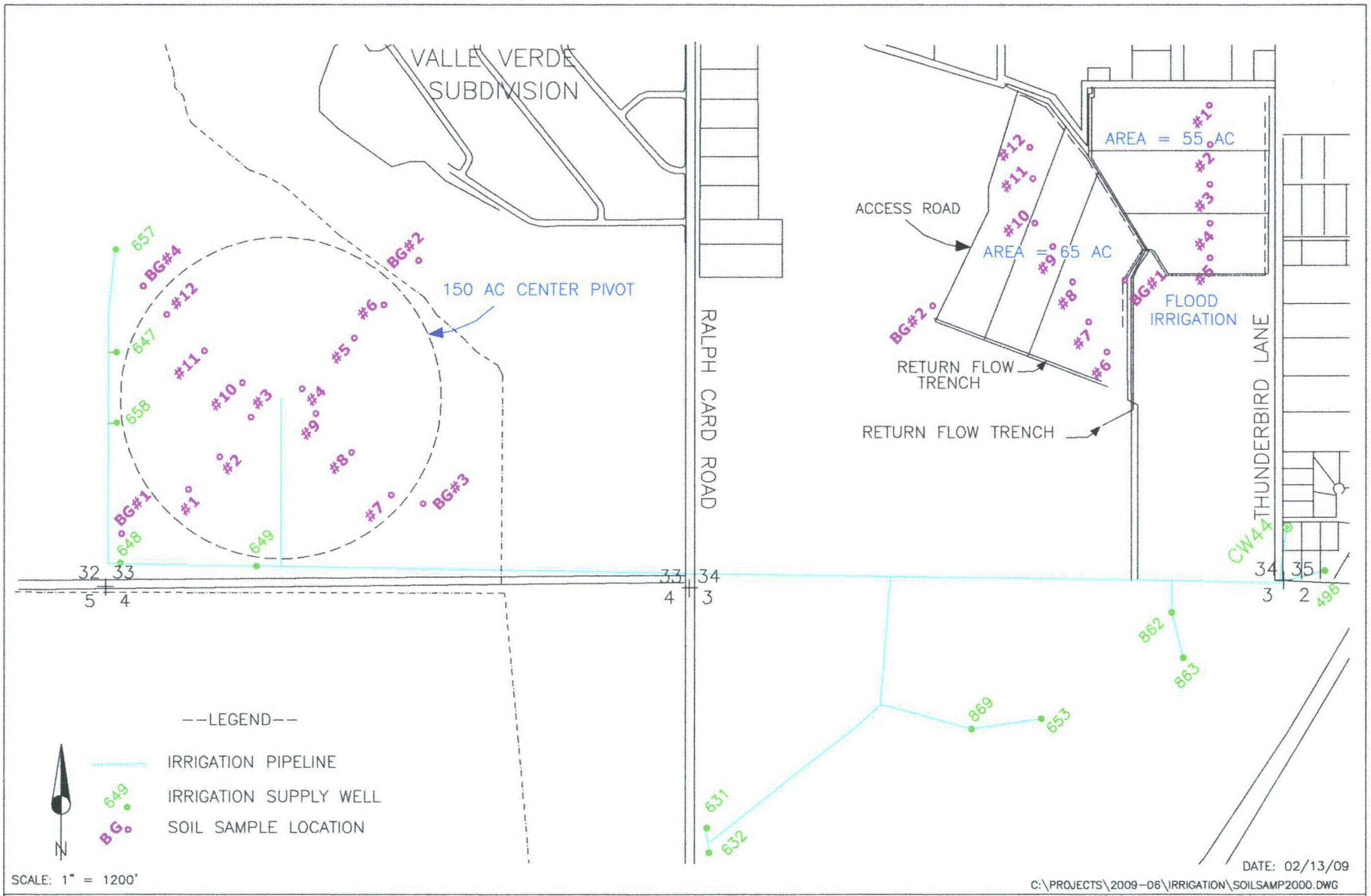

FIGURE 4. 2002 SECTIONS 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

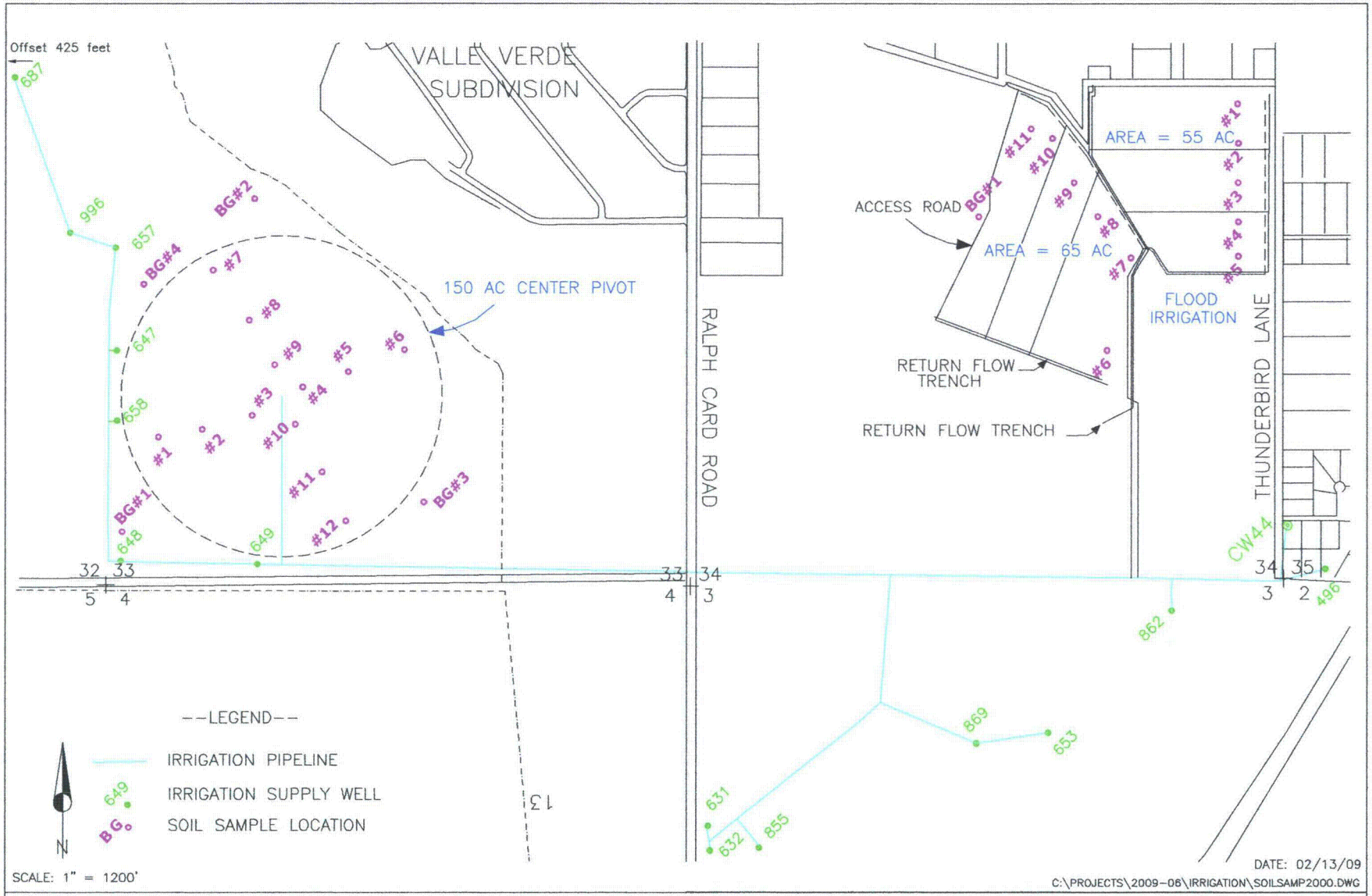

FIGURE 5. 2003 SECTIONS 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

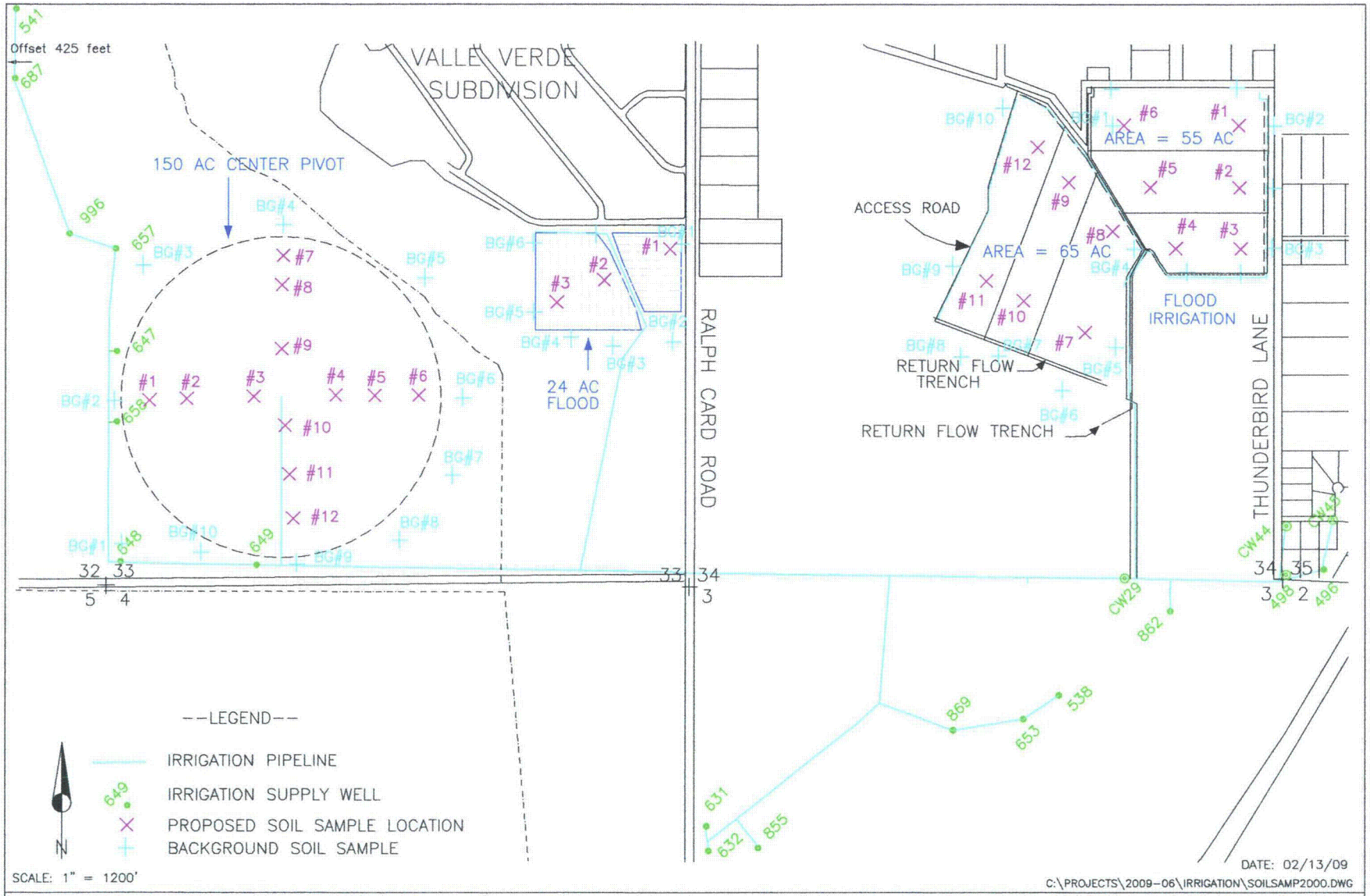

FIGURE 6. 2004 SECTIONS 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

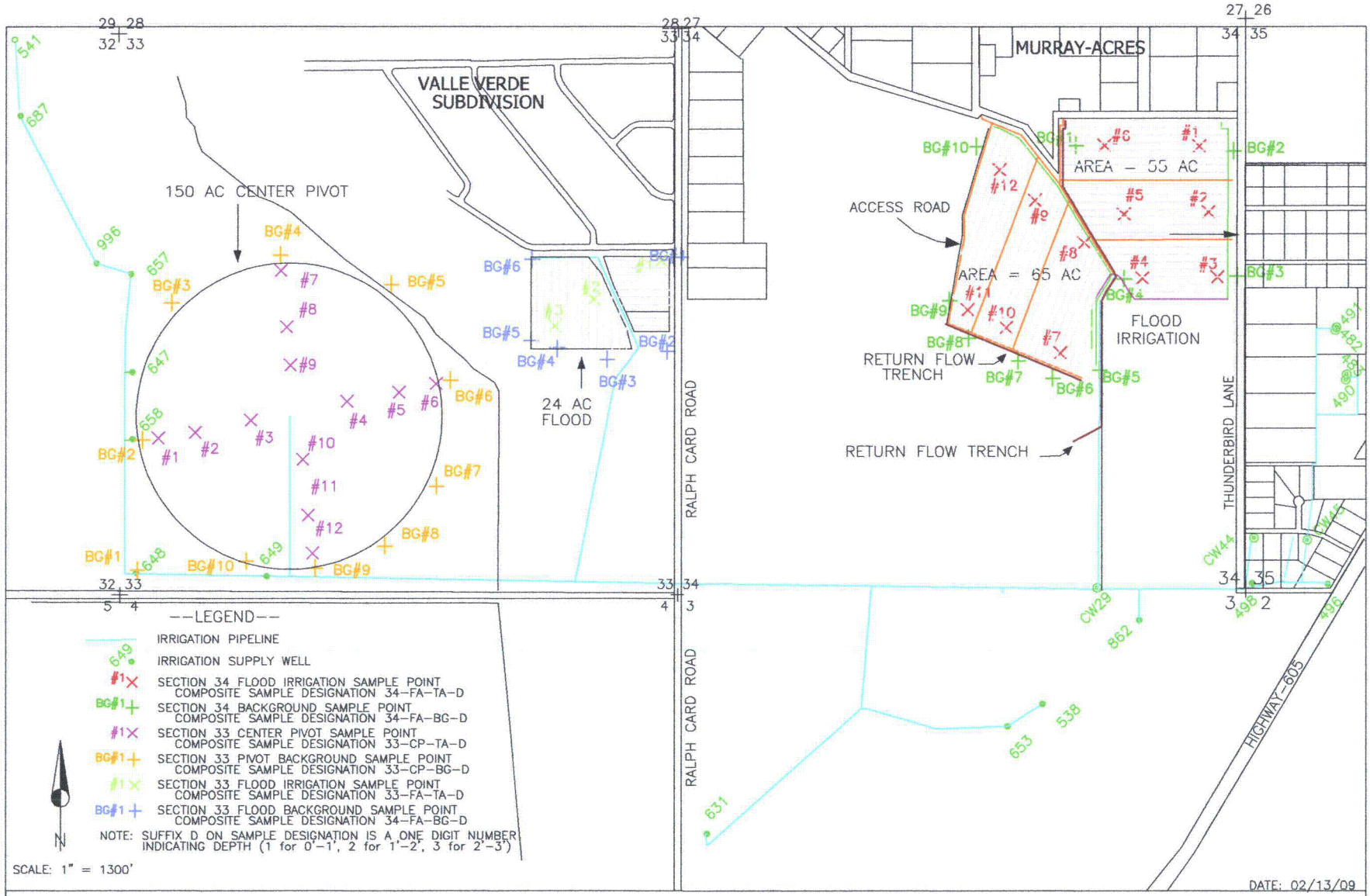

