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March 19, 2009

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Dallas, TX 75202

Re: *Homestake Mining Company's Comments to
Draft Final Remedial System Evaluation*

Dear Mr. Appajii:

Enclosed please find Homestake Mining Company's ("HMC") comments to the Draft Final Remedial System Evaluation ("RSE") Report for the HMC site located in Grants, New Mexico. As evidenced by HMC's comments, HMC believes the review of the current groundwater extraction and treatment system in place at this site indicates the current system is working to reclaim the site.

HMC appreciates the opportunity to comment on the RSE and looks forward to discussing these comments with EPA.

Very truly yours,



Jon J. Indall

JJI:rlr
Enclosure

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*SUNSI Review Completed
per John Buckley
Public Available*

*FSME 21
Add: John Buckley
E-RDS*

HOMESTAKE MINING COMPANY'S
COMMENTS TO DRAFT FINAL
REMEDIATION SYSTEM EVALUATION
GRANTS SITE
MARCH 19, 2009

TABLE OF CONTENTS

Exhibits:

- Exhibit 1: HMC's comments to draft ATSDR report
- Exhibit 2: MOA with NMED, dated January 12, 2009
- Exhibit 3: Copy of HMC's latest irrigation report

A. General Comments		1
	Comment 1	1
	Comment 2	1
	Comment 3	2
Transmittal Letter	Comment 4	2
Transmittal Letter, Bullet Point 1	Comment 4(a)	3
Transmittal Letter, Bullet Point 2	Comment 4(b)	3
Transmittal Letter, Bullet Point 3	Comment 4(c)	4
Transmittal Letter, Bullet Point 4	Comment 4(d)	4
Transmittal Letter, Bullet Point 5	Comment 4(e)	4
Transmittal Letter, Bullet Point 6	Comment 4(f)	5
	Comment 5(a)	5
	Comment 5(b)	6
	Comment 5(c)	6
B. Executive Summary		7
Page iii, ¶ 2	Comment 6	7
Page iii, ¶ 4	Comment 7	7
Page iii, ¶ 5	Comment 8	7
Page iii, ¶ 5	Comment 9	7
Page iii, ¶ 5 last sentence	Comment 10	7
	Comment 11	8
	Comment 11(a)	8
	Comment 11(b)	8
	Comment 11(c)	8
	Comment 11(d)	8
	Comment 11(e)	9
Page iv, ¶ 3	Comment 12	9
	Comment 12(a)	9
	Comment 12(b)	9
	Comment 12(c)	10
	Comment 12(d)	10
	Comment 12(e)	10
	Comment 12(f)	11
	Comment 12(g)	11
	Comment 12(h)	11

Comment 12(i)	12
Comment 12(j)	12
Comment 12(k)	13

C. Report **13**

Page 1, ¶ 3	Comment 13	13
Page 2, ¶ 2	Comment 14	14
Page 2, § 1.3	Comment 15	14
Page 2, § 1.4	Comment 16	14
Page 2, § 1.4	Comment 17	14
Page 4, § 1.5.1, ¶ 3, fifth sentence	Comment 18	14
Page 4, § 1.5.2, ¶ 1	Comment 19	14
Page 8, § 1.5.2.2, ¶ 2	Comment 20	15
Page 10, § 1.5.3.3 ¶ 1	Comment 21	15
Page 11, § 1.5.3.3 ¶ 1, line 1	Comment 22	15
Page 11, § 1.5.3.3 ¶ 1, lines 6 and 7	Comment 23	15
Page 11, § 1.5.3.4, ¶ 1, line 4	Comment 24	15
Page 11, § 1.5.3.4, ¶ 1, lines 6 and 7	Comment 25	15
Page 11, § 1.5.3.5, ¶ 1, lines 5 and 6	Comment 26	16
Page 12, § 1.5.4, ¶ 2	Comment 27	16
Page 12, § 1.5.4, ¶ 4	Comment 28	16
Page 15, § 2.2.1, first full ¶	Comment 29	16
Page 15, § 2.2.2, ¶ 1, line 3	Comment 30	17
Page 15, § 2.2.2, ¶ 1, line 8	Comment 31	17
Page 15, § 2.2.2, ¶ 3	Comment 32	17
Page 16, § 2.2.4, ¶ 1	Comment 33	17
Page 16, § 2.2.5, ¶ 1	Comment 34	17
Page 16, § 2.2.5, ¶ 1, lines 3 and 4	Comment 35	17
Page 16, § 2.2.3, ¶ 2, lines 6 to 8	Comment 36	17
Page 18, § 2.3.2, ¶ 1, line 2	Comment 37	18
Page 18, § 2.3.3, ¶ 1, line 3	Comment 38	17
Page 19, § 2.5.2, ¶ 1, line 2	Comment 39	18
Page 19, § 2.5.1, ¶ 1, line 14	Comment 40	18
Page 19, § 2.5.2, ¶ 2, lines 1 to 3	Comment 41	18
Page 20, § 2.5.2, ¶ 1, line 2	Comment 42	18
Page 20, § 2.5.2, ¶ 3, last sentence	Comment 43	19
Page 20, § 2.6, ¶ 1	Comment 44	19
Page 21, § 3.1, ¶ 4, lines 1 and 2	Comment 45	19
Page 23, § 4.1, ¶ 2	Comment 46	19
Page 24, § 4.2.1.1, ¶ 2, line 5	Comment 47	20
Page 24, § 4.2.1.1, ¶ 2	Comment 48	20
Page 24, § 4.2.1.1, ¶ 3, last sentence	Comment 49	20
Page 24, § 4.2.1.2, ¶ 1, second sentence	Comment 50	20
Page 26, § 4.2.1.2, ¶ 3	Comment 51	20
Page 26, § 4.3.1.2, ¶ 2, fourth sentence	Comment 52	20

Page 27, § 4.3.2, ¶ 1, last sentence	Comment 53	21
Page 27, § 4.3.2, ¶ 2	Comment 54	21
Page 27, § 4.3.2, ¶ 3, lines 9 and 10	Comment 55	21
Pages 27-28, § 4.3.3	Comment 56	21
Page 28, § 4.3.3, ¶ 2	Comment 57	21
Page 28, § 4.3.3, ¶ 7	Comment 58	22
Page 29, § 4.3.4, ¶ 1	Comment 59	22
Page 29, § 4.3.4, ¶ 2	Comment 60	23
Page 29, § 4.3.5, ¶ 1	Comment 61	23
Page 29, § 4.3.5, ¶ 2, last line	Comment 62	23
Page 32, § 4.6, ¶ 1, lines 2 to 4	Comment 63	23
Page 32, § 4.6, ¶ 2	Comment 64	24
Page 32, § 4.8, ¶ 2, lines 5 and 6	Comment 65	24
Page 33, § 4.8, ¶ 2, lines 1 and 2		
Page 34, § 5.1, ¶ 3, last sentence	Comment 66	24
Page 35, § 5.2, ¶ 1, last sentence	Comment 67	25
Page 35, § 5.4, ¶ 1	Comment 68	25
Page 36, § 5.4, ¶ 2, top of page	Comment 69	25
Page 36, § 5.4, ¶ 3	Comment 70	26
Page 36, § 5.6, ¶ 1	Comment 71	26
Page 37, § 5.7.2, ¶ 1, line 5	Comment 72	26
Page 37, § 5.7.3, ¶ 1	Comment 73	26
Page 37, § 5.7.4, ¶ 1	Comment 74	26
Page 37, § 5.7.4, ¶ 2	Comment 75	27
Page 38, § 6.1, ¶ 2, lines 3 and 4; lines 5 and 6	Comment 76	27
Page 38, § 6.1.1	Comment 77	27
Page 39, § 6.1.2, ¶ 1	Comment 78	27
Page 39, § 6.1.3, ¶ 1	Comment 79	27
Page 39, § 6.1.4, ¶ 1	Comment 80	28
Page 39-40, § 6.1.5, ¶¶ 1 and 2	Comment 81	28
Page 40, § 6.1.5, ¶ 2	Comment 82	28
Page 40, § 6.1.6, ¶ 1	Comment 83	28
Page 40, § 6.1.6	Comment 84	28
Page 40, § 6.1.7, ¶ 1, line 2	Comment 85	28
Page 40, § 6.1.7, ¶ 1, line 6	Comment 86	29
Page 41, § 6.1.7, ¶ 1	Comment 87	29
Page 41, § 6.2.1, ¶ 3; ¶ 5, line 1; ¶ 5	Comment 88	29
Page 42, § 6.2.3, ¶ 1	Comment 89	30
Page 42, § 6.2.3, ¶ 2	Comment 90	30
Page 42, § 6.2.3, ¶ 3	Comment 91	30
Page 43, § 6.3.1, ¶ 1, lines 6 and 7	Comment 92	31
Page 43, § 6.3.1, ¶¶ 2 and 3	Comment 93	31
Pages 43-44, § 6.3.2, ¶ 2	Comment 94	31
Page 44, § 6.3.3, ¶ 2	Comment 95	31
Page 44, § 6.4.1, ¶ 2	Comment 96	32
Page 45, § 6.4.2, ¶ 1	Comment 97	32

Page 45, § 6.4.2, ¶ 2	Comment 98	32
Page 45, § 6.4.2, ¶ 3	Comment 99	32
Page 45, § 6.4.3, ¶ 1	Comment 100	32
Page 46, § 7.0, ¶ 1, line 5	Comment 101	33
Page 46, § 7.1, ¶ 1	Comment 102	33
Page 46, § 7.2, ¶ 1, line 7	Comment 103	33
Page 46, § 7.2, Item 1	Comment 104	33
Page 46, § 7.2, Item 2	Comment 105	34
Page 47, § 7.2, Item 3	Comment 106	34
Page 47, § 7.3, Item 1, ¶ 2	Comment 107	34
Page 47, § 7.3, Item 2	Comment 108	35
Pages 47-48, § 7.4, Item 1	Comment 109	35
Page 48, § 7.4, Items 2 and 3	Comment 110	35
Page 48, § 7.4, Item 4	Comment 111	35
Page 48, § 7.4, Item 5	Comment 112	35
Pages 48-49, § 7.5, Item 1	Comment 113	36
Page 50, § 8.0	Comment 114	36

**HOMESTAKE MINING COMPANY'S
COMMENTS TO DRAFT FINAL
REMEDIATION SYSTEM EVALUATION
GRANTS SITE**

A. General Comments.

1. The draft final Remediation System Evaluation (“RSE”) reflects that the federal and state governments have expended significant time and money, and plan to spend even more, to involve a fifth government agency and its consultant to evaluate Homestake Mining Company’s (“HMC’s”) cleanup of the Grants site. The cleanup has already been found to be operating as designed. It will continue to undergo thorough review by the existing permitting agencies and EPA. It is unnecessary, wasteful and inimical to the goal of advancing the cleanup to suggest that yet another layer of government be added to an already Balkanized field of government overseers. Homestake continues to reserve the right not to reimburse or advance any of the involved agencies for any of the costs associated with the RSE and to withhold from any future advances it may make that relate to any unreasonable expenditures.

2. The draft RSE underwent two rounds of review before being provided to HMC for its review. The failure to have involved HMC earlier in the process has resulted in a draft that is materially incomplete and inaccurate in many places. The failure has also caused a diversion of resources from more pressing endeavors that will have a much more immediate and beneficial effect on the environment and in advancing the cleanup. HMC has been the operator of the site for more than fifty years. Among all of stakeholders involved, the company has the most experience and knowledge about the subjects addressed in the draft evaluation. Ironically, while Homestake has been given only a belated opportunity for involvement in the evaluation, parties with much less experience and relevant knowledge of the site (specifically, EPA’s new consultant, the Army Corps of Engineers (the “Corps”) and the New Mexico Environment

Department (“NMED”)), have been given multiple opportunities to shape the document outside of the purview of the public and without HMC’s participation. So that HMC is better informed of the information that led to the current iteration of the document, HMC requests prior drafts of the RSE and any comments by other parties and agencies that have been submitted, but not yet provided to HMC.

3. The draft final RSE relies on the draft ATSDR Report, but then fails to incorporate the extensive comments HMC provided regarding the draft ATSDR Report in August 2008. We enclose a copy of the comments as Exhibit 1. HMC strongly urges the RSE report to incorporate HMC’s comments to the ATSDR report into the draft final RSE where appropriate. For example, the draft ATSDR Report was deficient in its failure to distinguish between background (including naturally occurring) levels of uranium and selenium in groundwater, which NMED, EPA and NRC have established, and any levels that may have originated from HMC’s operations. The background levels of these constituents exceed the EPA safe drinking water levels, and are the reason NMED issued a drinking water advisory for the area. HMC urges the RSE to review HMC’s comments to the draft ATSDR report to better understand site conditions and to modify the draft RSE report accordingly.

4. Transmittal Letter. HMC objects to any proposed follow-on evaluation as set forth in Ms. Yeager’s transmittal letter to Mr. Appaji. The reviews and evaluations suggested are currently underway, and there is no justification for additional technical evaluation of the topics raised by parties other than those who are currently actively involved in the operational remediation at the HMC’s Grants Mill site. HMC’s project already undergoes Five Year Review studies which cover the issues raised in the RSE report. As noted in the RSE draft report, the construction and operation of a third evaporation pond will greatly benefit the remediation of this

site.¹ The approval for the construction and operation of this third pond has been delayed for approximately two years while HMC and its regulators have been awaiting the completion of this report. Other delays in the review and permitting processes have occurred as well. Specifically addressing the proposals in Ms. Yeager's transmittal letter:

a. Bullet Point 1. There is no indication that the overall remediation strategy of HMC, NRC, NMED and EPA is deficient in protecting human health and the environment.² The RSE has suggested no alternative strategies to optimize short-term or long-term protection of human health and the environment, except the construction and operation of an additional evaporation pond, which HMC long ago proposed and which should also have been approved and constructed long ago. No additional study, above and beyond the various studies and evaluations that were completed in the NEPA Environmental Assessment process (and related decision document), is necessary.

b. Bullet Point 2. Past and current sampling information has established that the groundwater flow regime is understood and containment of the contaminant plume has been achieved through implementation of a hydraulic barrier downgradient of the Grants site tailings piles at the site. There is no ongoing contribution of contaminants from the tailing piles to off-site groundwater. According to the RSE draft report, the contaminant capture is working.³ Further review of this system is unnecessary and wasteful. Continued ongoing sampling and monitoring programs are sufficient.

¹ See draft RSE report pp. 26, 27, 28, 45 and 47.

² See draft RSE report pp. iv, 12, 50, 34-37.

³ See draft RSE report pp. 23; p. 31, § 5.1; p. 36, § 5.7.1; p. 37, § 5.7.2; p. 37, § 5.7.4.

c. Bullet Point 3. Prior reviews by the agencies have confirmed that the groundwater monitoring network is achieving its objectives, both spatially and temporally. Detailed monitoring review is already ongoing and is included in the proposed CAP revision that is currently under permitting agency review. HMC is also currently conducting seven times more monitoring than is required under present permits and license approvals. Monitoring issues can be raised by the regulators at each annual review. There does not appear to be any reason or need for yet another governmental agency to be involved or for changes to the monitoring program to be evaluated or made.

d. Bullet Point 4. The RSE has provided no alternative source-control treatment technologies for the large tailings pile. Emphasis should be placed on maximizing treatment with the existing system; resources and assets should not be diverted to searching for and evaluating alternative technologies when the current system is performing as designed and approved. As the draft evaluation itself concludes, “The RSE Team did not identify significant shortcomings or limitations to the efforts being conducted by HMC.”⁴

e. Bullet Point 5. The bullet point regarding a spray irrigation system does not make sense. HMC does not have a “spray irrigation system.” The current *evaporation* spray system is critical to the efficiency of the remediation system. Again, HMC agrees that the third evaporation pond is crucial to advancing remediation of the site; however, HMC believes remediation of the site will be enhanced and accelerated using both the land application irrigation system and the third pond with forced spray evaporation. Spray evaporation is necessary to remove the amount of water necessary to keep the reclamation project progressing on schedule. HMC is already discussing this issue with current regulators. New reviews by others are unnecessary.

⁴ See draft RSE report p. iv.

f. Bullet Point 6. An assessment of the ecological and human health risks and effects related to the land application crop irrigation program has been completed annually since the program started in 2000. Each annual assessment includes the most recent data and undertakes a review of the accumulated data since the project's inception. This annual report has been provided to the regulatory agencies and it is very apparent that this report has not been reviewed by the RSE evaluation team. These annual reports establish that no human health or ecological risks are present due to the irrigation program. New reviews would be extraneous and unnecessary to the ultimate goal of achieving site closure in a timely manner. It is presumptuous to make any assertions or draw any conclusions with regard to this aspect of the project when it is evident that the existing data and reports have not been reviewed.

5. a. HMC, NMED, EPA and NRC have jointly worked to remediate the Grants mill site. The ongoing remediation has made significant gains.⁵ Seepage from the large tailings pile has been intercepted and is not leaving HMC's property. Windblown tailings from the tailings pile have been recovered and returned to the pile. The main tailings pile is essentially covered, and radon emissions from all sources are within established standards, as evidenced by annual review evaluations that are provided in the project Annual Performance Review reports filed with NRC, EPA and NMED. All residents in the areas around the mill facility have or will shortly have the opportunity to be connected to the Village of Milan drinking water system. Recent sampling has established that the vast majority of groundwater wells are within state water quality standards or below background levels common to the area. Additional evaporation of the water captured from the large tailings pile by the construction and operation of an additional evaporation pond will accelerate the remediation of the site and provide an earlier

⁵ See RSE pp. iii-iv, 9-10-11, 15, 23, 25, 34, 36, 37, 40, 42, 44, 46, 50.

completion date of the reclamation project. The RSE Team's two-day site visit and partial review of the project's records does not allow for an informed or helpful contribution to achieving the goals and completion of the project. The only positive contribution of the draft is the support it provides for the earliest possible construction and operation of a third evaporation pond.

b. Adding the Corps to the already large number of regulatory agencies involved in reclaiming the HMC site will only prolong and complicate matters and contribute to further confusion in the oversight regime. The RSE has responded to all concerns raised by the unidentified subdivision "stakeholders." The RSE determined that their concerns were generally misplaced and without merit.⁶ HMC believes the existing program is working and does not need further modeling or study above that already in place by its regulatory authorities.

c. HMC's reclamation project is working and will take time to complete. The completion time will depend on permitting HMC to put additional programs into operation, such as the third evaporation pond, in a timely manner. Current regulatory approvals have not been timely, thus slowing the rate of reclamation. Certain stakeholders are dissatisfied with the fact that background levels established by the regulatory agencies are above recently established drinking water and groundwater standards. In the case of the groundwater standard for uranium, this standard has been reduced by a factor of 167 since the operation and cessation of the HMC mill.⁷

⁶ See draft RSE report pp. 15, 23, 26, 29, 38, 39, 40, 41 and 43-44.

⁷ The New Mexico table standard for uranium in the groundwater was reduced from 5000 parts per billion to 30 parts per billion in 2004.

B. Executive Summary.

6. Executive Summary, page iii, paragraph two. It should be noted the levels of radium-226 and radium-228 in the groundwater are not significant and are not found other than immediately adjacent to the Large and Small Tailings Piles within the boundaries of the HMC property.

7. Executive Summary, page iii, paragraph four. HMC agrees that the San Andres formation has not been directly affected by contaminants from the Site operations.