FIGURE 7. 2005 SECTIONS 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

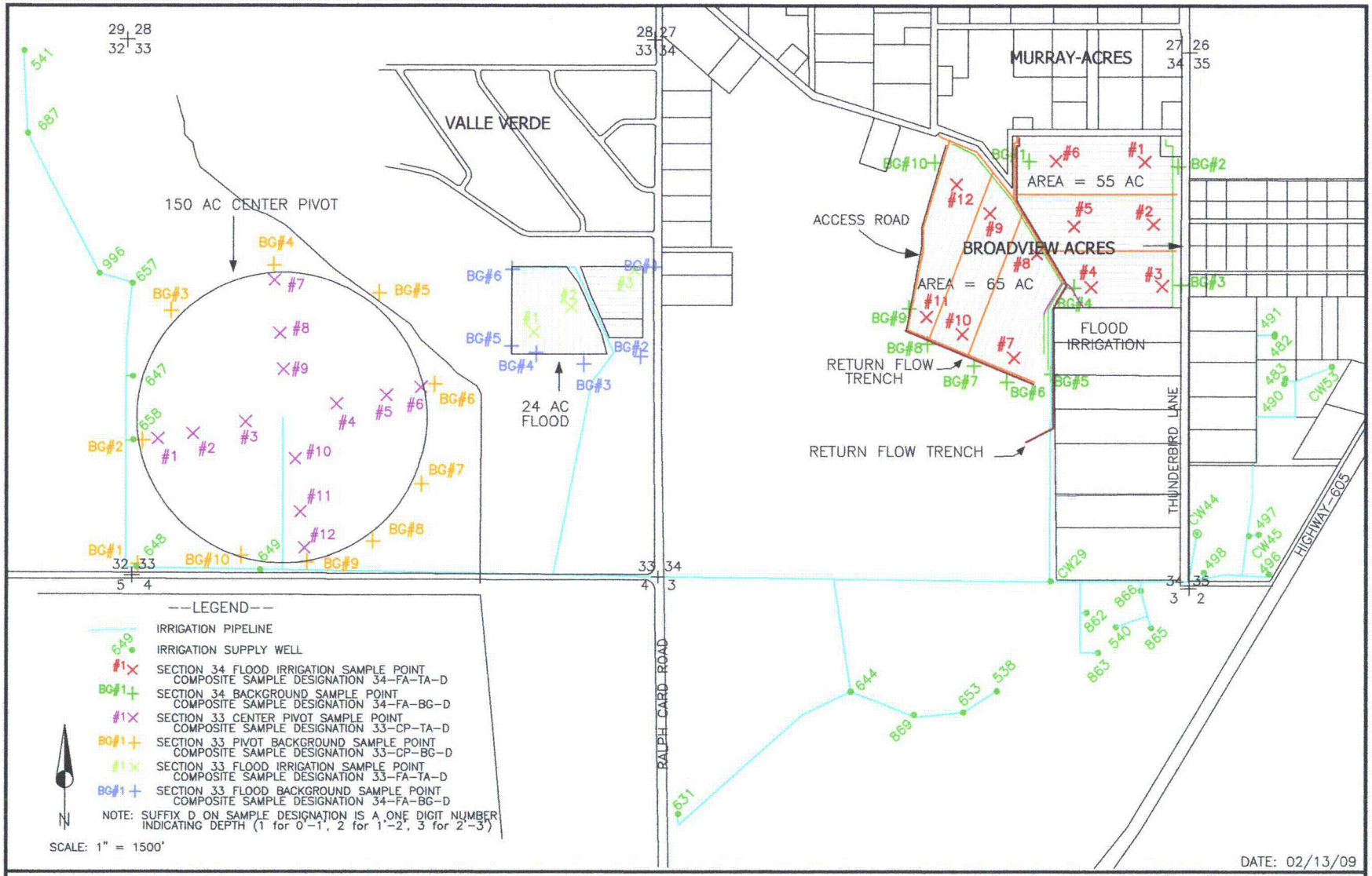

FIGURE 8. 2006 SECTION 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

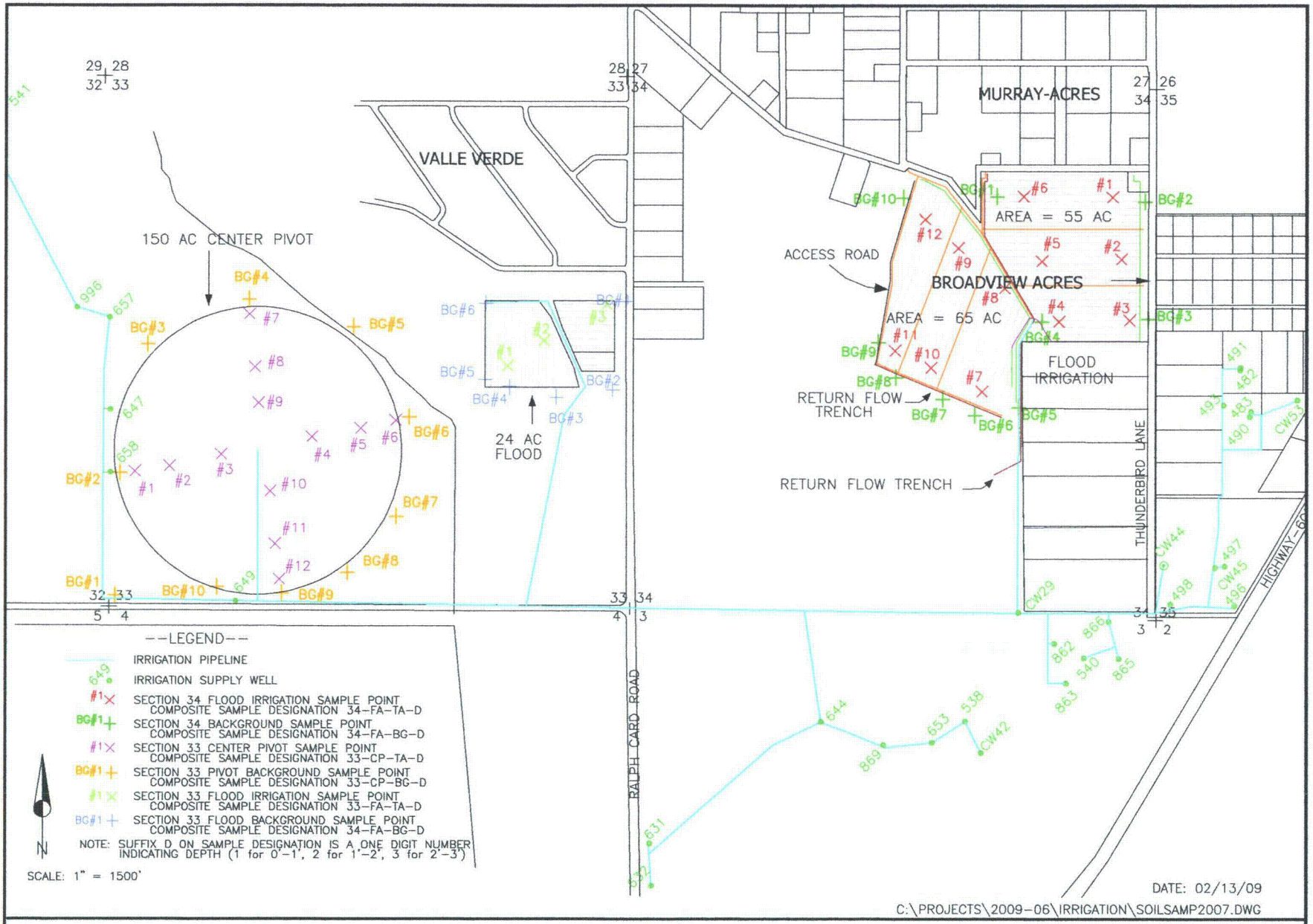

FIGURE 9. 2007 SECTION 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

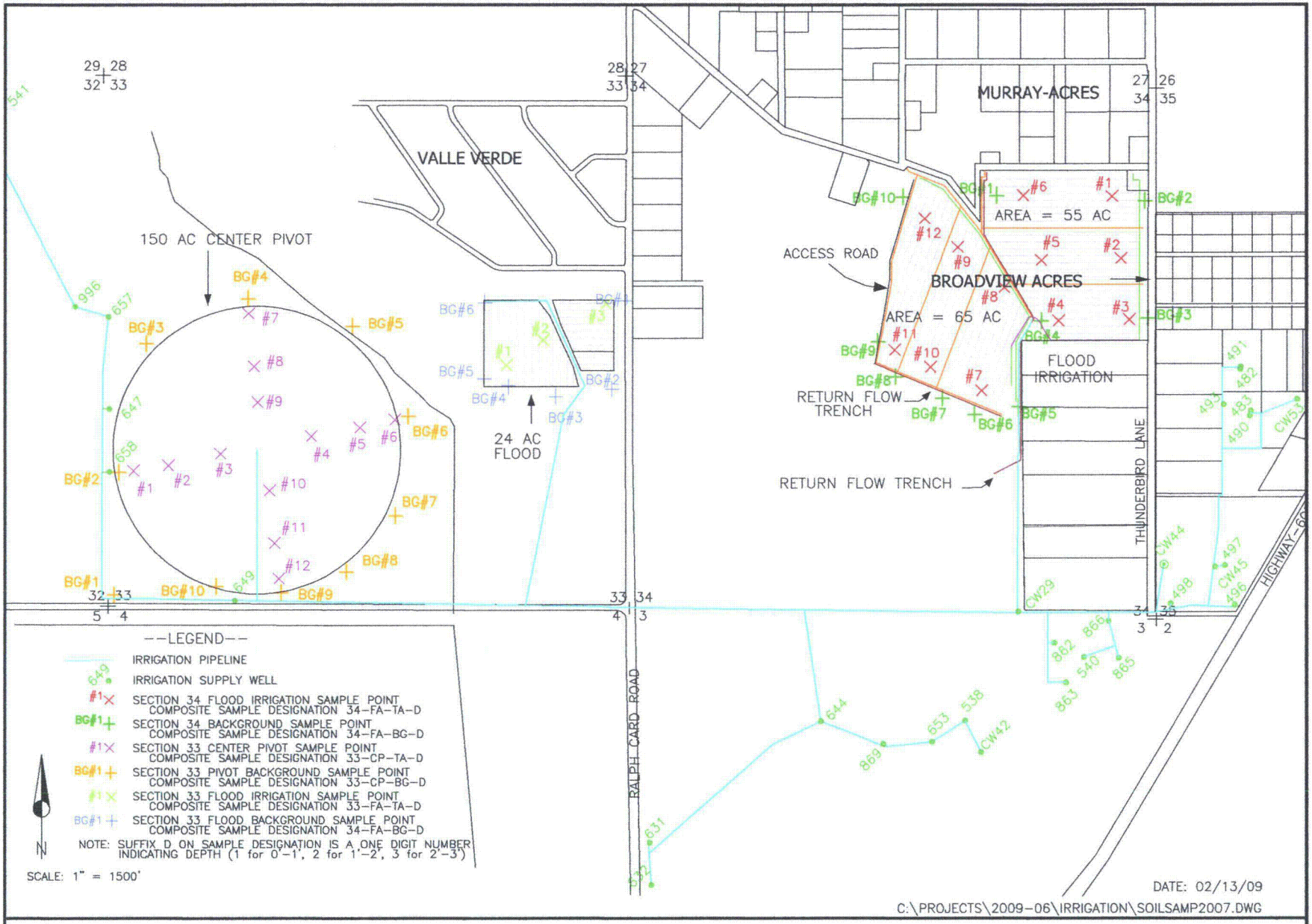

FIGURE 10. 2008 SECTION 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

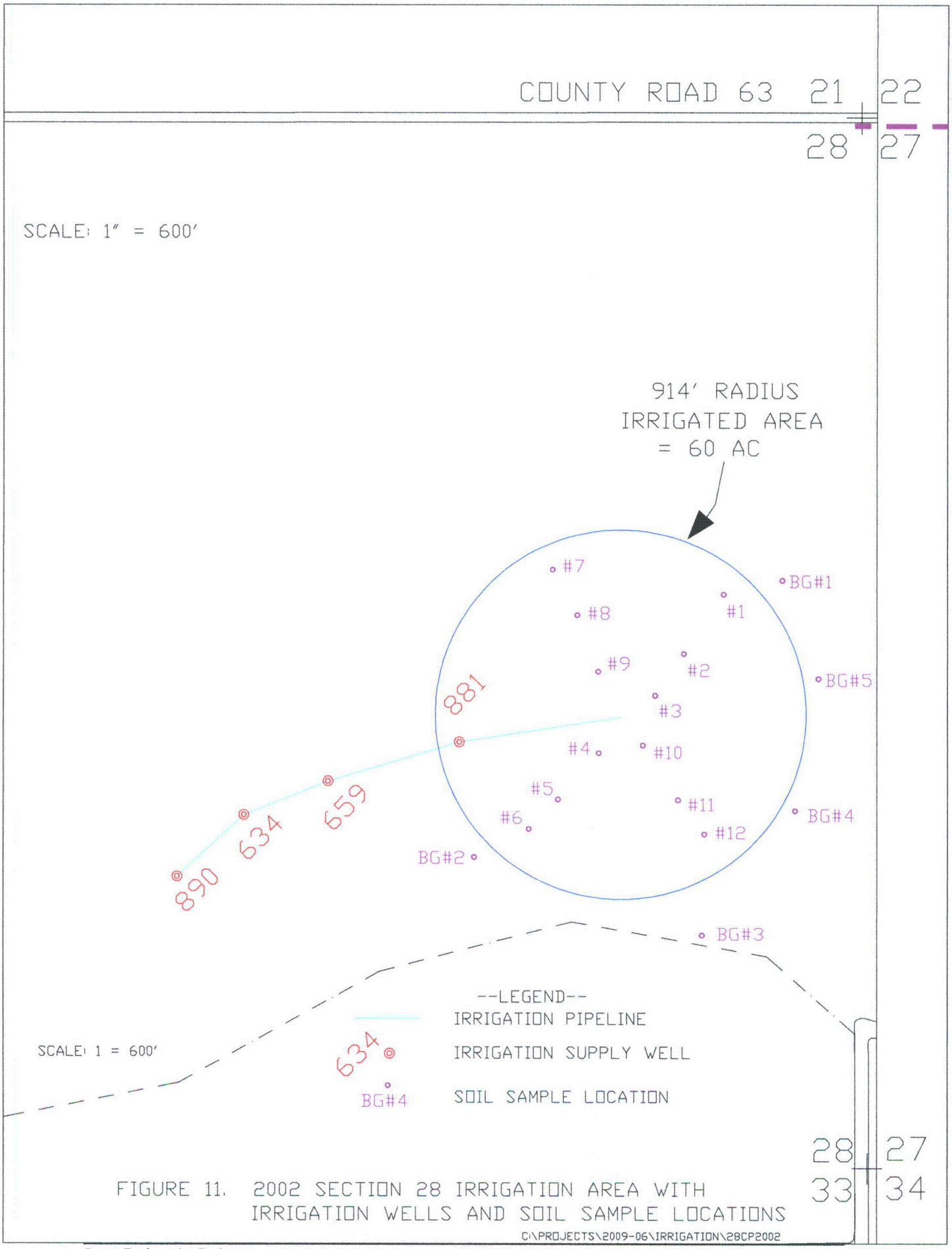

FIGURE 11. 2002 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

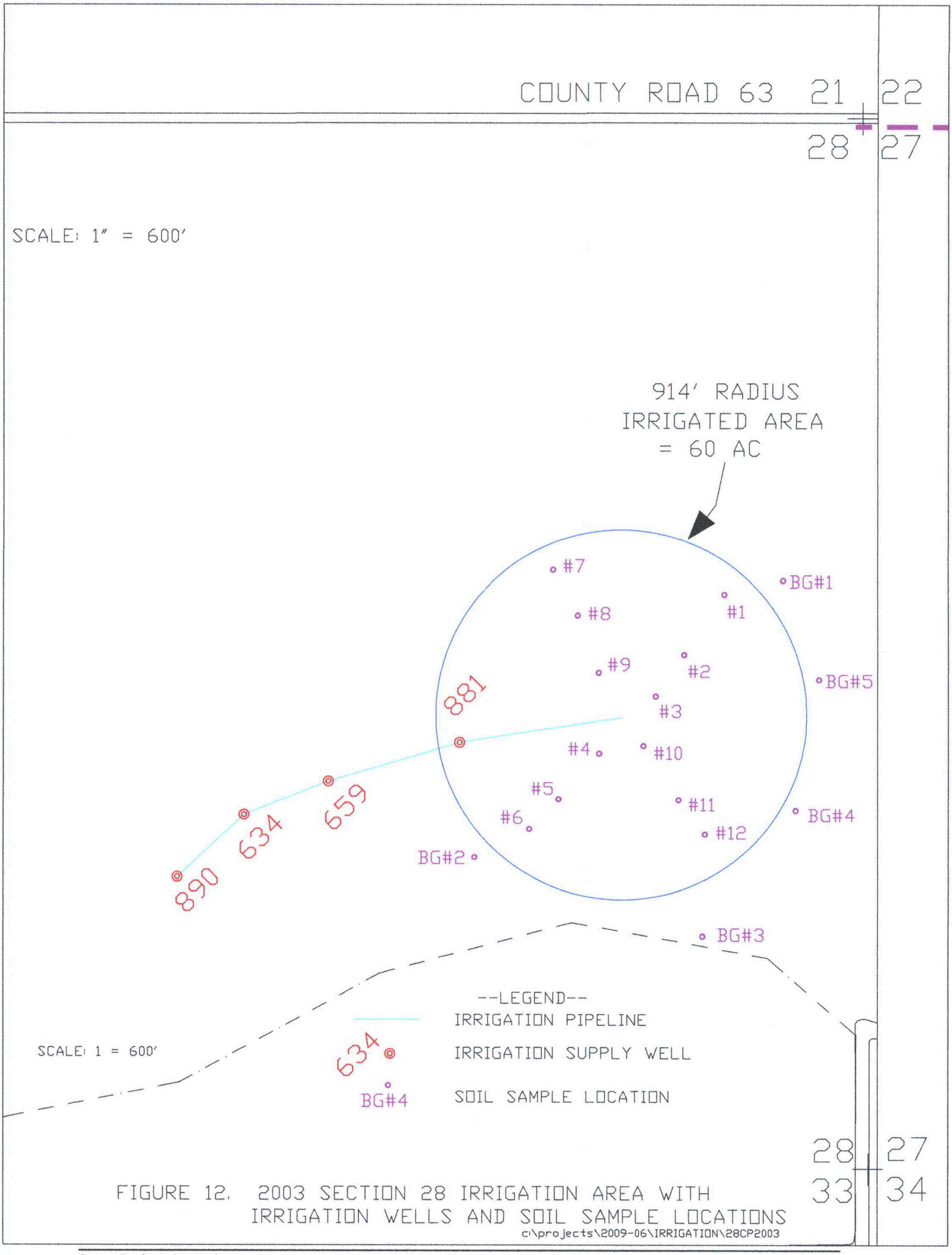

FIGURE 12. 2003 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

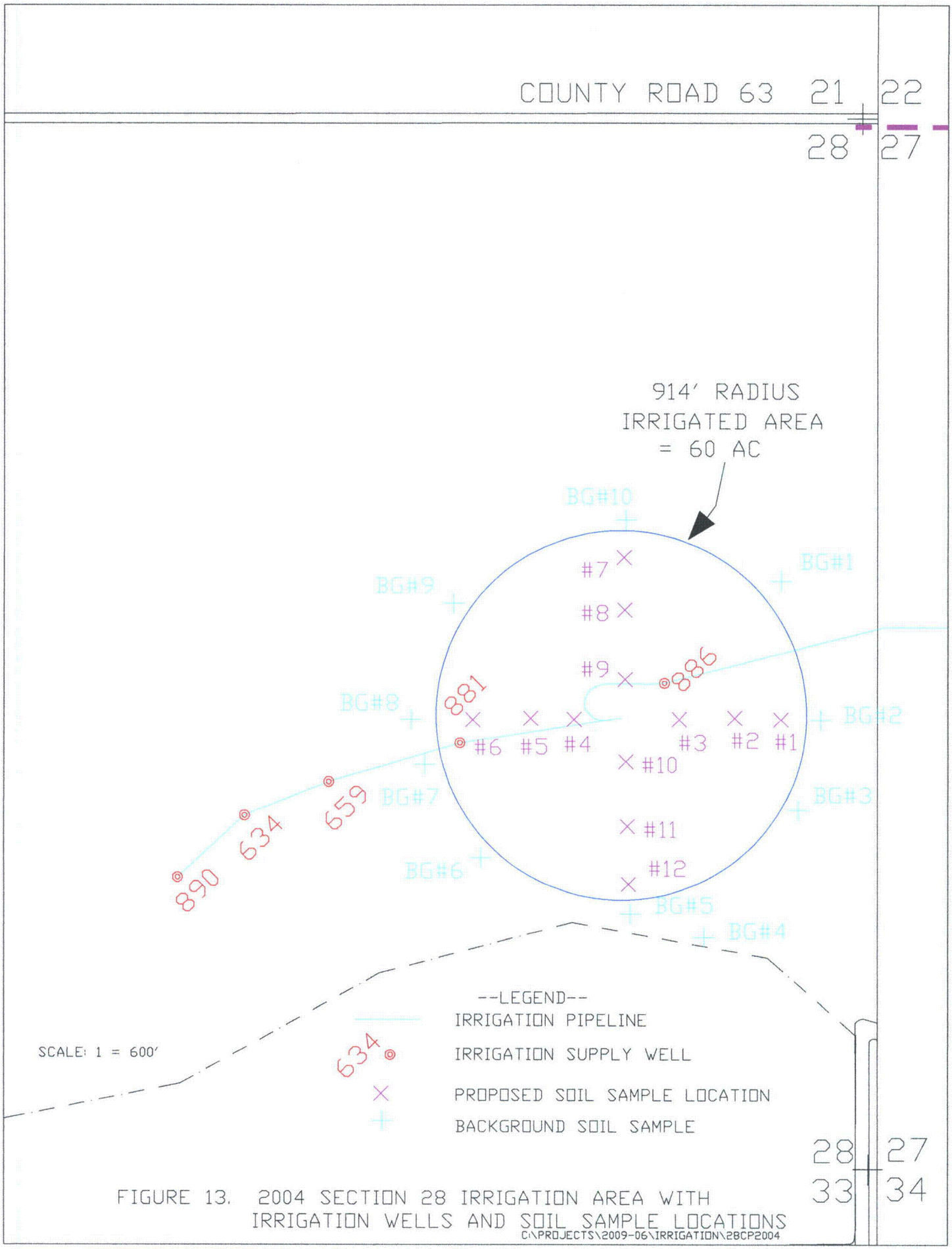

FIGURE 13. 2004 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

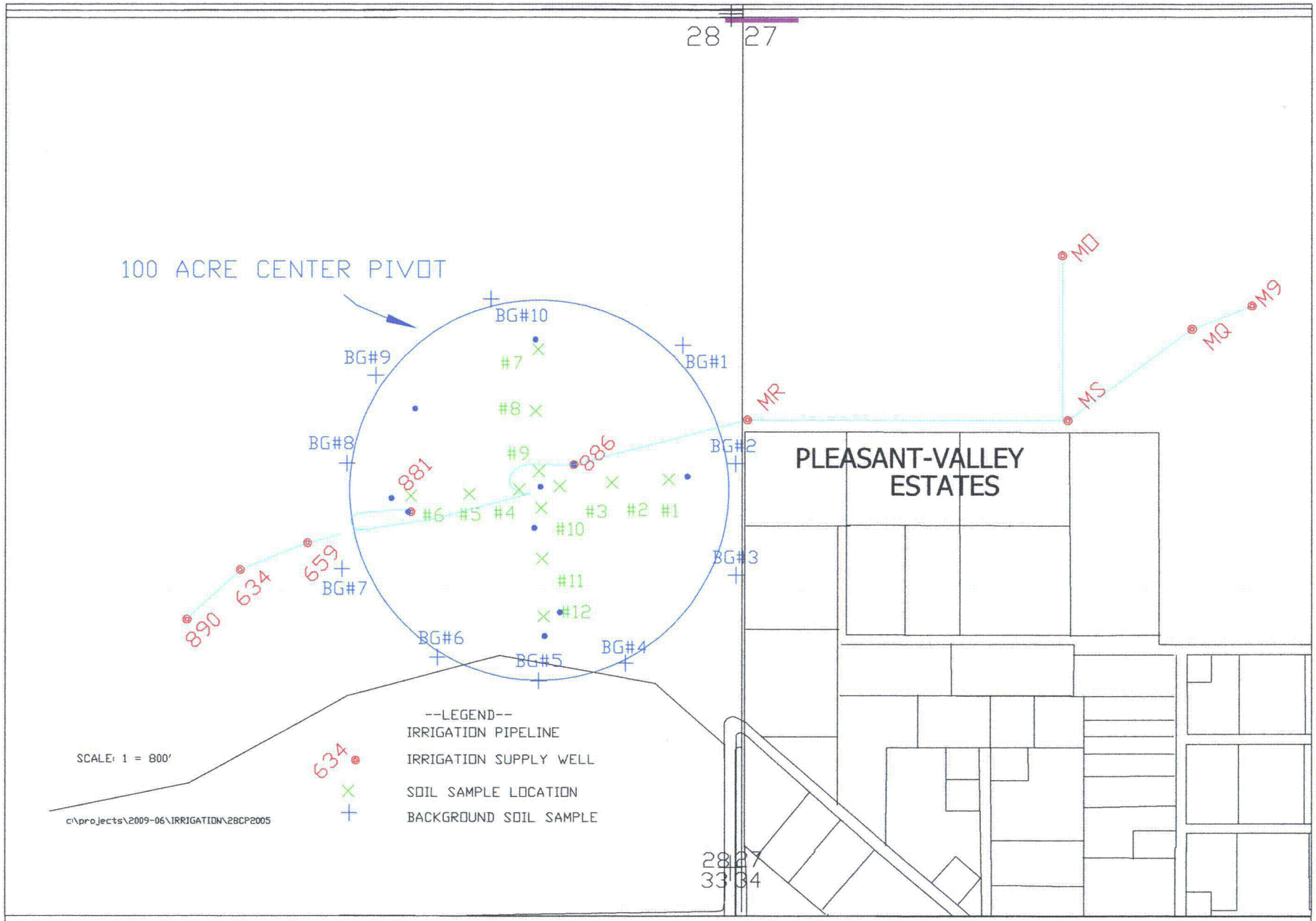

FIGURE 14. 2005 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

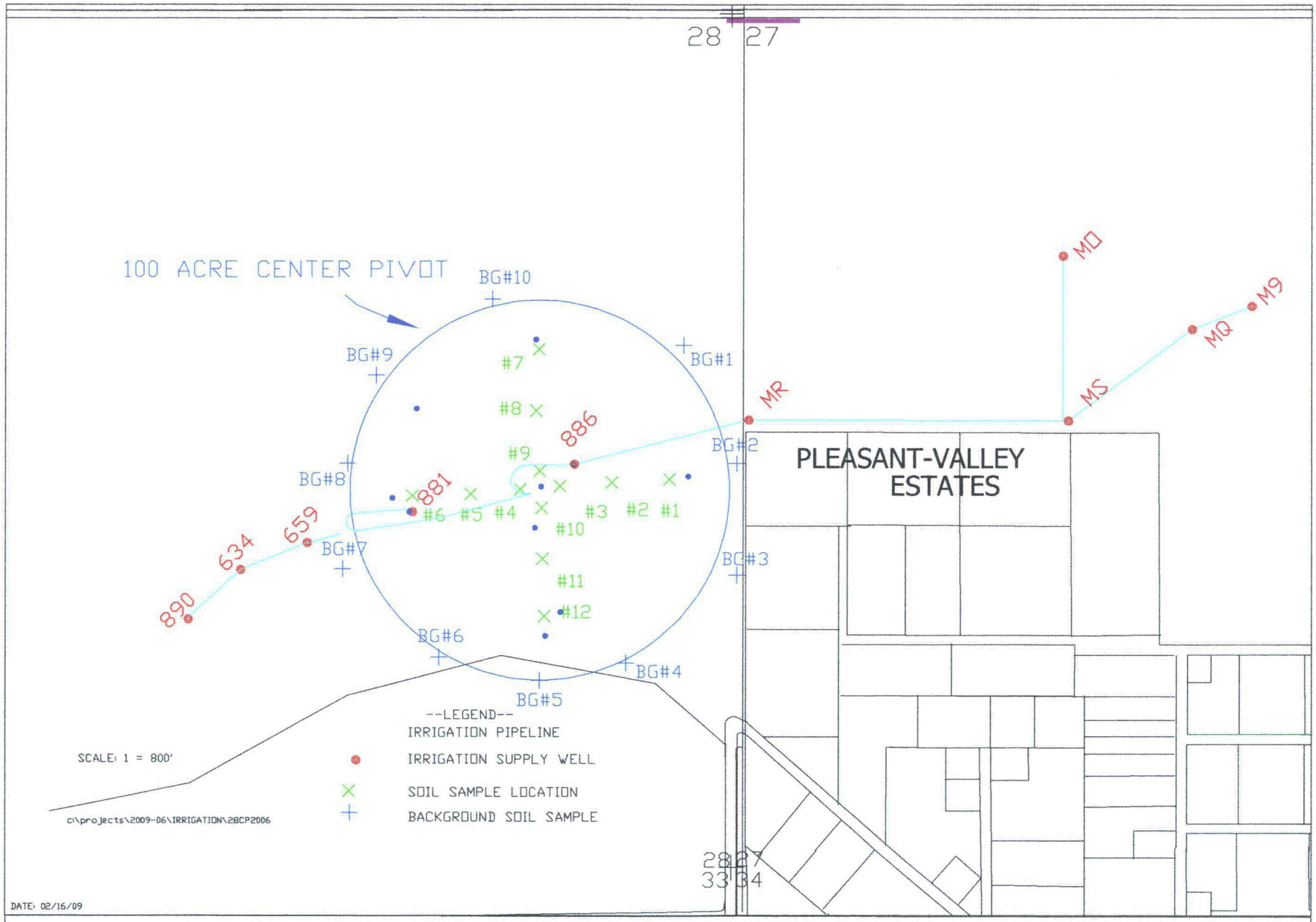