8. Executive Summary, page iii, paragraph five. Homestake has recently completed a Memorandum of Agreement (“MOA”) with NMED to provide connections for the subdivision residents that are not already connected to the Village of Milan water system, attached hereto as Exhibit 2. For those choosing to connect with the Village of Milan system, connections should be in place within a reasonable time. Homestake has also volunteered to plug groundwater wells in the area for residents who choose to have a current well plugged. NMED has published a Water Well Advisory for the area due to prior milling operations and the elevated background levels of some constituents found in the area. This advisory will put new residents on notice that the groundwater in the area is generally unfit for drinking water purposes due to the background levels of several constituents.

9. Executive Summary, page iii, paragraph five. “City” of Milan should be “Village” of Milan.

10. Executive Summary, page iii, paragraph five, last sentence. It would be more accurate to replace the last sentence in this paragraph with “Several wells formerly used to supply drinking water are still used for lawn, garden and livestock watering. A good quality

water well drilled by HMC in the San Andres formation for the Murray Acres subdivision residents is used by these residents for irrigation.”

11. Executive Summary, page iv, first full paragraph. Regarding the objectives of the current remediation effort listed on page iv, items 1 through 5, the draft RSE should state that Homestake has successfully:

a. Limited radon emissions from the tailings pile by covering the pile, as required by Homestake’s NRC license conditions.

b. Remediated contamination in soil that resulted from windblown tailings. This remediation component was signed off by NRC.

c. Provided drinking water for residents of the four subdivisions adjacent to the site through a Settlement Agreement reached with regulatory agencies in the mid-1980’s. In 1977, HMC began to provide bottled water to these residents. Furthermore, in 1985, HMC provided the majority of the four subdivision residents with the opportunity, at HMC’s cost, to connect to the Village of Milan water system for drinking water supplies. HMC and NMED subsequently signed a Memorandum of Agreement on January 12, 2009, wherein HMC voluntarily agreed to pay to connect other identified residents referenced in the MOA to the Milan water system if the residents so choose. A copy of the MOA is attached as Exhibit 2. Additionally, HMC voluntarily agreed to reimburse residents in the area -- subject to the MOA -- for the costs of connections to the Village water system since January 1, 2004.

d. With respect to the objective of remediating groundwater to levels stipulated in NRC License SUA-1471 and NMED DP-200, HMC and its regulators included site standards for the various aquifers in HMC’s license and permit. Homestake has achieved many

of these site standards already and is working diligently to bring the remainder below the background standards the agencies have established.

e. With respect to the objective of dewatering the Large Tailings pile, the dewatering of the Large Tailings Pile is accomplished by flushing the Large Tailings Pile, treating the water and evaporating the treated water. This effort is ongoing and will be enhanced and accelerated by regulatory approval of an additional evaporation pond.

12. Executive Summary, page iv, paragraph 3. HMC appreciates that the RSE Team did not identify significant shortcomings or limitations to the efforts being conducted by HMC. HMC responds to the eleven recommendations made by the RSE on pages iv and v of the Executive Summary as follows:

a. HMC has a plan to assure continued efforts to remediate the west and south plumes in the Alluvial Aquifer. HMC's plan, which has been underway for several years, is to continue to utilize fresh water injection adjacent to the irrigation supply extraction wells as the affected aquifer areas are restored.

b. HMC disagrees with the suggestion that it should consider terminating pumping from the Chinle Aquifers until the Alluvial Aquifer action levels have been achieved at the subcrops. Flow in the subdivision areas of the Middle and Lower Chinle Aquifers and the Upper Chinle Aquifer, except in the Felice Acres subdivision, is downward from the Alluvial Aquifer to the Chinle Aquifers. Therefore, water will move downward in these subcrops with or without Chinle pumping. The Chinle pumping is important in the reclamation effort because it is necessary to prevent any plume migration. Further, termination of pumping from local wells would not have much impact because these wells do not produce a significant quantity of water.

c. The recommendation to provide drinking water from an alternate source is unnecessary due to the MOA between HMC and NMED dated January 12, 2009. See previous discussion details regarding terms of the MOA. The MOA renders this recommendation moot.

d. The recommendation that HMC evaluate the effectiveness of the clarifier and sand filter systems in connection with the anticipated increase inflow due to full-scale operations is something HMC already has planned to do, as was pointed out to the RSE team during the abbreviated site visit. We agree that these systems will require evaluation for potential “bottlenecking” under full-scale operating conditions. With regard to the pH control systems, we disagree with the recommendations made. Lime is used for water pretreatment to precipitate calcium and improve RO membrane life and function. Caustic can also be used in the system to accomplish the same objective or, alternatively, can be used to trim the system while primarily utilizing lime addition for water pre-treatment. Lime or caustic obviously raises the pH of the water to be treated; however, it is an incidental consequence of using either lime or caustic for calcium removal. Lime is tremendously more cost-effective than caustic, despite the difference in sludge volume generated in the process. Acid is added to the water after pre-treatment to lower the pH to near neutral prior to final pre-filtration and reporting of the water to the RO membrane system.

e. HMC strongly disagrees with the recommendation that the irrigation system should be terminated. The irrigation system is critical to the groundwater remediation program at the Grants site. The human health and environmental risk is low for the irrigation program, as evidenced by HMC’s annual sampling results. Since 2001, HMC has monitored the quality of water applied to the irrigation areas, sampled soils and vegetation in the irrigated areas, and has annually prepared an evaluation report including this data. This data has been

supplied to the regulatory agencies. The annual sampling results are reviewed to assure that that there is no identified human health or environmental risk associated with the irrigation program. A perceived risk, in contrast to an objective review and assessment of empirical data, should not limit or prevent HMC from using this cost-effective and necessary option.

f. HMC agrees that the immediate construction and operation of additional evaporation capacity would enhance the reclamation effort. HMC has requested the authority to construct additional evaporation capacity. NRC has approved the request. NMED approval has yet to be provided.

g. The concern expressed over HMC's existing pond liners is misplaced. As with any pond liner system, HMC's liner systems require maintenance and repair with age. However, it is inaccurate to state that the liners are deteriorating. The liners have, and will continue to be, inspected and repaired when necessary to assure liner function. Nevertheless, and more importantly, the pond liner systems are not an integral consideration to the final closure of the evaporation pond(s). At such time as HMC finishes the dewatering of the Large Tailings Pile, and ground-water restoration and evaporation is complete, HMC will solidify the remaining material in the evaporation pond. This material will be covered with an infiltration barrier and final cover, as NRC specified and agreed to, under final tailings pile closure criteria, to prevent future precipitation from penetrating the material and for erosion control. The specifications for final closure cover of both the Large and Small Tailings Piles (e.g., thickness, compaction, permeability, etc.) have been technically reviewed, agreed upon and accepted by, the NRC in previous written correspondence communications and agency acceptance approvals.

h. The effectiveness of the entombment of all wastes in Evaporation Pond #1 is discussed in HMC's reclamation plan and through written communications that are referenced

in the NRC License for the Grants site. HMC has demonstrated that this is a technologically sound plan and one which has been accepted by NRC. The engineered design of a cap will prevent infiltration. The waste material will be solidified and will not create any seepage from the system. Regulatory approval for the engineered cap has been obtained as described above in paragraph (g).

i. HMC does not believe that there are any human health and environmental protection issues associated with the spray from the evaporation ponds and dust from the collection ponds. The spray system is an essential part of HMC's ability to evaporate the requisite amounts of water and will continue to be critical even with the addition of additional evaporation pond capacity. The amount of evaporation without spray calculated in the RSE report is overstated. The spray is contained on HMC's property. The monitoring HMC is required to conduct under its NRC license shows that emissions are and always have been under the extremely conservative limits the license sets for exposure to members of the public. Further, HMC does not spray if conditions are not proper for spray operation. The procedures and system for evaporative spraying are currently undergoing a performance evaluation and are intended to automatically shut down spray operations in the event wind conditions that create a risk of off-site transport.

The location of the planned additional evaporation pond, which has been approved by NRC and incorporated into HMC's license from the NRC, is situated away from populated areas, providing additional assurance that the spray will be contained on HMC's property.

j. To assure human health and environmental protection, HMC already takes soil samples for potential contaminants in soil around the irrigation areas. As mentioned above,

HMC has annually developed reports of soil sample results since 2000. A copy of the latest Irrigation Report is attached as Exhibit 3 to these comments. The HMC sampling results establish that human health and the environment are not adversely affected by HMC's irrigation program. A copy of the 2007 annual Irrigation Report has been previously provided to the regulatory agencies for their review. Soils around the evaporation ponds are within the boundary of the HMC site. In accordance with HMC's reclamation plan and related NRC license conditions, the soils will be sampled and, to the extent necessary, cleaned up and reclaimed at the time of final site closure.

k. HMC disagrees with the recommendation that its current disposal of purge water resulting from well sampling should be terminated. Volumes and concentrations of contaminants in water sampled off-site are small, resulting in an inconsequential addition to the soil concentration. The amounts of purge water are so small that they are undetectable and would not significantly change the soil concentrations. There would be no discernable environmental benefit from discontinuing the current disposal procedure. Standard operating procedures are in place to determine volume and concentration levels and require notice to regulatory authorities if any volume or concentration level is exceeded.

C. Report.

13. Page 1, paragraph 3. HMC's comments 11(a) through (e) are incorporated herein by reference. The report is deficient in not stating the current status of the objectives for remedial activities. For example, HMC has successfully remediated contamination resulting from windblown tailings. Other objectives have been partially achieved. As written, this paragraph ignores the significant progress towards final closure that has been achieved at the HMC site.

14. Page 2, paragraph 2. As indicated in HMC's General Comment 2, HMC was not included as a commenter to the earlier RSE draft report(s). Thus, it is impossible for HMC to comment on the "significant changes" that the report has undergone.