FIGURE 15. 2006 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

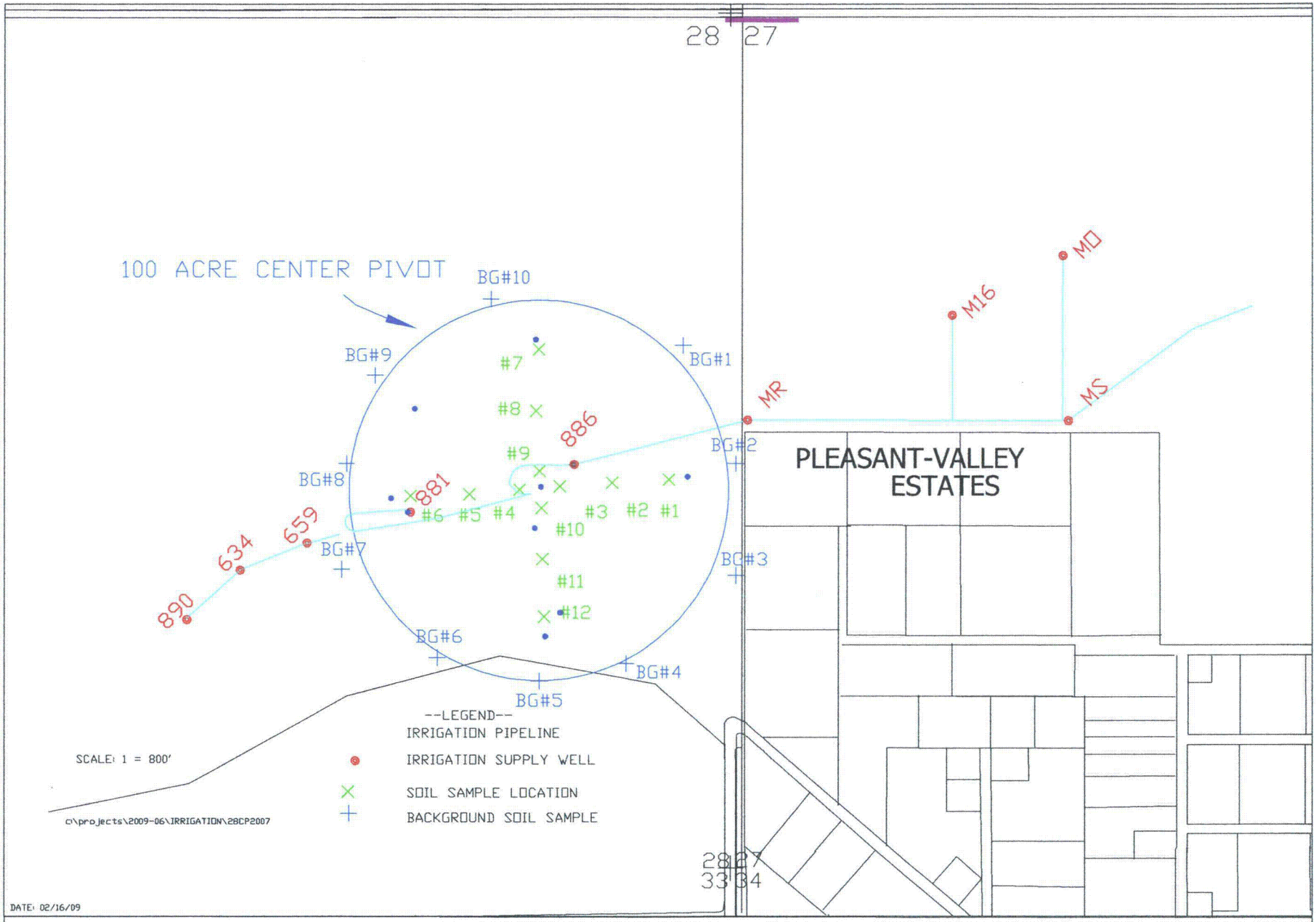

FIGURE 16. 2007 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

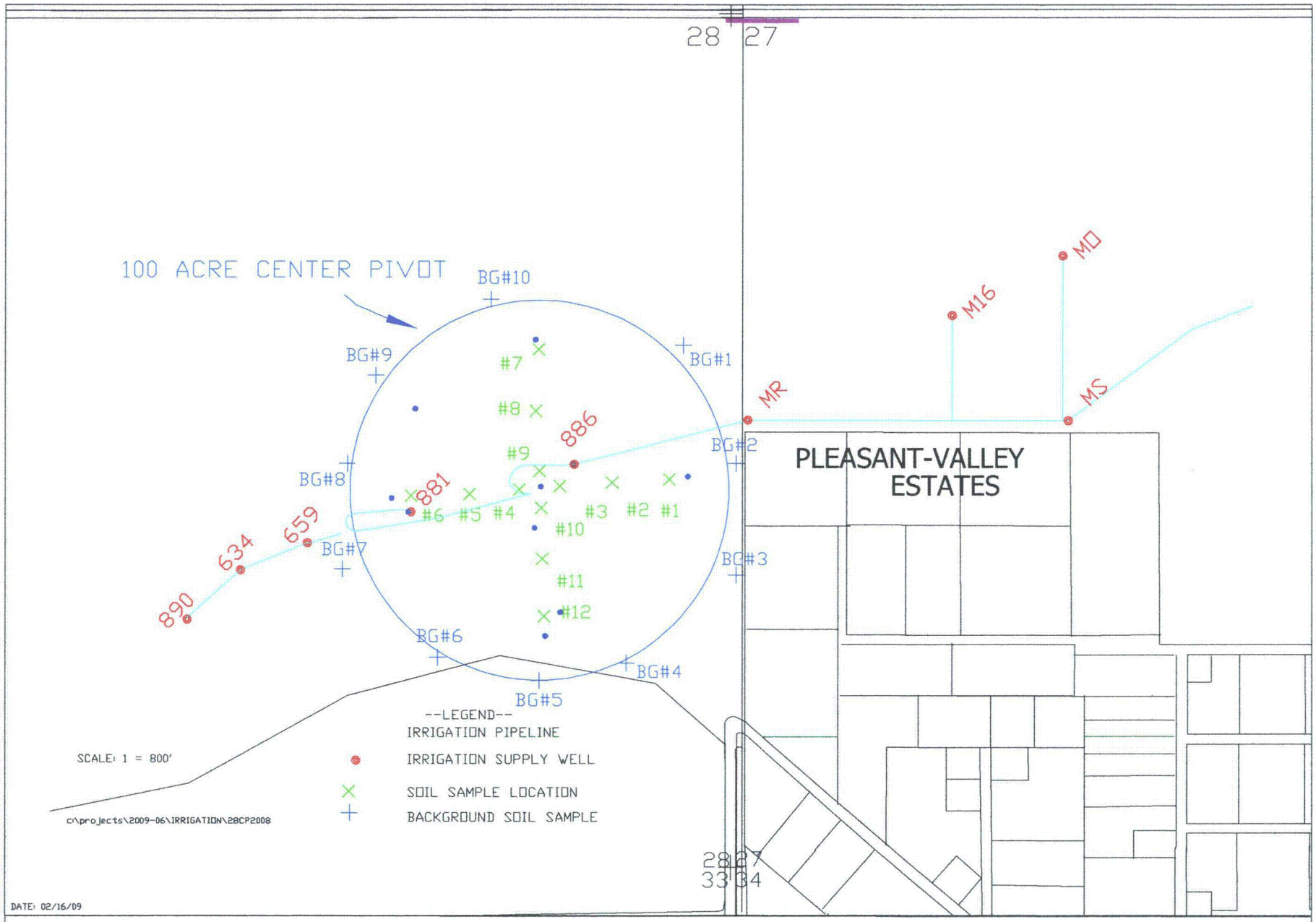

FIGURE 17. 2008 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

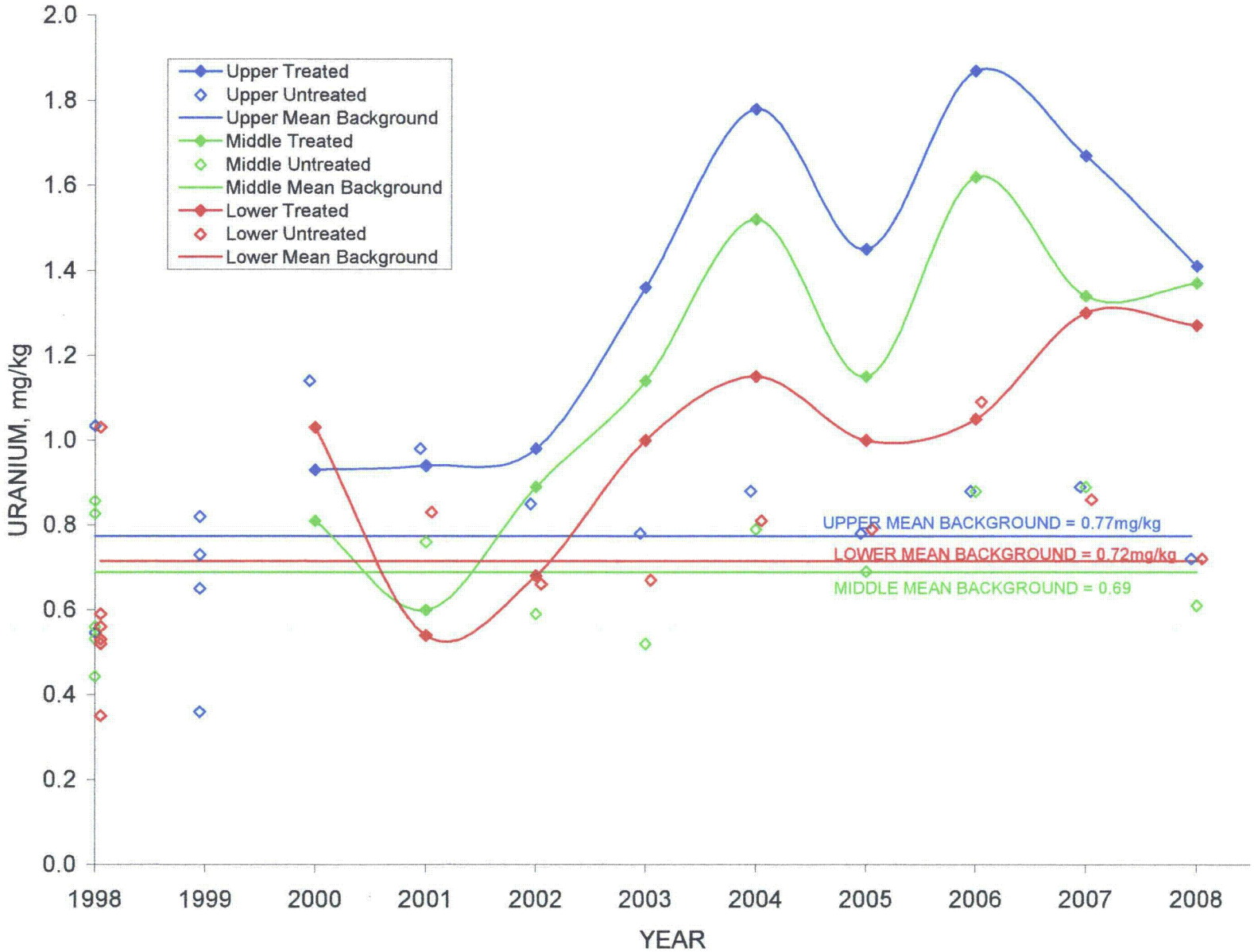

FIGURE 18. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTION 33 CENTER PIVOT SOIL SAMPLES

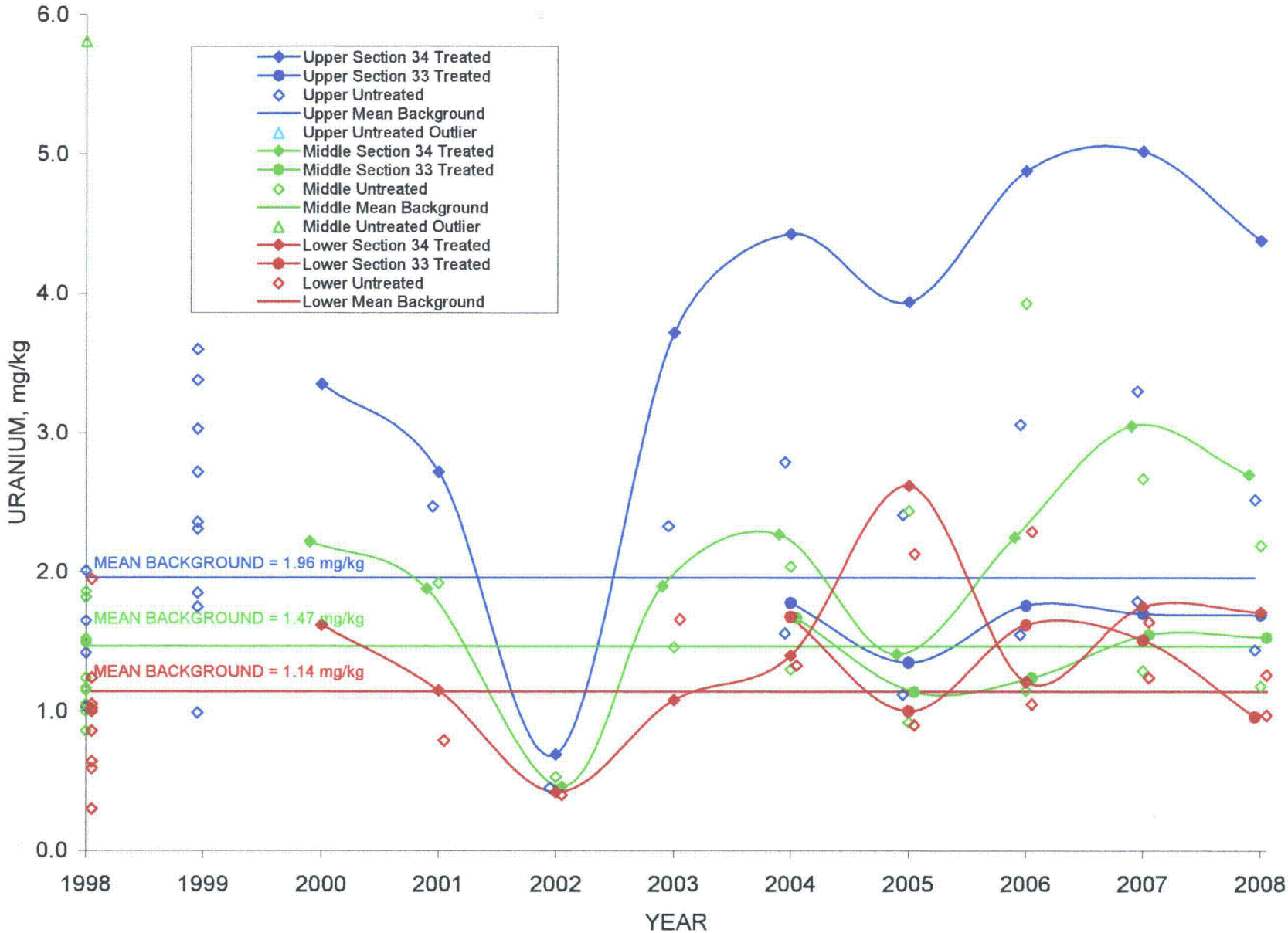

FIGURE 19. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTIONS 33 AND 34 FLOOD SOIL SAMPLES

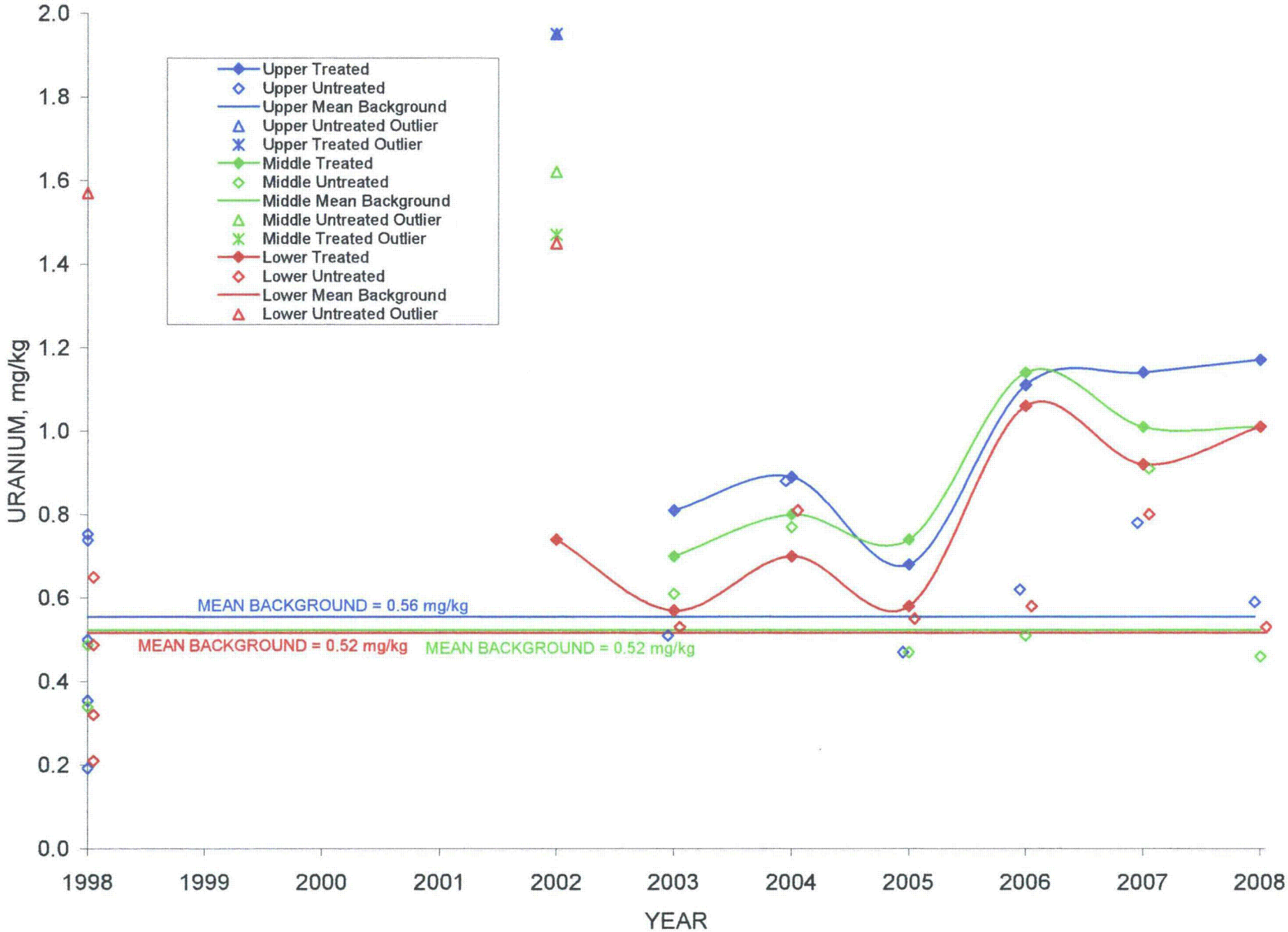

FIGURE 20. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTION 28 CENTER PIVOT SOIL SAMPLES

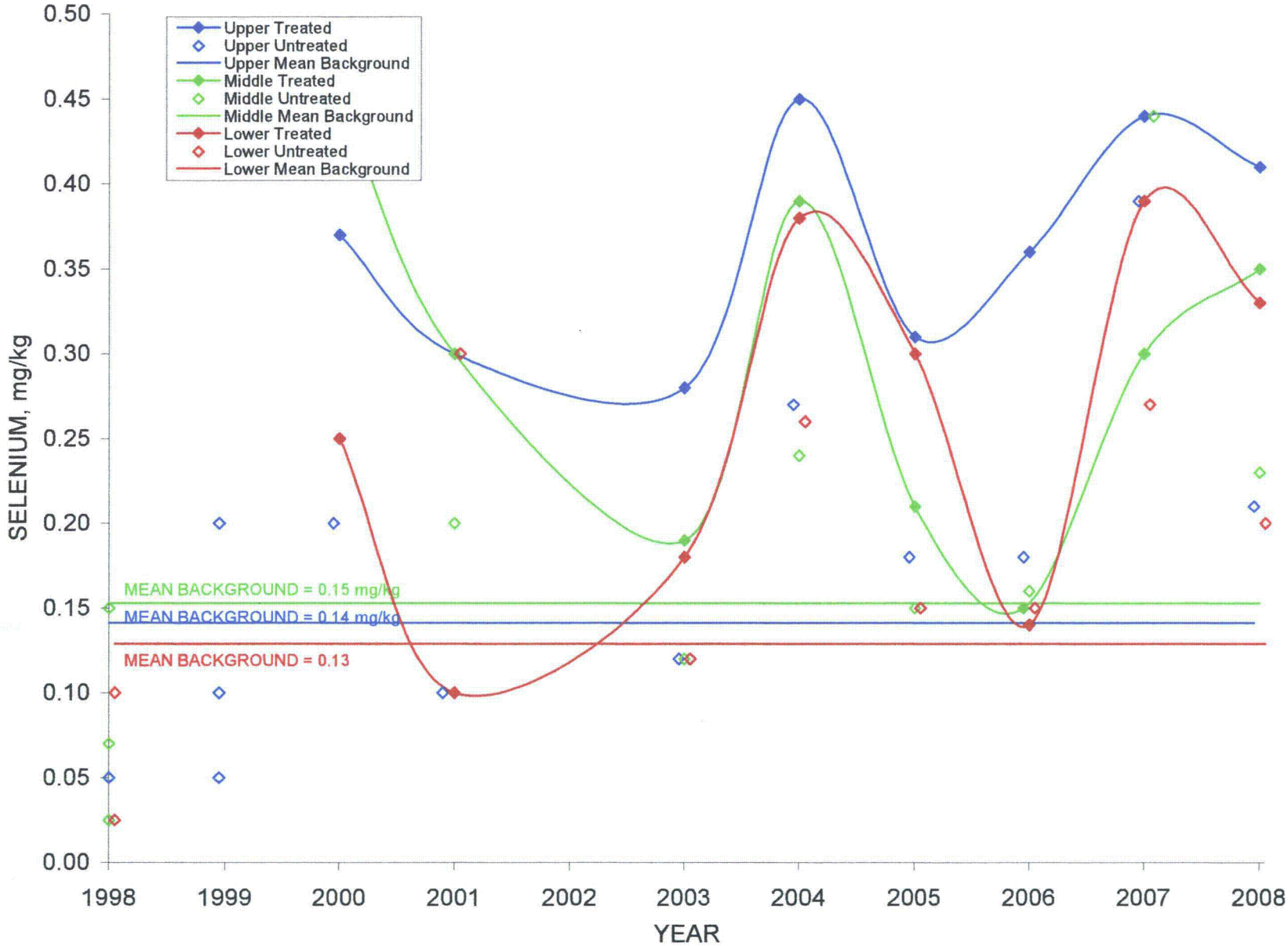

FIGURE 21. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTION 33 CENTER PIVOT SOIL SAMPLES