15. Page 2, Section 1.3, Documents Reviewed, line 2, Alan Cox's name is misspelled.

16. Page 2, Section 1.4, Persons Contacted, line 2, Alan Cox's name is misspelled; also, Ken "Barker" should be Ken "Baker."

17. Page 2, Section 1.4, Persons Contacted. Throughout the draft RSE report references are made to concerns raised by local stakeholders. These stakeholders are not identified. HMC suggests that those local stakeholders who are raising concerns should be identified. This is important in light of the fact that the vast majority of concerns raised by local stakeholders were found by the RSE Team to be without merit.⁸

18. Page 4, Section 1.5.1, Location, paragraph 3, fifth sentence. After this sentence, a sentence should be added as follows: "At the time that the HMC mill was constructed and operated, lined tailing ponds were not required by the government or industry norms. The AEC reviewed the plans for the construction of the HMC mill and tailings facility and did not require it to have lined tailings piles." To the best of HMC's knowledge, no uranium mill facilities licensed by the Atomic Energy Commission had lined tailings ponds.

19. Page 4, Section 1.5.2, Hydrogeologic Setting, paragraph 1. This paragraph contains erroneous statements. HMC's CSM has been misinterpreted by the RSE Review Team. EQM's conceptual model shows that the Chinle Aquifer is being recharged by the Alluvial Aquifer. This is not correct for the Upper Chinle Aquifer between the two faults and the Middle Chinle Aquifer west of the west fault. Figure CSM-1 is correct for the Upper Chinle Aquifer

⁸ See draft RSE report pp. 15, 23, 26, 29, 38, 39, 40, 41 and 43-44.

east of the East Fault, the Middle Chinle Aquifer between the two faults, the Middle Chinle Aquifer east of the East Fault and all of the Lower Chinle Aquifer.

20. Page 8, Section 1.5.2.2, Chinle Aquifers, paragraph 2, The Mixing Zone. The first sentence states that “water from the Chinle Aquifers flows upward into the overlying Alluvial Aquifer in the subcrop areas.” This statement is not accurate. The natural flow in the Middle Chinle Aquifer east of the West Fault and all of the Lower Chinle Aquifer is northerly, as stated in the previous paragraph. The Chinle Formation geochemically changes the high-calcium water in the subcrop area to a low-calcium water downgradient in the non-mixing zones of the Chinle Aquifers. The zone of the Chinle Aquifers where this change is occurring is called the Mixing Zone.

21. Page 10, Section 1.5.3.3, Middle Chinle Aquifer, paragraph 1, line 4, “CW55” should be “WR25”; line 5, “CE45” should be “CW45”; line 11, “Figure 6.2-12” should be “Figure 6.3-12”; line 12, “Figure 6.2-13” should be “Figure “6.3-13.”

22. Page 11, Section 1.5.3.3, Middle Chinle Aquifer, paragraph 1, line 1, “Upper” should be “Middle.”

23. Page 11, Section 1.5.3.3, Middle Chinle Aquifer, paragraph 1, lines 6 and 7. HMC drilled the wells that the RSE Team suggests may have been inadequately sealed. HMC believes that these wells were adequately sealed. These selenium concentrations are small concentrations that exceed the mixing zone level near the boundary with the mixing zone.

24. Page 11, Section 1.5.3.4, Lower Chinle Aquifer, paragraph 1, line 4, “Felice” should be “Pleasant Valley.”

25. Page 11, Section 1.5.3.4, Lower Chinle Aquifer, paragraph 1, lines 6 and 7. HMC drilled wells 653, 538, CW41 and CW42 and believes these wells were all properly sealed.

Wells 653 and 538 are near the subcrop between the Lower Chinle and Alluvial Aquifer and therefore were completed in both of these aquifers for irrigation supply wells in this area. These wells are close to the subcrop area and contain concentrations due to migration of water from the subcrop to their area in the Lower Chinle Aquifer.

26. Page 11, Section 1.5.3.5, San Andres Aquifer, paragraph 1, lines 5 and 6. HMC disagrees with the impact of transfer from the Alluvial Aquifer to the San Andres due to inadequately sealed wells. First, HMC believes that the wells it drilled were adequately sealed. Further, the leakage rate from the Alluvial Aquifer to the San Andres Aquifer through a well would be limited. It is unlikely that this leakage, should it be occurring in this fashion, would change the water quality in the San Andres Aquifer due to the Aquifer's large size and transmissivity.

27. Page 12, Section 1.5.4, Potential Receptors, paragraph 2. The reference to the nine Valle Verde residents should be updated to reflect the MOA entered into between HMC and NMED on January 12, 2009, attached hereto as Exhibit 2.

28. Page 12, Section 1.5.4, Potential Receptors, paragraph 4. While HMC concurs with the conclusions in this paragraph, it should be noted that the ATSDR evaluations are not complete since the evaluations have not yet incorporated HMC's comments to the ATSDR report. A copy of HMC's ATSDR comments are attached here as Exhibit 1. *See also* HMC Comment 3.

29. Page 15, Section 2.2.1, San Andres Aquifer, first full paragraph. In this paragraph, HMC is unsure what the RSE Team's response to the stakeholder concerns means. Normal precipitation in this area does not provide much recharge to the San Andres Aquifer. Heavy snowfall provides more recharge to this Aquifer. The area is currently experiencing a dry

cycle. The Aquifer is also subject to a number of additional users, such as Plains Electric, the Village of Milan, the City of Grants, and local irrigation by others. HMC is not the sole user of the San Andres Aquifer.

30. Page 15, Section 2.2.2, Tailings Flushing, paragraph 1, line 3, “Lower” Chinle should be “Middle” Chinle.

31. Page 15, Section 2.2.2, Tailings Flushing, paragraph 1, line 8, “Aquifer” should be “material.”

32. Page 15, Section 2.2.2, Tailings Flushing, paragraph 3, after the first sentence, add, “Some of the 106 gpm is in the Large Tailings Pile due to an increase in storage.”

33. Page 16, Section 2.2.4, Upper Chinle Aquifer, paragraph 1:

Line 3, strike “immediately south of” and replace with “in.”

Line 5, strike “irrigation and.”

Line 7, strike “2005” and replace with “January 2007.”

34. Page 16, Section 2.2.5, Middle Chinle Aquifer, paragraph 1, first sentence after “498” add “482.” Also strike “CW28” and replace with “483.”

35. Page 16, Section 2.2.5, Middle Chinle Aquifer, paragraph 1, sentences 3 and 4, strike “injection to the Upper Chinle Aquifer to control plume migration.” and replace with “the tailings flushing program.”

36. Page 16, Section 2.2.3, Alluvial Aquifer, paragraph 2, lines 6 through 8. HMC strongly believes that the irrigation use concentration levels must remain at present levels to assure timely continuation of groundwater remediation efforts. HMC’s annual soil and vegetative sampling results establish that current irrigation application levels are protective of the public health and environment. To cease irrigation at current application levels would adversely

affect HMC's ability to reduce plume concentrations and size in a timely manner and would greatly increase the amount of water required to accomplish cleanup objectives. Additionally, a total cessation of irrigation could potentially allow the plumes to move up to three tenths of a mile per year.

37. Page 18, Section 2.3.2, Alluvial Aquifer, carryover paragraph 1, line 2, "Figure E" should be "Figure D."

38. Page 18, Section 2.3.3, Chinle Aquifers, paragraph 1, line 3, strike "CW46" and replace with "CW4R."

Line 6, strike "in."

Paragraph 2, line 1, strike "36" and replace with "46."

39. Page 19, Section 2.5.2, Evaporation Ponds, paragraph 1, line 2, strike "49 gpm" and replace with "50 gpm."

40. Page 19, Section 2.5.1, Reverse Osmosis Treatment System, paragraph 1, line 14, strike "waste". HMC's RO unit does not produce two "waste" streams. It produces one stream of production water that is very clean and one brine stream with a high level of dissolved solids.

41. Page 19, Section 2.5.2, Evaporation Ponds, paragraph 2, lines 1 through 3. The first two sentences in paragraph 2 of this section are incorrect. They should read as follows: "The brine stream from the RO plant is transferred to the East Collection Pond. The water from the East Collection Pond is typically pumped to Evaporation Pond #2 (i.e., the smaller west pond) which is in turn periodically pumped to Evaporation Pond #1 (i.e., the larger east pond)."

42. Page 20, Section 2.5.2, carry over paragraph, line 2, strike "these ponds" and replace with "the West Collection Pond."

43. Page 20, Section 2.5.2, paragraph 3, last sentence. HMC disagrees with the statement that “Water will cascade from Pond #2.” Water from Evaporation Pond #2 does not cascade to any other pond. The water remains in the pond for evaporation or occasionally is transferred by pumping to Evaporation Pond #1.

44. Page 20, Section 2.6, Groundwater Monitoring System, paragraph 1

Line 2, in both places “4” should be “3.”

Line 3, strike “6” and replace with “2”; strike “3” and replace with “2”; and strike “2. Lower Chinle” as there are no Lower Chinle wells.

Line 4, strike “4” and replace with “2.”

45. Page 21, Section 3.1, Current System Objectives and Closure Criteria. Paragraph 4, lines 1 and 2. Although the RSE Team did not conduct model validation, HMC does not believe any further model validation or evaluation is required. It also does not believe that independent groundwater modeling is warranted or appropriate. The extensive modeling that has been conducted for the site to date is being validated and evaluated in the Cap Review by HMC’s regulatory authorities. HMC believes this review will be sufficient for the reclamation program in place and future restoration timing.

46. Page 23, Section 4.1, Tailings Flushing, paragraph 2. HMC agrees that “[n]o identifiable trend for release of contaminants not currently addressed was identified.” This response to the stakeholders emphasizes the need not to allow the concerns of uninformed stakeholders to drive evaluation of the project. Although stakeholders certainly have the right to be informed about the project, the project should be carried out under sound technological and scientific principals and techniques and not driven by unsupported speculative remarks that have no scientific basis and detract from achieving groundwater cleanup objectives in a timely fashion.

47. Page 24, Section 4.2.1.1, Alluvial Aquifer, paragraph 2, line 5, strike “is” and replace with “in.”

48. Page 24, Section 4.2.1.1, Alluvial Aquifer, paragraph 2. HMC disagrees with the RSE Team’s unsubstantiated conclusion that the continued implementation of HMC’s approach for the west and south uranium/selenium plumes may not allow HMC to achieve its objective. The actual and planned irrigation pumping is approximately 40% greater than the injection in the south system, which has caused a decline in the water levels in this area. Injection is fairly balanced with pumping in the north irrigation area, but the plume has pulled back more than one mile between 1998 and 2005. HMC is achieving the project goals in this area. *See* HMC Comment 12(a).

49. Page 24, Section 4.2.1.1, Alluvial Aquifer, paragraph 3, last sentence. HMC fails to understand the importance or merit of the stated RSE observation. HMC plans to shut off the upgradient pumping when the collection rates to the RO plant can be increased. Operation of a newly constructed Evaporation Pond #3 is required to increase the collection amounts to discontinue the upgradient pumping.

50. Page 24, Section 4.2.1.2, Chinle Aquifers, paragraph 1, second sentence. The RSE observation is a vague and unsupported speculation. HMC does not agree with it. RSE's incorrect understanding of the flow direction between the Chinle Aquifers and the Alluvial Aquifer has led to this incorrect conclusion. *See* Comments 12(b), 20, 66, 75 and 105.

51. Page 26, Section 4.2.1.2, Chinle Aquifers, paragraph 3. HMC agrees that conditions associated with subsidence are not present.

52. Page 26, Section 4.3.1.2, Injection Systems, paragraph 2, fourth sentence. HMC has not estimated that the groundwater flow in the Alluvial Aquifer has increased by about 330

gpm. The 330 gpm figure is HMC's estimate of groundwater flow downgradient of the site, not the amount of increased flow.

53. Page 27, Section 4.3.2, Reverse Osmosis Plant, carryover paragraph 1, last sentence, strike "82 to 90 gpm (33 to 41 gpm increase" and replace with "112 gpm (63 gpm increase)."

54. Page 27, Section 4.3.2, Reverse Osmosis Plant, paragraph 2, the correct increase in RO product water for injection is estimated to be 185 gpm.

55. Page 27, Section 4.3.2, Reverse Osmosis Plant, paragraph 3, lines 9 through 10, the statement that citric acid was added to reduce the suspended solids load to the sand filters is incorrect. HMC uses lime and/or caustic in the clarifier section along with small amounts of chemical flocculant and coagulant to reduce the suspended solids load to the sand filters.

56. Pages 27-28, Section 4.3.3, Evaporation Ponds. HMC disagrees with the RSE Report conclusions concerning the need for spray evaporation in the project evaporation system. The evaporation calculation amounts described in Section 4.3.3 are incorrect. These calculations are too general and fail to take into account the conditions of the water evaporated from the site. The calculated rates are simply too high compared to actual evaporation rates that take place at the site.

Based on accurate evaporation rates, HMC strongly believes that spray evaporation is critical to the project's success. The current spray evaporation program is conducted in a manner that protects public health and the environment.

57. Page 28, Section 4.3.3, Evaporation Ponds, paragraph 2. The RSE concern about the evaporation pond liner is misplaced. As stated in HMC Comments 12(g), 12(h), 57, 65 and 96, the liner is not an integral part of HMC's evaporation pond and Small Tailings Pile final

closure plan. HMC does not spray water on the liner for the purpose of protecting the liner from solar exposure. Residual solids on the liner, however, do offer some UV protection on the liner, as the RSE points out. The supposed “cracking” that was observed, from looking at the photo in the draft RSE Report, is nothing more than mottling of the asphalt membrane liner, which has been present since the time the liner was originally installed. The text should be changed to avoid the inference that the liner is leaking because of cracks.

58. Page 28, Section 4.3.3, Evaporation Ponds, paragraph 7. Homestake does not believe the RSE Team’s concern regarding the location of the proposed Evaporation Pond #3 is valid. The proposed site of Evaporation Pond #3 will not affect HMC’s reclamation program to control the Alluvial Aquifer. The upgradient alluvial pumping can still occur with Evaporation Pond #3 in place. The preset upgradient wells that are pumped are outside of the construction area of Evaporation Pond #3.

59. Page 29, Section 4.3.4, Irrigation Systems, paragraph 1.

Line 1, after “irrigate” add “producing agricultural.”

Line 3, “plum” should be “plume.”

Line 9, after “grown.” add new sentences:

This potential accumulation has been evaluated annually by HMC since the start of the irrigation program. Reports of these analyses indicate that some accumulation is occurring in the soils as predicted but to acceptable levels. A very small amount is being transferred to the vegetation which makes bioaccumulation unimportant at this site.

Line 9, strike “Over” and replace with “Poor water.”

Line 9, after “application,” add “management.”

Line 11, after “zone.” add new sentences:

Common agricultural practice is to apply suitable quality water in slight excess of that consumed by evaporation and transpiration to prevent

buildup of salts in the root zone. The soils in the irrigation areas have sufficient permeability to allow acceptable irrigation applications and rainfall to avoid buildup of salts.

Line 13, after “plumes.” add a final sentence to this paragraph as follows:

The seasonal water usage also allows some recovery in the groundwater system, which in turn may allow a slightly larger irrigation extraction rate early in the year.

60. Page 29, Section 4.3.4, Irrigation Systems, paragraph 2. Add a sentence at the end of the paragraph as follows: “HMC’s annual evaluation has established the risk to be very low.”

61. Page 29, Section 4.3.5, Solids Handling, paragraph 1.

Line 3, “#2” should be “#1.”

Line 3, after “as” change “as Collection Ponds #1 and #2 fill.” to “the West Collection Pond fills.”

Line 4, after “the” add “West” before “collection” and make “Ponds” singular.

62. Page 29, Section 4.3.5, Solids Handling, paragraph 2, last line. According to water quality data from the evaporation ponds, sulfates make up less than 50% of the solids in the evaporation ponds.

63. Page 32, Section 4.6, Treatment Process Excursions, Upsets and Accidental Contaminant Releases, paragraph 1, lines 2 to 4. Although the sprayers are of sufficient height to allow salts to be blown beyond the pond, any excursions are contained on HMC’s property and will be recovered and placed where the evaporation ponds are encapsulated. The use of spray evaporation at a constructed Evaporation Pond #3 would have even less potential impact on the public due to its location away from any residential areas. Again, HMC would limit any potential excursions to within its site boundaries and is currently optimizing a new system on Evaporation Pond # 1 that provides for automatic shutdown of the spray systems when adverse

wind conditions are present. As correctly noted by the RSE Team, the amount of salts was not sufficient to adversely affect vegetation growth around the evaporation ponds.

64. Page 32, Section 4.6, Treatment Process Excursions, Upsets and Accidental Contaminant Releases, paragraph 2. HMC reiterates that there is no factual basis for the stakeholders' concern on this subject. The spray evaporation system is critical to HMC's ability to remove water from its evaporation ponds in a timely manner. Removal of the spray evaporation system would significantly lengthen the reclamation project at the site. Adding a third evaporation pond with a spray evaporation system will significantly shorten the time needed to reclaim the site. HMC believes the public will be best served by completing the site reclamation in the shortest time so long as the project is conducted in a safe and technologically sound manner.

65. Pages 32-33, Section 4.8, Project Closeout, paragraph 2, lines 5 and 6 on page 32 and lines 1 and 2 on page 33. As set forth in HMC's Comments 12(g), 12(h), 57 and 96, the RSE Team's response to the stakeholder's concern over the long-term safety of encapsulation of the evaporation pond does not take into account the fact that the pond liners will not play an integral role in the final closeout of the ponds. The material remaining in the ponds will be solidified as part of the pond reclamation and closure process and integrated into the final closure activities for the Small Tailings Pile. These materials will not be able to enter any underlying aquifers. This closeout plan has been engineered, submitted to HMC's regulatory authorities and approved.

66. Page 34, Section 5.1, Groundwater, paragraph 3, last sentence. The RSE statement that "[c]ontinued pumping from the Chinle Aquifers by HMC and residents of the five subdivisions will continue to provide a pathway for contaminants to migrate from the Alluvial

Aquifer to the Chinle Aquifers, either through the subcrops or by transfer down inadequately sealed wells,” is incorrect and illustrates the RSE Team’s lack of understanding regarding the area’s hydrology. The flow of the Middle and Lower Chinle Aquifers is downward from the Alluvial Aquifer and therefore Chinle pumping does not change the flow direction. The Chinle pumping is important to prevent the movement of the Chinle plumes downgradient in these aquifers.

67. Page 35, Section 5.2, Surface Water, paragraph 1, last sentence. HMC disagrees that potential runoff of salts and other contaminants at the irrigation areas and downward of Evaporation Pond #1 is likely to occur locally. An excessive amount of rainfall would be necessary on the flat terrain in the area to cause runoff. This very infrequent runoff should not contain measurable concentrations of key contaminants.

68. Page 35, Section 5.4, Soil, paragraph 1. This paragraph implies that the irrigation program is increasing levels of contaminants in the soil. HMC annually evaluates the irrigation program and includes such evaluation results in its annual irrigation review report. HMC’s annual evaluation of the irrigation program has established that the soil concentrations are acceptable for crop production. *See* HMC Comments 4(f), 12(e), 12(j), 36 and 108.