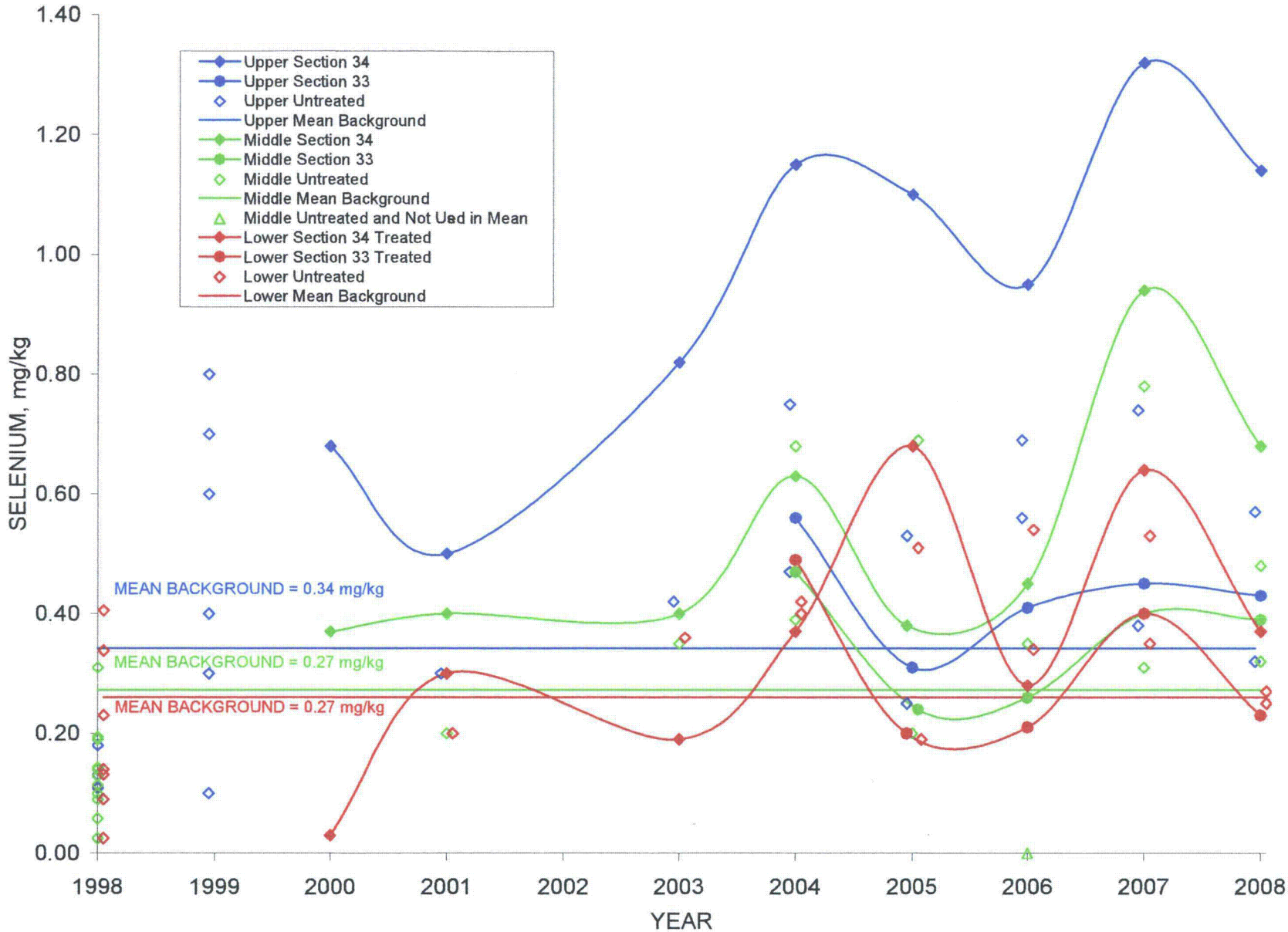

FIGURE 22. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTIONS 33 AND 34 FLOOD SOIL SAMPLES

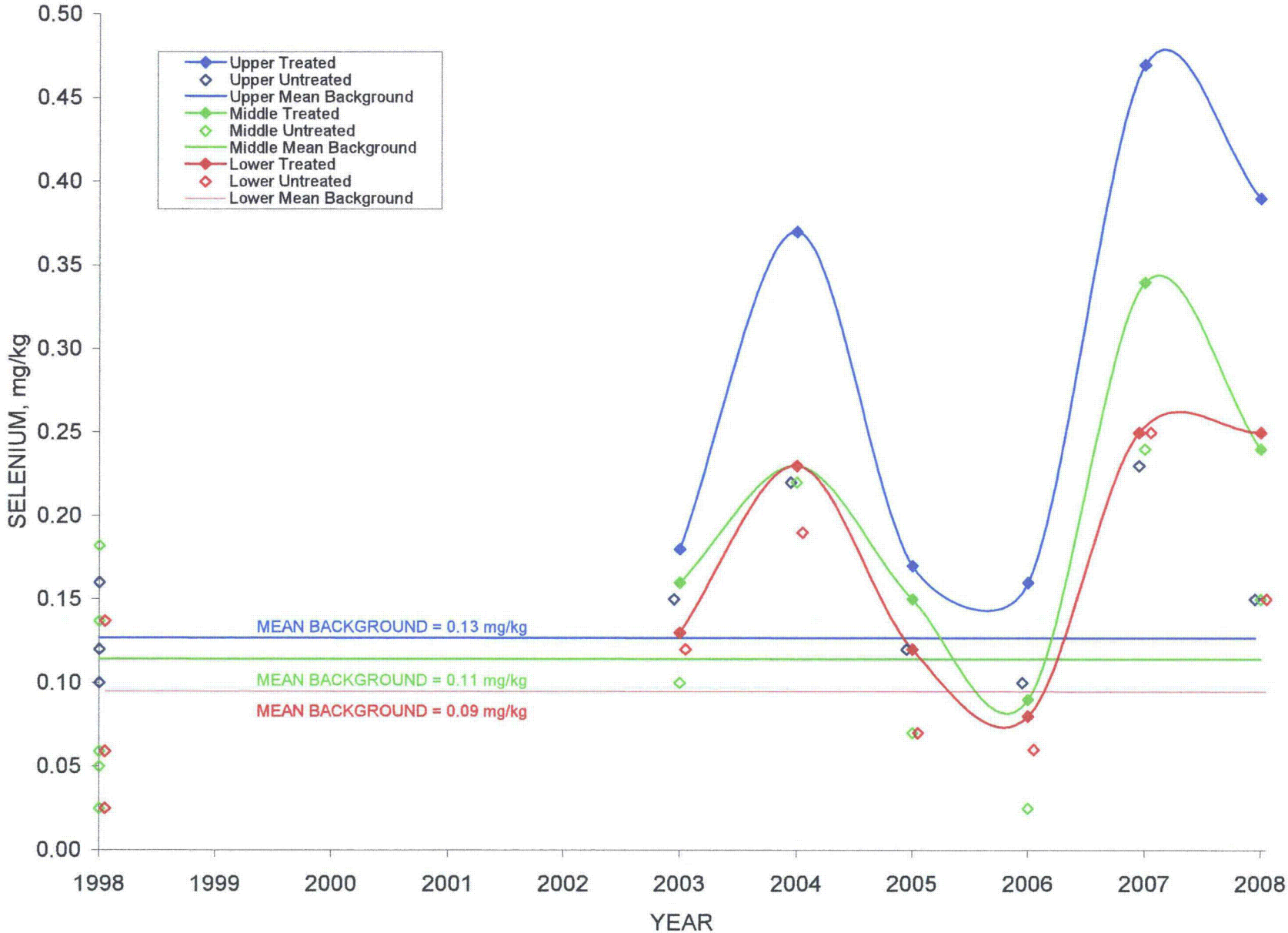

FIGURE 23. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTION 28 CENTER PIVOT SOIL SAMPLES

APPENDIX A

1999 and 2000 Irrigation Soil Analyses

TABLE OF CONTENTS
Appendix A

Page Number

Tables

A-1 1999 and 2000 Irrigation Soil Analyses for Section 33 ..... A-1

A-2 1999 and 2000 Irrigation Soil Analyses for Section 34 ..... A-2

Table A-1. 1999 and 2000 Irrigation Soil Analyses for Section 33

Sample Site	Date	U (mg/kg)	Se (mg/kg)	Mo (mg/kg)	pH (units)	Cond. (mmhos/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR (ratio)	Cl (mg/kg)	SO4 (mg/kg)
						SECTION 33						
33A	10/1/1999	0.36	0.1	<1	7.7	0.350	2.51	0.68	0.28	0.22	13	330
33A1	12/7/2000	0.84	0.6	<1	7.8	1.890	7.84	2.28	10.4	4.62	50	220
33A2	12/7/2000	0.65	0.4	<1	7.7	1.950	8.84	2.55	10.1	4.23	53	210
33A3	12/7/2000	0.62	0.2	<1	7.6	2.170	11.70	3.33	10.0	3.65	49	210
33B	10/1/1999	0.82	0.2	<1	7.7	0.445	3.30	0.73	0.17	0.12	7	40
33B1	12/7/2000	1.05	0.2	<1	7.8	0.576	2.33	0.86	3.18	2.52	14	50
33B2	12/7/2000	0.96	0.5	<1	7.8	1.010	3.75	1.21	5.44	3.45	38	370
33B3	12/7/2000	1.44	0.3	<1	7.6	1.270	5.00	1.24	6.66	3.77	22	210
33C	10/1/1999	0.65	<0.1	<1	7.8	0.474	3.10	0.72	0.15	0.10	35	440
33C1	12/7/2000	0.91	0.3	<1	8	0.495	1.84	0.68	3.42	3.05	13	<50
33D	10/1/1999	0.73	0.2	<1	7.7	0.840	5.48	1.24	0.69	0.37	22	130
33D1	12/7/2000	1.14	0.2	<1	7.6	1.240	9.07	2.64	0.64	0.26	18	<50
	1999 AVG:	0.61	0.12	0.5	7.7	0.423	2.97	0.71	0.20	0.15	18	270
	2000-1 AVG:	0.93	0.37	0.5	7.9	0.987	4.00	1.27	5.67	3.40	26	98
	2000-2 AVG:	0.81	0.45	0.5	7.8	1.480	6.30	1.88	7.77	3.84	46	290
	2000-3 AVG:	1.03	0.25	0.5	7.6	1.720	8.35	2.29	8.33	3.71	36	210

NOTE: 2000 Sample: 1 = 0 - 6 inches, 2 = 6 - 18 inches and 3 = 18 - 36 inches

Table A-2. 1999 and 2000 Irrigation Soil Analyses for Section 34

Sample Site	Date	U (mg/kg)	Se (mg/kg)	Mo (mg/kg)	pH (units)	Cond. (mmhos/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR (ratio)	Cl (mg/kg)	SO4 (mg/kg)
						SECTION 34						
34A	9/29/1999	2.72	0.4	<1	7.7	3.56	17.10	7.40	16.6	4.74	36	1280
34A1	12/7/2000	2.78	0.6	<1	7.7	1.94	8.68	3.29	9.32	3.81	40	350
34A2	12/7/2000	2.49	0.4	<1	7.5	3.13	19.50	6.42	13.2	3.67	52	780
34A3	12/7/2000	1.37	0.2	<1	7.5	2.76	16.30	5.08	12.9	3.95	20	450
34B	9/29/1999	2.36	0.4	<1	7.7	3.89	17.60	7.36	20.3	5.75	54	3470
34B1	12/7/2000	3.61	0.6	<1	7.6	4.01	16.70	7.30	24.3	7.01	72	1020
34B2	12/7/2000	3.04	0.4	<1	7.6	5.03	18.90	9.26	32.8	8.74	159	3490
34B3	12/7/2000	2.02	0.3	<1	7.7	6.27	20.10	7.90	47.0	12.6	106	2220
34C	9/29/1999	1.75	0.3	<1	7.6	5.25	22.90	9.00	29.2	7.31	79	4560
34C1	12/7/2000	3.00	0.4	<1	7.8	1.61	5.46	2.13	9.64	4.95	58	470
34D	9/29/1999	3.60	0.6	<1	7.8	1.40	4.60	2.13	7.28	3.97	36	160
34D1	12/7/2000	3.29	0.5	<1	7.6	3.88	20.20	6.97	21.3	5.78	88	2520
34E	9/29/1999	2.31	0.4	<1	7.8	2.67	12.20	5.24	12.8	4.33	25	690
34E1	12/7/2000	4.21	0.7	<1	7.8	2.26	8.49	3.86	13.8	5.55	44	380
34F	9/29/1999	3.03	0.8	<1	7.7	4.76	22.80	8.80	23.1	5.81	68	5040
34F1	12/7/2000	4.68	1.3	2	7.8	4.18	19.40	9.43	23.0	6.06	66	1140
34G	10/6/1999	1.85	0.3	<1	7.6	1.62	9.39	3.60	1.59	0.62	13	100
34G1	12/7/2000	2.64	0.8	<1	7.6	1.69	8.19	3.50	8.18	3.38	25	150
34G2	12/7/2000	1.13	0.3	<1	7.6	1.55	4.85	2.34	9.73	5.13	24	220
34G3	12/7/2000	1.48	0.4	<1	7.7	1.16	4.50	2.08	6.72	3.70	41	270
34H	10/7/1999	3.38	0.7	<1	8	0.969	3.23	1.13	5.28	3.58	43	520
34H1	12/7/2000	4.23	1.0	<1	7.6	2.75	15.90	4.33	15.0	4.72	52	430
34I	10/7/1999	0.99	0.1	<1	7.8	1.46	4.99	0.89	8.29	4.83	42	480
34I1	12/7/2000	1.73	0.2	<1	7.5	1.03	4.57	1.11	6.72	3.99	59	440
	1999 AVG:	2.44	0.44	0.50	7.7	2.84	12.76	5.06	13.83	4.55	44	1811
	2000-1 AVG:	3.35	0.68	0.67	7.7	2.59	11.95	4.66	14.58	5.03	56	767
	2000-2 AVG:	2.22	0.37	0.50	7.6	3.24	14.42	6.01	18.58	5.85	78	1497
	2000-3 AVG:	1.62	0.30	0.50	7.6	3.40	13.63	5.02	22.21	6.75	56	980