69. Page 36, Section 5.4, Soil, paragraph 2 – top of page. The RSE Team’s concerns regarding soil contamination resulting from spraying of water in the Evaporation Ponds is overstated. Any dispersal of contaminants is limited by HMC’s termination of spraying when weather conditions dictate that spraying should be curtailed. The spraying residuals are contained on HMC’s property and are limited, as evidenced by the RSE Team’s observation that vegetation downwind from the Ponds is not stressed. As noted by the RSE Team, HMC will take all action necessary to remediate any soils affected by spraying. HMC believes the benefits

of the spraying system far outweigh any potential threats to human health because HMC controls the spraying in adverse weather conditions and does not allow the spray material offsite. *See* HMC Comments 4(e), 12(i), 56, 63 and 64.

70. Page 36, Section 5.4, Soil, paragraph 3. HMC disagrees that discharge of purge water creates any contamination to the soil during water sampling efforts. Purging this water is a commonly followed practice, and the amounts of water purged are so small as to not contribute measurable amounts of contaminants or salts to the soil.

71. Page 36, Section 5.6, Crops, paragraph 1. HMC conducts annual measurements in its irrigation project that established that crop uptakes are very small.

72. Page 37, Section 5.7.2, Clean Up the West and South Plumes of the Alluvial Aquifer, paragraph 1, line 5. The statement at line 5 is incorrect. HMC has achieved site standards at POC well X, but not at POC wells D1 and S4. HMC does not believe additional modeling is necessary to validate HMC's goal of achieving site standards at these additional wells because the current modeling is being reviewed by its regulatory authorities.

73. Page 37, Section 5.7.3, Use Low TDS Water from the RO Unit to Improve the Rate of Contaminant Recovery, paragraph 1. The RSE team correctly notes that this water has good potential for restoration efforts. Studies and monitoring of the injection of RO-treated water south of the evaporation ponds and south of the tailings piles have demonstrated that the RO-treated water is very effective in restoring groundwater in the areas.

74. Page 37, Section 5.7.4, Keep Contaminants Away from Subdivision, paragraph 1. All selenium levels in the subdivisions have been lowered to the site standards for all wells, except one well located on property HMC owns off-site that is not used for potable purposes.

75. Page 37, Section 5.7.4, Keep Contaminants Away from Subdivision, paragraph 2. The RSE Team's concern set forth in this paragraph is based on a misunderstanding of the flow between the Middle Chinle and Lower Chinle Aquifers in the subdivisions. The flow in the Middle and Lower Chinle Aquifers in the subdivisions is from the Alluvial Aquifer to the Chinle Aquifers and therefore pumping of the Chinle Aquifers will not change flow direction. Further, the quantity of well water used by subdivision residents (other than the Murray Acres Association irrigation well) is extremely small compared to HMC's water usage in the plume area. HMC respectfully suggests that the RSE Team finding on this topic is incorrect. See HMC Comments 12(b), 19, 20, 50, 66 and 106.

76. Page 38, Section 6.1, Tailing Pile, paragraph 2, lines 3 and 4. Alternatives 3 and 4 mentioned in this paragraph fail to note that monitoring associated with current flushing at the site indicates that constituents are not being stripped from the tailings material.

Lines 5 and 6 – The draft should state that HMC is addressing alternatives 5 and 6 with its plan to add additional dewatering wells to improve collection capacity.

77. Page 38, Section 6.1.1, Tailings Removal for Off-Site Disposal. HMC agrees with the RSE Team finding that moving the tailings will not allow HMC to achieve its reclamation objectives. HMC believes that its reclamation plan to cap the tailings will protect human health and the environment.

78. Page 39, Section 6.1.2, paragraph 1. The tailing piles will have a low permeability cap in place after the tailings reclamation program is complete.

79. Page 39, Section 6.1.3, In-Situ Fixation, paragraph 1. HMC disagrees with this alternative. The flushing program is working without an in-situ fixation additive. This type of additive would reduce permeability and slow the flushing process.

80. Page 39, Section 6.1.4, Increase Contact with Flushing Water, paragraph 1. HMC is considering injection trenches to flush the sand portion of the tailings. It is preferable to allow excess water from the slimes to move outward and into the sand portion of the tailings mass.

81. Pages 39-40, Section 6.1.5, Use Amended Water, paragraphs 1 and 2. The flow velocity in the slime tailings portions of the Large Tailings Pile is the critical component affecting the amount of time required to reduce concentrations. Use of amendments for injection water, as speculatively suggested in the RSE Report will not affect flow velocity and is therefore not a material factor to be considered in reducing groundwater usage associated with this aspect of the project groundwater remediation program. Larger injection and collection rates maximize water velocity, which is important to meet a reasonable restoration schedule.

82. Page 40, Section 6.1.5, Use Amended Water, paragraph 2. HMC has already considered injecting non-oxygenated water near the end of the flushing process. The tailings water is still reduced at the dewatering wells. The use of non-oxygenated water at the end of the flushing process will be considered if monitoring indicates some re-mobilization.

83. Page 40, Section 6.1.6, Improve Collection of Discharge, paragraph 1. The movement of a large amount of the flushing water down to the Alluvial Aquifer is necessary to flush constituents from the Alluvial material above the water table.

84. Page 40, Section 6.1.6, Improve Collection of Discharge. HMC evaluated the use of horizontal wells during early stages of the program. HMC concluded that more vertical wells in the slimes greatly decreased hydraulic travel times, which in turn increases the ability to accomplish timely site closure and related tailings and pile closure.

85. Page 40, Section 6.1.7, Conclusion, paragraph 1, line 2. Strike "was" and replace with "has."

86. Page 40, Section 6.1.7, Conclusion, paragraph 1, line 6. HMC has not indicated that the rebound from the tailings may occur for up to 50 years after flushing is terminated. HMC's observations during the flushing program have been that uranium restoration is very similar to other conservative parameters and therefore no indication of stripping of additional uranium concentrations from the tailings material has been observed. Some rebound after a flushing program ceases could occur if pockets of higher concentrations are left in the tailings. These higher concentration pockets would disperse and decrease their concentrations, but would increase concentrations in adjacent areas in the tailings. HMC is monitoring the decline of concentrations in each area to determine whether concentrations have adequately decreased in the entire area. Careful monitoring of the restoration of concentrations in the tailings should minimize the areas of higher concentrations that are left in the tailings and therefore minimize the rebound of the tailings concentrations. HMC expects to decrease uranium concentrations enough below 2 mg/l so that the rebound will not result in an average concentration above 2 mg/l.

87. Page 41, Section 6.1.7, Conclusion, paragraph 1. The RSE concludes that "detailed computer simulation is needed to predict if the resultant concentrations of COCs released from the Large Tailings Pile will allow HMC to achieve the NRC Alluvial Aquifer and Upper Chinle Aquifer action levels." This simulation has already been done. That the suggestion is made in the draft RSE reflects once again an inadequate understanding on the part of RSE drafters of what has already occurred at the site.

88. Page 41, Section 6.2.1, In-Situ Treatment, paragraph 3. Homestake did not indicate that bioremediation for in-situ treatment has been found to be unsuccessful at the site. To the contrary, HMC is currently conducting field studies in two locations within the hydraulic

containment area near the Large Tailings Pile to evaluate the potential for in-situ bioremediation. In-situ bioremediation testwork has been conducted in the past on the Large Tailings Pile; however, that work was terminated in 2002. Consideration is currently being given to initiating new testwork on the tailings materials to further evaluate whether the technology has merit for enhancing ongoing cleanup and closure efforts for the tailings pile.

Paragraph 5, line 1, strike “is potentially” and replace with “has potential.”

Paragraph 5, HMC has already considered a Permeable Reactive Barrier (“PRB”) as a potential application in the immediate downgradient vicinity of the Large Tailings Pile. A PRB was rejected because the large depths and linear distances encountered at the site make its use very costly and of questionable success. HMC believes a fixation process that can be distributed within the aquifer is better suited to this site and is evaluating this process.

89. Page 42, Section 6.2.3, Conclusion, paragraph 1. HMC disagrees that control in the Upper Chinle Aquifer is not demonstrated. Control in the Upper Chinle aquifer is in the CE wells just downgradient of the Collection Ponds. The collection wells are used in conjunction with fresh water injection in several Upper Chinle wells to control the plume in the Upper Chinle near the tailings.

90. Page 42, Section 6.2.3, Conclusion, paragraph 2. This paragraph is not accurate. The majority of this water is flowing west of the tailings in the area where the plume has been reduced by more than one mile between 1998 and 2005. The annual pumping for irrigation in the Section 3 (south) plume is more than 10% greater than the combined injection and groundwater flow in this area. This has resulted in drawdowns in wells in this area.

91. Page 42, Section 6.2.3, Conclusions, paragraph 3. HMC plans to collect larger volumes of water after Evaporation Pond #3 is permitted. The use of large volumes of fresh

water injection is necessary to maintain large collection rates and to minimize the time for completing the restoration.

92. Page 43, Section 6.3.1, Groundwater Treatment Unit, paragraph 1, lines 6 and 7. It is incorrect and inaccurate to state that HMC indicated the RO treatment was “not” an integral part of its program to manage groundwater. Furthermore, HMC has considered a number of other technologies and treatment alternatives and concepts in addition to RO, contrary to the RSE statement. A rigorous evaluation of options was undertaken in the late 1990’s prior to selecting an RO treatment process and subsequent commissioning (and expansion) of the present plant in the 1999-2002 timeframe. Periodic remedial system and program reviews of the Grants site have been undertaken since that time to confirm that there are no other feasible, viable or more attractive options to the current remediation program

93. Page 43, Section 6.3.1, Groundwater Treatment Unit, paragraphs 2 and 3. HMC has already reviewed ion exchange technology for use at the site, but the metallurgy of the site’s wastewater makes ion exchange technology an inappropriate alternative technology. HMC has rejected ion exchange technology because this process would not reduce concentrations to the desired levels. RO reduces the waste to lower levels. Further, ion exchange does not remove TDS but instead exchanges one constituent for another. The RO technology in use has been proven to be an integral part of HMC’s reclamation program.

94. Pages 43-44, Section 6.3.2, Irrigation, paragraph 2. HMC concurs with the RSE Team statement that stakeholder concerns on irrigation are not supported by the facts.

95. Page 44, Section 6.3.3, Conclusion, paragraph 2. The irrigation program is a cost-effective method of restoring the large quantities of low concentration water. HMC will continue to monitor the impacts of the irrigation program.

96. Page 44, Section 6.4.1, Solid Waste, paragraph 2. Once again, the liner is not an integral part of HMC's consideration as to final closure of the Small Tailings Pile. The final closure plan relies on a cap and final cover to minimize infiltration through the waste. The evaporation pond waste will be solidified and covered by the cap. See HMC Comments 12(g), 12(h), 57, 65 and 110.

97. Page 45, Section 6.4.2, Water, paragraph 1. Any discharge of solids from spraying has been commented on several times previously.

98. Page 45, Section 6.4.2, Water, paragraph 2. The construction and operation of Evaporation Pond #3 will not suspend HMC's need to use spray evaporation during proper weather conditions. HMC will require continued spray evaporation with the addition of Evaporation Pond #3. HMC's estimate of lake evaporation capacity with Evaporation Pond #3 is 145 gpm. HMC's calculations show that Evaporation Pond #3 will be full in less than two years without enhanced spray evaporation.

99. Page 45, Section 6.4.2, Water, paragraph 3. The RSE Team's evaporation quantities are incorrect and do not account for site conditions. HMC's current pond system has an estimated lake evaporation of 6,000 gallons/hour, not 7,400 gallons/hour. The additional third pond will increase the lake evaporation by 3,300 gallons/hour, not 4,500 gallons/hour. HMC has considered additional evaporation systems. Large volumes of high TDS water makes these evaporation systems infeasible; they not only use a large amount of power but would be difficult to maintain due to the high TDS in this water.

100. Page 45, Section 6.4.3, Conclusion, paragraph 1. HMC concurs that the construction and operation of Evaporation Pond #3 is important to the success of HMC's

program. HMC believes that the current spray operating procedures prevent undue migration of contaminants.

101. Page 46, Section 7.0, Recommendations, paragraph 1, line 5, add an “s” to “recommendation.”

102. Page 46, Section 7.1, Tailings, paragraph 1. Additional modeling of the tailings could be conducted, but the current monitoring is more critical, since it will define what levels can be achieved. Monitoring of dewatering and monitoring wells will define where additional efforts are required. This monitoring has already defined large areas in the slime tailings that are below or slightly higher than 2 mg/l. Actual monitoring will define how low the concentrations will go. How low the level of concentrations go will not be derived from additional modeling. Success will be determined by monitoring as HMC’s efforts continue. Achieving the 2 mg/l goal depends on HMC’s ability to monitor the progress of pushing or sweeping of injection water from the injection locations to the dewatering wells. HMC fails to understand the value of any additional modeling at this time.

103. Page 46, Section 7.2, Groundwater Remediation, paragraph 1, line 7. HMC plans to move the injection lines to the south as concentrations in the plume areas are reduced, to decrease travel time between the injection lines and the irrigation pumping. Alternatives to fix the constituents in the alluvial material are being evaluated onsite.

104. Page 46, Section 7.2, Groundwater Remediation, Item 1. HMC has estimated quantities of water treatment and disposal based on its present plan. These projections are reviewed and adjusted, as appropriate, on an annual basis. As such, HMC already has a “plan of attack” that is based on annual and continuous review of empirical data and results to augment and guide future remediation program activities. To suggest that HMC needs to develop an

attack plan is unfounded and once again reflects a serious lack of understanding of HMC's present activities and plans.

105. Page 46, Section 7.2, Groundwater Remediation, Item 2. The RSE Team recommendations in this paragraph result from its lack of understanding of the hydrology at the HMC site. *See* HMC Comments 12(b), 19, 20, 50 and 66. The alluvial water will enter the Middle and Lower Chinle Aquifers in the area of the subdivisions with or without the Chinle pumping. It is important to continue the Chinle pumping to prevent further migration of impacted water from moving further downgradient in the Chinle. Ceasing the Chinle pumping will not allow the upward hydraulic gradient to be achieved because the natural gradient is downward. The flow is naturally downward in the subdivisions from the Alluvial Aquifer to the Middle and Lower Chinle Aquifers.

106. Page 47, Section 7.2, Groundwater Remediation, Item 3. HMC entered into an MOA with NMED on January 12, 2009, to provide connections to the Village of Milan Water System for the nine residents mentioned in this recommendation. *See* HMC Comment 8.

107. Page 47, Section 7.3, Water Treatment, Item 1, paragraph 2. Comments made here by the RSE team are reflective of the lack of understanding of the current RO plant operation. It is presently operated utilizing lime for water pretreatment, with a caustic trim to maintain consistent pH level. Caustic is used only as a primary additive for pretreatment when operational problems occur with the lime system. HMC is and has been cognizant of the issue of full capacity operation of the plant and potential complications with turbidity control downstream of pretreatment clarification. Several modifications have already been made to the process to address this concern.

108. Page 47, Section 7.3, Water Treatment, Item 2. For reasons previously discussed, HMC strongly disagrees that the irrigation system should be terminated. *See* HMC Comments 4(f), 12(e), 12(j) and 36. The RSE Team earlier noted in Section 6.3.2 that information available to the RSE Team suggests that stakeholder concerns in this area are not supported by facts.

109. Pages 47 and 48, Section 7.4, Waste Disposal, Item 1. HMC has attempted to obtain regulatory approval for Evaporation Pond #3 for more than two years. Even with the addition of a third evaporation pond, spray evaporation will be required during proper weather conditions in order to make the system work at optimum results. *See* HMC Comments 4(e), 12(i), 63, 64, 69, 98 and 111.

110. Page 48, Section 7.4, Waste Disposal, Items 2 and 3. As previously set forth in HMC's Comments, the liner does not play an integral role in HMC's closure of the evaporation ponds. *See* HMC Comments 12(g), 12(h), 57, 65 and 96.

111. Page 48, Section 7.4, Waste Disposal, Item 4. This conjectural concern about off-site impact from spray evaporation fails to appreciate the current monitoring network and data demonstrating that this is not an issue. As noted before, HMC has not used the spray system when weather conditions are not conducive to this system. HMC is also implementing controls that will automatically shut down the spray system based upon wind speed and directions. This system will complement HMC's past procedures. *See* HMC Comments 4(e), 12(i), 63, 64, 98 and 109.

112. Page 48, Section 7.4, Waste Disposal, Item 5. HMC will evaluate onsite soils at the completion of the reclamation program and remediate any problem identified. Additionally, NRC decommissioning and license requirements will dictate that this be completed and will be an integral part of HMC's final closure plans.

113. Pages 48-49, Section 7.5, Other Considerations, Item 1. HMC disagrees with this recommendation. The sampling water away from the immediate site contains lower concentrations of uranium and other constituents. The effects of these concentrations on the soil is de minimus. For example, if a well containing 0.44 mg/l of uranium is pumped at 10 gpm for 20 minutes during sampling, the soil density is 110 pounds/cubic foot, the contact area is 100 square feet, the contact depth is one foot, and all the uranium is absorbed in the soil, then the average increase in concentration would be 0.06 mg/Kg. Natural uranium soil concentrations in the irrigation areas are between 1 and 2 mg/Kg. This example shows that containment of purge sampling is not necessary. Further, containment of purge sampling water is inconvenient and a time-consuming waste of resources in relation to gains or environmental protection achieved.

114. Page 50, Section 8.0. HMC appreciates the limited amount of time allowed the RSE Team to conduct the project review. However, the recommendations proposed in the draft RSE Report generally result from a misunderstanding or misapplication of site conditions and operations. For example, the RSE concerns about the evaporation pond liner, the hydrologic flow of water in the area, evaporation calculations, HMC's operation of its spray system, the critical importance of the spray and irrigation systems, impacts of purge sampling water and ion exchange technology are just a few of the inaccuracies or misapplications raised in the draft report.

HMC does concur with the RSE Team's observation that the construction of additional evaporation capacity is essential. HMC also concurs with the RSE Team's responses to stakeholders' concerns that are unsubstantiated and without factual basis.

HMC does not concur with the RSE Team's recommendation for additional modeling of the reclamation project. As stated, current monitoring of the project is critical and is providing

information that the system is working. HMC believes it and its regulatory authorities' objective should be to maximize the effectiveness of the current system in order to complete remediation as soon as reasonably possible. The RSE Team did not identify significant shortcomings or limitations to the efforts conducted by HMC. Rather than contemplate additional modeling, regulatory focus should be to approve the additional pond storage and evaporation capacities at the site.

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Grants Office

Alan D. Cox
Project Manager - Grants

August 1, 2008

Mr. Andy Dudley
ATSDR
4770 Buford Hwy, NE
Mailstop: F-59
Atlanta, GA 30341-3717

RE: ATSDR Health Consultation, Cibola County, New Mexico – May 19, 2008
Comments on Draft Report

Dear Mr. Dudley:

Enclosed please find Homestake Mining Company of California's (Homestake's) comments to ATSDR's Health Consultation, Homestake Mining Company Mill Site, dated May 19, 2008.

We have additionally enclosed a "redlined" version of the Consultation Report that incorporates our comments and suggested changes.

Thank you for your time and attention on this matter, and we appreciate your consideration of our comments on the document.

Sincerely yours,

**Homestake Mining Company
Of California**
Alan D. Cox
Project Manager

Cc: R. Chase – SLC
B. Ferdinand – SLC
T. Grandy – SLC
R. Haddock - SLC

Comments of Homestake Mining Company of California to ATSDR Health Consultation, Homestake Mining Company Mill Site, May 19, 2008

Homestake Mining Company of California (“Homestake”) submits the following general and specific comments to ATSDR’s May 19, 2008 draft Health Consultation, Homestake Mining Company Mill Site in Milan, New Mexico (the “Consultation”). Our comments are organized and presented in three ways. First, we discuss general or overarching comments that apply to the document as a whole. Second, we address specific sections of the Consultation. Finally, we include a “redlined” version of the draft Consultation that reflects most of our suggested changes for ATSDR’s consideration.