NOTE: 2000 Sample: 1 = 0 - 6 inches, 2 = 6 - 18 inches and 3 = 18 - 36 inches

APPENDIX B

Hay Analyses

TABLE OF CONTENTS
Appendix B

Page Number

B.1 2008 Hay Analyses B-1

Tables

B-1 2000 Hay Analyses B-1
B-2 2001, 2002, 2003 and 2004 Hay Analyses B-2
B-3 2005 through 2008 Hay Analyses B-5

B.1 2008 Hay Analyses

The western 65 acres of the Section 34 flood was tilled and replanted in 2008 with triticale. Triticale was also seeded with the alfalfa in the eastern 55 acres of the Section 34 flood area, but this area was not tilled prior to adding the triticale. Vegetation samples 7-12 of Section 34 flood area in the first cutting are from the west side and therefore are form triticale. Samples 1, 2, 5 and 6 of the second cutting are from the east side and were mostly triticale with some alfalfa. Samples 3 and 4 were from the east side were mostly alfalfa with some triticale.

In the south pivot (Section 33) there was 25 acres of canola seeded into the alfalfa in the southeast quarter. Camelina was also seeded into 25 acres of the western half of the south pivot. The 12 samples collected form the south pivot during the first cutting were alfalfa. The 12 samples collected during the second cut of the south pivot were from alfalfa except for sample number 11.

The 24 acres of flood irrigated area in Section 33 was retilled during 2008. Triticale was planted in the eastern portion of this flood area in 2008, but a crop was not obtained from this area due to the later season planting.

Table B-1. 2000 Hay Analyses

Sample	Uranium (mg/Kg)	Selenium (mg/Kg)	Moisture Content (%)	Percent Solids (%)
Homstake Hay				
Section 33 - 1st Cut	1.12	1.1	2.8	93.9
Section 34 - 1st Cut	0.73	0.5	2.9	95.1
Section 33 - 2nd Cut - Unwashed	0.62	1.4	4.6	95.7
Section 33 - 2nd Cut - Washed	0.58	1.5	33.4	95.9
Other Hay				
Carver	0.19	0.2	13.1	96.4
Elkin	0.05	0.1	7.4	95.7

Table B-2. 2001, 2002, 2003 and 2004 Hay Analyses

Irrigation Area	Sample	2001 Uranium (mg/kg)	2001 Selenium (mg/kg)	2002 Uranium (mg/kg)	2002 Selenium (mg/kg)	2003 Uranium (mg/kg)	2003 Selenium (mg/kg)	2004 Uranium (mg/kg)	2004 Selenium (mg/kg)
Section 33 - 1st Cut	#1	0.460	0.950	0.89	1.40	0.58	2.25	6.90	1.60
	#2	0.650	1.500	1.60	2.17	0.62	1.73	2.40	1.50
	#3	0.700	1.450	1.51	1.39	0.87	2.08	1.90	1.30
	#4	0.550	1.650	0.99	1.89	0.70	1.56	1.70	1.50
	#5	0.690	1.400	1.10	1.40	0.87	2.01	1.50	1.30
	#6	0.490	1.850	1.45	1.83	0.80	1.16	0.70	1.20
	#7	0.500	0.950	1.21	1.93	0.95	1.52	0.90	0.90
	#8	0.600	1.550	1.81	2.36	0.83	1.59	0.70	1.00
	#9	-----	-----	-----	-----	0.68	0.90	0.70	0.70
	#10	-----	-----	-----	-----	0.63	2.15	0.80	0.90
	#11	-----	-----	-----	-----	0.59	1.02	0.80	1.70
	#12	-----	-----	-----	-----	0.64	2.48	0.50	1.30
	Average	*0.580*	*1.413*	*1.32*	*1.80*	*0.73*	*1.70*	*1.63*	*1.24*
Section 33 - 2nd Cut	#1	0.700	1.500	0.17	0.68	0.67	1.56	0.60	0.80
	#2	0.680	1.000	0.31	0.90	0.77	1.75	0.40	0.80
	#3	0.500	1.650	0.32	1.27	0.81	1.44	0.40	1.40
	#4	1.050	1.250	0.38	1.48	0.76	1.26	0.50	1.60
	#5	0.500	0.750	0.51	1.12	0.81	1.68	0.70	0.20
	#6	0.400	0.950	0.33	1.14	0.69	1.98	0.40	<0.2
	#7	0.350	0.550	0.35	1.57	0.57	1.67	0.40	0.60
	#8	0.350	0.750	0.59	1.23	0.39	0.60	0.40	0.70
	#9	-----	-----	-----	-----	0.68	0.99	0.90	0.90
	#10	-----	-----	-----	-----	0.89	2.07	0.50	0.40
	#11	-----	-----	-----	-----	0.82	1.36	0.40	0.50
	#12	-----	-----	-----	-----	0.54	1.22	0.50	0.30
	Average	*0.566*	*1.050*	*0.37*	*1.17*	*0.70*	*1.47*	*0.51*	*0.69*
Section 33 - 3rd Cut	#1 Pivot	0.252	0.990	0.54	1.36	0.49	1.05	0.71	1.10
	#2 Pivot	0.286	0.930	0.93	1.68	0.73	1.43	0.73	1.20
	#3 Pivot	0.322	1.260	1.10	1.64	0.90	2.00	0.46	1.10
	#4 Pivot	0.202	1.450	0.96	1.82	0.46	1.15	0.55	0.90
	#5 Pivot	0.289	1.090	0.78	2.12	0.43	1.36	0.67	1.40
	#6 Pivot	0.250	0.820	0.61	2.13	0.58	1.60	0.60	1.00
	#7 Pivot	0.312	0.620	0.69	1.66	0.57	1.59	1.20	1.60
	#8 Pivot	0.479	1.110	0.59	2.07	0.81	0.83	1.31	1.00
	#9 Pivot	0.177	0.510	-----	-----	0.45	1.39	1.39	1.30
	#10 Pivot	0.195	0.680	-----	-----	1.97	3.59	1.09	1.50
	#11 Pivot	0.205	0.680	-----	-----	0.60	1.20	0.92	1.40
	#12 Pivot	0.182	0.660	-----	-----	0.78	1.35	1.18	1.40
	#13 Pivot	0.703	1.080	-----	-----	-----	-----	-----	-----
	#14 Pivot	0.522	0.930	-----	-----	-----	-----	-----	-----
	#15 Pivot	0.263	0.620	-----	-----	-----	-----	-----	-----
	#16 Pivot	0.104	0.460	-----	-----	-----	-----	-----	-----
	Average	*0.296*	*0.868*	*0.78*	*1.81*	*0.73*	*1.55*	*0.90*	*1.24*

Table B-2. 2001, 2002, 2003 and 2004 Hay Analyses (cont.)

Irrigation Area	Sample	2001 Uranium (mg/kg)	2001 Selenium (mg/kg)	2002 Uranium (mg/kg)	2002 Selenium (mg/kg)	2003 Uranium (mg/kg)	2003 Selenium (mg/kg)	2004 Uranium (mg/kg)	2004 Selenium (mg/kg)
Section 34 - 1st Cut	#1	0.600	0.950	0.73	0.82	0.74	2.02	1.30	1.70
	#2	0.750	1.250	0.94	1.38	1.40	1.86	1.20	1.50
	#3	0.550	0.950	0.84	0.82	0.61	1.40	0.90	0.90
	#4	0.650	0.600	0.75	0.74	0.92	1.67	1.10	1.30
	#5	0.450	0.750	0.59	0.41	0.92	1.12	1.50	1.30
	#6	0.500	0.800	1.62	0.83	1.06	2.08	0.70	1.20
	#7	0.550	1.950	-----	-----	0.61	1.52	0.90	0.80
	#8	0.400	1.050	-----	-----	0.66	1.68	0.70	0.90
	#9	0.450	1.200	-----	-----	0.49	1.44	1.40	1.50
	#10	0.600	1.000	-----	-----	0.39	1.67	1.00	1.00
	#11	-----	-----	-----	-----	0.97	1.45	1.00	0.90
	#12	-----	-----	-----	-----	1.87	1.53	0.60	1.30
	Average	*0.550*	*1.050*	*0.91*	*0.83*	*0.89*	*1.62*	*1.03*	*1.19*
Section 34 - 2nd Cut	#1 Flood	0.203	0.900	1.63	0.95	0.69	1.18	0.80	<0.2
	#2 Flood	0.420	1.420	0.84	1.05	0.47	0.56	1.00	0.30
	#3 Flood	0.318	0.440	3.51	1.48	0.59	1.09	0.80	<0.2
	#4 Flood	0.402	1.050	0.89	0.96	0.44	0.50	0.90	0.30
	#5 Flood	0.358	0.530	0.53	1.28	0.71	0.92	0.70	0.50
	#6 Flood	0.195	0.330	1.72	1.14	0.58	0.54	1.10	0.20
	#7 Flood	0.450	1.120	-----	-----	0.41	0.79	-----	-----
	#8 Flood	0.514	0.660	-----	-----	-----	-----	-----	-----
	#9 Flood	0.408	1.160	-----	-----	-----	-----	-----	-----
	#10 Flood	0.535	0.610	-----	-----	-----	-----	-----	-----
	Average	*0.380*	*0.822*	*1.52*	*1.14*	*0.56*	*0.80*	*0.88*	*0.25*
Section 34 - 3rd Cut	#1 Flood	1.040	1.110	0.81	1.20	1.56	2.32	-----	-----
	#2 Flood	0.672	0.712	0.44	1.59	1.36	1.19	-----	-----
	#3 Flood	0.538	0.817	0.32	0.62	1.28	1.40	-----	-----
	#4 Flood	0.489	0.630	0.48	1.00	0.87	0.75	-----	-----
	#5 Flood	0.612	0.530	0.65	1.03	1.18	1.60	-----	-----
	#6 Flood	0.823	0.710	0.53	0.94	1.00	1.19	-----	-----
	#7 Flood	0.586	0.782	-----	-----	1.32	0.62	-----	-----
	#8 Flood	0.948	0.980	-----	-----	1.59	0.74	-----	-----
	#9 Flood	-----	-----	-----	-----	0.80	1.18	-----	-----
	#10 Flood	-----	-----	-----	-----	0.91	0.44	-----	-----
	#11 Flood	-----	-----	-----	-----	1.16	0.92	-----	-----
	#12 Flood	-----	-----	-----	-----	0.74	0.93	-----	-----
	Average	*0.714*	*0.784*	*0.54*	*1.06*	*1.15*	*1.11*	-----	-----
Section 34 - 4th Cut	#1 Flood	-----	-----	0.80	1.65	-----	-----	-----	-----
	#2 Flood	-----	-----	0.97	1.09	-----	-----	-----	-----
	#3 Flood	-----	-----	1.29	1.21	-----	-----	-----	-----
	#4 Flood	-----	-----	0.58	0.50	-----	-----	-----	-----
	#5 Flood	-----	-----	0.84	1.48	-----	-----	-----	-----
	#6 Flood	-----	-----	0.83	1.11	-----	-----	-----	-----
	Average	-----	-----	*0.89*	*1.17*	-----	-----	-----	-----

Table B-2. 2001, 2002, 2003 and 2004 Hay Analyses (cont.)

Irrigation Area	Sample	2001 Uranium (mg/kg)	2001 Selenium (mg/kg)	2002 Uranium (mg/kg)	2002 Selenium (mg/kg)	2003 Uranium (mg/kg)	2003 Selenium (mg/kg)	2004 Uranium (mg/kg)	2004 Selenium (mg/kg)
Section 28 - 1st Cut	#1 Pivot 2	-----	-----	0.40	0.81	0.68	1.30	1.16	1.00
	#2 Pivot 2	-----	-----	0.27	0.74	1.50	1.52	1.25	1.00
	#3 Pivot 2	-----	-----	0.28	0.65	1.74	1.18	1.79	1.10
	#4 Pivot 2	-----	-----	0.33	0.86	0.81	1.82	1.07	1.00
	#5 Pivot 2	-----	-----	0.23	0.99	0.86	1.70	1.57	1.40
	#6 Pivot 2	-----	-----	0.25	0.70	0.98	1.82	1.08	1.20
	#7 Pivot 2	-----	-----	-----	-----	0.61	1.54	0.94	1.10
	#8 Pivot 2	-----	-----	-----	-----	0.93	1.89	0.85	0.90
	#9 Pivot 2	-----	-----	-----	-----	1.28	1.53	0.67	0.70
	#10 Pivot 2	-----	-----	-----	-----	0.81	1.70	1.18	1.00
	#11 Pivot 2	-----	-----	-----	-----	0.83	1.87	0.68	1.00
	#12 Pivot 2	-----	-----	-----	-----	0.84	1.52	0.80	1.00
	Average	-----	-----	*0.29*	*0.79*	*0.99*	*1.62*	*1.09*	*1.03*
Section 28 - 2nd Cut	#1 Pivot 2	-----	-----	-----	-----	1.26	1.36	0.80	<0.2
	#2 Pivot 2	-----	-----	-----	-----	0.72	1.45	0.80	0.30
	#3 Pivot 2	-----	-----	-----	-----	0.77	1.14	0.70	0.40
	#4 Pivot 2	-----	-----	-----	-----	0.82	1.37	1.10	1.60
	#5 Pivot 2	-----	-----	-----	-----	1.21	1.31	1.30	1.20
	#6 Pivot 2	-----	-----	-----	-----	0.97	1.80	1.50	1.40
	#7 Pivot 2	-----	-----	-----	-----	0.66	1.15	1.20	1.80
	#8 Pivot 2	-----	-----	-----	-----	0.91	1.41	0.90	1.00
	#9 Pivot 2	-----	-----	-----	-----	0.88	0.84	1.50	1.30
	#10 Pivot 2	-----	-----	-----	-----	1.16	1.28	0.90	1.40
	#11 Pivot 2	-----	-----	-----	-----	0.94	1.08	1.90	1.20
	#12 Pivot 2	-----	-----	-----	-----	1.44	1.18	1.40	1.20
	Average	-----	-----	-----	-----	*0.98*	*1.28*	*1.17*	*1.08*
Section 28 - 3rd Cut	#1 Pivot 2	-----	-----	-----	-----	1.54	1.57	0.73	1.50
	#2 Pivot 2	-----	-----	-----	-----	0.79	0.86	1.12	1.60
	#3 Pivot 2	-----	-----	-----	-----	0.78	1.14	0.96	1.20
	#4 Pivot 2	-----	-----	-----	-----	1.33	1.29	1.12	1.80
	#5 Pivot 2	-----	-----	-----	-----	1.40	0.58	0.63	0.80
	#6 Pivot 2	-----	-----	-----	-----	1.14	1.41	0.79	1.10
	#7 Pivot 2	-----	-----	-----	-----	0.94	0.49	0.91	1.00
	#8 Pivot 2	-----	-----	-----	-----	1.44	0.96	0.49	0.40
	#9 Pivot 2	-----	-----	-----	-----	1.00	0.81	0.83	1.30
	#10 Pivot 2	-----	-----	-----	-----	0.81	0.37	1.20	0.60
	#11 Pivot 2	-----	-----	-----	-----	1.14	1.02	0.58	0.20
	#12 Pivot 2	-----	-----	-----	-----	1.35	1.46	0.84	0.80
	Average	-----	-----	-----	-----	*1.14*	*1.00*	*0.85*	*1.03*

Table B-3. 2005 through 2008 Hay Analyses

Irrigation Area	Sample	2005 Uranium (mg/kg)	2005 Selenium (mg/kg)	2006 Uranium (mg/kg)	2006 Selenium (mg/kg)	2007 Uranium (mg/kg)	2007 Selenium (mg/kg)	2008 Uranium (mg/kg)	2008 Selenium (mg/kg)
Section 33 - Pivot - 1st Cut	#1	0.9	1.5	0.7	1.2	0.7	0.7	0.3	1.3
	#2	0.8	1.5	1.2	1.4	0.9	1.2	0.8	1.3
	#3	0.8	0.8	0.1	1.2	1.3	1.6	0.8	1.4
	#4	1.1	0.8	1.1	1.3	0.7	0.7	0.4	1.4
	#5	0.7	1.2	0.7	1.5	0.9	1.3	0.7	1.5
	#6	0.9	1.2	0.9	1.2	1.2	1.5	0.3	0.8
	#7	0.8	1.5	0.8	1.2	0.8	1.0	0.5	1.1
	#8	0.8	1.5	0.9	1.1	1.0	1.3	0.4	0.7
	#9	0.6	1.0	0.6	1.1	1.6	1.8	0.6	1.0
	#10	1.0	1.1	1.0	1.4	1.1	1.4	0.2	1.3
	#11	0.9	1.6	0.9	1.2	1.3	1.7	0.2	0.8
	#12	0.8	1.3	0.7	1.2	1.0	1.1	0.4	1.1
	Average	*0.84*	*1.3*	*0.80*	*1.3*	*1.04*	*1.3*	*0.47*	*1.1*
Section 33 - Pivot - 2nd Cut	#1	0.6	1.3	0.6	1.4	1.7	1.2	1.7	3.1
	#2	0.5	1.3	0.7	1.5	0.8	0.6	1.2	1.1
	#3	0.7	1.4	0.7	1.0	0.9	1.5	1.3	1.6
	#4	1.3	1.4	0.6	1.8	1.1	1.5	0.8	1.3
	#5	0.6	1.2	0.5	0.5	1.2	0.7	0.6	0.7
	#6	0.8	1.1	0.6	2.1	1.2	1.6	0.6	0.6
	#7	0.6	1.6	0.7	1.1	1.3	1.1	0.4	1.2
	#8	0.5	1.4	0.5	0.7	0.9	1.6	0.5	1.2
	#9	0.6	1.0	0.7	1.0	0.8	1.0	0.3	0.9
	#10	0.6	1.6	0.4	1.6	2.1	2.0	0.7	1.4
	#11	0.5	1.0	0.7	1.4	0.9	1.6	0.7	1.3
	#12	0.4	1.2	0.7	1.4	1.2	1.8	1.2	1.2
	Average	*0.64*	*1.3*	*0.62*	*1.3*	*1.18*	*1.4*	*0.83*	*1.3*
Section 33 - Pivot - 3rd Cut	#1	0.7	1.1	0.5	1.6	1.7	1.2	----	----
	#2	0.7	1.3	0.5	1.0	2.0	1.2	----	----
	#3	0.4	0.8	0.6	1.0	1.8	1.2	----	----
	#4	0.5	0.9	0.4	0.9	1.5	1.9	----	----
	#5	0.9	1.2	0.6	0.9	1.5	1.9	----	----
	#6	0.8	1.6	0.4	0.8	0.9	1.6	----	----
	#7	0.8	1.3	0.3	0.9	1.7	1.7	----	----
	#8	0.6	1.2	0.4	1.0	1.5	1.9	----	----
	#9	1.0	2.6	0.5	1.2	2.0	1.3	----	----
	#10	0.6	1.2	0.3	0.7	1.4	1.5	----	----
	#11	0.7	0.9	0.5	1.1	1.3	1.1	----	----
	#12	0.8	1.1	0.4	0.9	1.9	1.0	----	----
	Average	*0.71*	*1.3*	*0.45*	*1.0*	*1.60*	*1.5*	----	----

Table B-3. 2005 through 2008 Hay Analyses (cont.)

Irrigation Area	Sample	2005 Uranium (mg/kg)	2005 Selenium (mg/kg)	2006 Uranium (mg/kg)	2006 Selenium (mg/kg)	2007 Uranium (mg/kg)	2007 Selenium (mg/kg)	2008 Uranium (mg/kg)	2008 Selenium (mg/kg)
Section 33 - Flood - 1st Cut	#1	0.5	0.3	----	----	----	----	----	----
	#2	0.3	<0.20	----	----	----	----	----	----
	Average	*0.40*	*<0.25*	----	----	----	----	----	----
Section 34 - Flood - 1st Cut	#1	2.0	1.8	0.7	0.9	1.3	2.4	----	----
	#2	1.8	1.7	1.1	0.9	0.7	1.3	----	----
	#3	1.4	2.0	1.2	0.6	0.9	1.0	----	----
	#4	0.6	1.7	0.8	0.6	1.2	1.6	----	----
	#5	2.4	2.0	0.8	0.7	0.8	1.4	----	----
	#6	2.1	1.7	0.7	1.0	1.2	0.9	----	----
	#7	1.6	2.5	0.8	0.8	----	----	0.3	2.0
	#8	3.0	2.7	0.6	0.7	----	----	0.2	1.8
	#9	2.2	1.7	0.6	0.9	----	----	0.2	1.1
	#10	2.4	1.5	0.6	0.4	----	----	1.2	2.2
	#11	1.0	1.9	----	----	----	----	0.8	1.8
	#12	1.3	1.6	----	----	----	----	0.2	1.9
	Average	*1.8*	*1.9*	*0.79*	*0.75*	*1.02*	*1.43*	*0.49*	*1.8*
Section 34 - Flood - 2nd Cut	#1	0.7	0.7	1.3	1.1	----	----	0.3	1.2
	#2	0.7	1.0	0.9	1.3	----	----	0.2	1.1
	#3	1.0	1.1	0.8	0.9	----	----	0.6	0.6
	#4	0.9	0.8	0.5	2.5	----	----	0.6	1.4
	#5	0.8	0.6	0.6	1.9	----	----	0.2	0.7
	#6	1.2	0.6	0.6	0.7	----	----	0.3	0.7
	#7	----	----	----	----	----	----	0.4	0.7
	#8	----	----	----	----	----	----	0.5	2.5
	#9	----	----	----	----	----	----	0.4	1.3
	#10	----	----	----	----	----	----	0.7	1.2
	#11	----	----	----	----	----	----	0.3	0.7
	#12	----	----	----	----	----	----	0.2	0.9
	Average	*0.9*	*0.8*	*0.78*	*1.40*	----	----	*0.43*	*1.3*

Table B-3. 2005 through 2008 Hay Analyses (cont.)

Irrigation Area	Sample	2005 Uranium (mg/kg)	2005 Selenium (mg/kg)	2006 Uranium (mg/kg)	2006 Selenium (mg/kg)	2007 Uranium (mg/kg)	2007 Selenium (mg/kg)	2008 Uranium (mg/kg)	2008 Selenium (mg/kg)
Section 28 - Pivot - 1st Cut	#1	1.6	1.4	1.0	0.6	0.7	1.0	1.6	1.4
	#2	1.6	1.7	1.2	1.1	1.1	1.2	1.5	1.4
	#3	2.1	1.7	1.0	0.8	0.9	1.2	2.3	1.6
	#4	1.8	1.8	1.5	1.3	0.9	0.9	2.2	1.8
	#5	1.8	1.1	1.5	1.3	0.6	0.6	1.5	1.7
	#6	1.5	1.5	1.3	1.7	0.6	0.7	1.3	1.3
	#7	1.5	1.6	0.7	1.1	0.6	0.7	1.3	1.4
	#8	1.9	0.9	1.3	1.5	1.0	0.7	2.3	1.6
	#9	3.3	1.5	1.3	1.1	1.3	1.0	1.2	1.6
	#10	1.9	1.5	1.4	1.4	0.7	1.1	2.0	1.5
	#11	1.7	2.4	1.3	1.2	0.9	1.0	1.4	1.6
	#12	1.3	0.9	1.0	0.9	0.9	0.9	1.6	1.4
	Average	*1.8*	*1.5*	*1.2*	*1.2*	*0.9*	*0.9*	*1.68*	*1.5*
Section 28 - Pivot - 2nd Cut	#1	0.8	1.3	0.5	1.5	1.3	1.4	----	----
	#2	0.9	1.4	0.9	1.2	0.7	1.0	----	----
	#3	1.0	1.4	1.3	1.5	0.8	0.8	----	----
	#4	0.8	1.1	0.7	1.7	1.0	1.0	----	----
	#5	1.0	1.3	0.6	1.3	0.9	1.0	----	----
	#6	0.9	1.3	0.6	1.5	1.5	1.3	----	----
	#7	1.1	0.9	0.8	1.0	2.4	1.1	----	----
	#8	0.6	1.2	1.0	1.3	1.8	1.6	----	----
	#9	0.9	1.3	0.7	0.8	1.3	1.1	----	----
	#10	0.9	1.0	0.6	1.2	1.7	1.3	----	----
	#11	1.5	1.1	0.7	1.1	2.2	1.1	----	----
	#12	0.9	1.6	0.8	1.1	3.5	1.2	----	----
	Average	*0.9*	*1.2*	*0.8*	*1.3*	*1.6*	*1.2*	----	----
Section 28 - Pivot - 3rd Cut	#1	1.2	1.6	0.8	0.9	1.6	1.8	----	----
	#2	1.2	1.8	0.7	0.7	1.1	1.3	----	----
	#3	1.0	1.9	0.7	0.7	0.9	1.5	----	----
	#4	1.7	1.4	0.9	1.0	0.6	1.0	----	----
	#5	1.5	1.4	0.7	1.1	0.8	1.4	----	----
	#6	1.5	1.2	0.8	1.1	1.7	1.6	----	----
	#7	1.4	1.2	0.9	1.0	1.1	1.3	----	----
	#8	1.2	1.3	0.2	1.1	1.2	1.2	----	----
	#9	1.8	1.3	0.5	1.0	1.4	1.2	----	----
	#10	1.4	1.5	0.3	1.0	1.5	1.3	----	----
	#11	1.8	1.2	0.4	0.8	1.2	1.4	----	----
	#12	1.4	1.9	0.5	1.0	0.9	1.0	----	----
	Average	*1.4*	*1.5*	*0.62*	*0.95*	*1.17*	*1.33*	----	----