GENERAL COMMENTS

Homestake’s primary concern is that the Consultation accurately portrays both the current and historical data regarding the levels of metals and other constituents in the San Mateo Alluvial and Chinle Aquifers, and that this information, along with any known risks associated with consuming water from these two sources, are clearly communicated to the public and other interested parties. We support ATSDR in its mission to educate the public about the risks of consuming groundwater with levels of certain elements above the recommended MCLs; however, it is imperative that the Consultation accurately reflect real risks and does not unnecessarily alarm the community. The public deserves accurate and objective information so that they can make informed decisions about their choices for domestic water supplies.

In helping the public understand the potential risks, it is also important that they understand the likely source of these risks. By titling the Consultation as the “Homestake Mining Company Mill Site” and categorizing the site as a public health hazard, ATSDR has created the mistaken impression that Homestake’s mill activities are the cause or primary cause

of the perceived hazard. In fact, background sources¹ other than the Homestake mill site are the predominant causes. Background concentrations of selenium exceed the federal drinking water standard (MCL) in the alluvium and all portions of the Chinle aquifers. Background concentrations of uranium exceed the MCL in the alluvium and the middle and upper portions of the Chinle. Consequently, ATSDR should clearly state that naturally occurring concentrations of these elements contribute to and likely are the sole source of concentrations in the wells that exceed their respective MCLs. Furthermore, ATSDR should be clear that it has not determined that the Homestake mill is a contributing source of the mineral concentrations that exceed MCLs or SMCLs.

To address this issue, Homestake suggests ATSDR revise the report in one of two basic ways: Either limit the focal point of the report to the *concentrations in the aquifers* and not to contamination from the Homestake mill site; or, if ATSDR wishes the focus to remain on the Homestake mill site, it should not characterize the Homestake mill site as the public health hazard because that is not an accurate representation of the facts. This would be consistent with the initial conclusions reached by ATSDR. Our comments below and our edits in the redlined version of the Consultation offer suggested changes to the language to make this clear.

Homestake's Historical Involvement with the Area

If ATSDR is going to discuss Homestake's involvement in the area, it is important ATSDR's account be complete and accurate. Homestake suggests ATSDR incorporate the following facts in its description of past operations and response actions.

Elevated concentrations of selenium were first discovered in alluvial groundwater near the Homestake mill in 1975 during a joint EPA and New Mexico Environmental Department

¹ By "background" we mean the level or range of a particular constituent that is attributable to sources other than the Homestake mill site, in particular naturally occurring levels in this heavily mineralized area of the State within the Grants Mineral Belt.

("NMED") study of groundwater conditions in the Grants mineral belt. Although the 1975 study did not conclude that the Homestake mill was the source of the selenium, Homestake immediately agreed to provide an alternate water supply to residents of Murray Acres and Broadview Acres, the affected communities. Homestake also voluntarily entered into a Groundwater Protection Plan with NMED, one of the earliest agreements of its kind, in which Homestake agreed to remediate the alluvial aquifer to background conditions and to contain any seepage from the tailings ponds to shallow groundwater. To accomplish the Plan's objectives, in 1977 Homestake installed the first in a series of collection wells to capture any seepage from the tailings ponds and injection wells to introduce clean water and create a hydraulic barrier between the tailings ponds and the subdivisions. Homestake continued to supply alternative water to subdivision residents until 1985, when Homestake paid to connect all residences near the mill to municipal water from the Village of Milan. Homestake then paid for water supplied to those residences for ten years, until 1995.

In 1981, Homestake submitted an application for a comprehensive Discharge Plan pursuant to New Mexico Water Quality Control Commission ("WQCC") requirements. NMED subsequently approved the Discharge Plan (DP-200), which superseded the 1976 Groundwater Protection Plan and is still in effect today. DP-200 sets forth an extensive groundwater remediation plan designed to reduce concentrations of certain constituents in the alluvial aquifer to WQCC groundwater standards or to background concentrations where background exceeds the WQCC standards.

Through a network of collection, injection and monitoring wells, Homestake continues to implement remedial measures pursuant to DP-200 and another related Discharge Plan, DP-725. The groundwater collection and injection control system that Homestake started in 1977 was one of the first and most sophisticated large groundwater cleanups in the United States and has

expanded to include more than 600 wells. To augment this system, a large reverse osmosis unit was added in 1999 to treat a large amount of water with constituent concentrations above drinking water standards. This treatment system concentrates virtually all of the constituents into approximately 30 percent of the treated water stream, which is directed to an on-site evaporation pond. The balance of the treated water is cleaner than the naturally occurring water in the alluvial or Chinle aquifers, and is re-injected into the alluvial aquifer to promote the groundwater restoration. Dewatering of the Large Tailings Pile (LTP) was started in 1995 to reduce seepage from the pile into groundwater. A flushing program for the LTP was started in 2000 and has greatly reduced concentrations of constituents in the LTP water. An irrigation program was also initiated in 2000 to accelerate remediation in off-site areas where uranium and selenium concentrations are slightly above background levels. Homestake continues to closely monitor the site and evaluate even better ways to restore the groundwater affected by its operations.

Background Concentrations

The benchmark for determining whether the levels of metals in the wells in question are “elevated” is the background level. The background concentrations referenced in the Consultation are based on a statistical analysis of water data from the alluvial and Chinle aquifers gathered over ten years, 1994-2003. All of the alluvial wells sampled were entirely upgradient of the Homestake mill site and all of the Chinle aquifer wells were either upgradient from or not influenced by the Homestake mill. Consequently, the referenced background concentrations are the levels of the constituents of concern that occur naturally in those aquifers, or which have not been impacted in any way by operations at the Homestake mill site. Background concentrations of selenium in the alluvium and all portions of the Chinle aquifer exceed the federal drinking water standards, the MCL that ATSDR uses as a reference point. Background concentrations of uranium exceed the MCL in all of the aquifers except the Lower

Chinle, where background is 20 ppb and the MCL is 30 ppb. The referenced background concentrations have been reviewed and accepted by the EPA, NMED and NRC.

In all cases in which concentrations of selenium or uranium in residential wells exceed the MCL but are below background, ATSDR should clearly state that the concentrations cannot be attributed to Homestake and that, in fact, ATSDR has made no determination that Homestake's operations have contributed to the concentrations. Moreover, ATSDR should be clear that, even when Homestake's groundwater restoration is completed, concentrations of these constituents in these aquifers will likely remain above the MCLs and not be regarded as safe for long-term consumption.

Once ATSDR clarifies the definition of the background it is applying, that definition should be applied consistently throughout the Consultation. As currently written, ATSDR applies different definitions of background at different times. For example, in the third paragraph on page four, ATSDR begins the paragraph by stating that background concentration refers to the naturally occurring levels of uranium and selenium. Later in the same paragraph, however, it is implied that background includes unspecified "uranium site activities" upgradient of the site. ATSDR should specify what data or evidence it is relying on for the assertion that upgradient uranium site activities have contributed to the background concentrations that have been accepted by EPA, NMED and NRC. In addition, ATSDR should clearly state that all constituent concentrations upgradient of the mill are unrelated to Homestake's mill operations. A clear definition and consistent usage of the term "background" will avoid potential confusion by the public regarding the standard.

Public Health Hazard

ATSDR's characterization of the "Homestake mill site" as a current public health hazard (Consultation at 2 and 24) mistakenly implies that the mill is the sole or predominant source of

the elevated levels of metals in private wells downgradient of or near the Homestake property. ATSDR's characterization of the site as an "indeterminate public health hazard" in the past is also questionable. (Consultation at 23). ATSDR states that it made this determination because of inconsistent historic well sampling data when, in fact, the wells from which people were drinking were sampled very regularly beginning in 1975, when the first elevated levels of selenium were detected. Homestake reduced the sampling program only after the residences where the wells were located had been connected to the Village of Milan municipal water supply. Even then, Homestake continued monitoring groundwater in the area pursuant to a monitoring program approved by NMED.

ATSDR should be clear that its conclusion that the Homestake mill site is a public health hazard is based solely on groundwater samples taken from outside the Homestake mill site. None of the sampled wells is actually on the Homestake mill site and, as previously discussed, all or most of the concentrations above MCL are below background levels. Homestake requests that the characterization of the site be changed from a public health hazard to "no apparent health hazard." At a minimum, ATSDR should refer only to the impacted aquifers as a public health hazard and should state that it has made no determination regarding the source or sources of the constituents of concern. In particular, ATSDR should avoid any statement or suggestion that the Homestake mill is a public health hazard or is known to have contributed to elevated constituent levels in the wells in question.

Defining the "Site"

Homestake is concerned with the ambiguous use of the word "site" to describe not only the Homestake mill property but also to describe the surrounding area including upgradient areas. Although the Homestake mill is an easy reference point, it is not an accurate point of reference. It is important that the word "site" be used carefully so that it is clear precisely to

which area ATSDR is referring. To avoid confusion, ATSDR should narrow the use of the word “site” so that it refers only to the actual mill property and use the names of the aquifers to describe affected areas outside of the Homestake property. Homestake would like to suggest that the Consultation be re-titled “Health Consultation, San Mateo Alluvial and Chinle Aquifers, Milan, Cibola County, New Mexico.”

Distinguishing Contaminants from Constituents

The word contaminant implies that the substance in question is a result of human activity, but the primary source of the metals and other constituents of concern in the aquifers is the high mineralization that occurs naturally in the study area. Use of words like “elements,” “constituents” or, when appropriate, “level” or “concentrations” more accurately reflect the makeup and origin of the constituents in question. Homestake suggests that ATSDR not use the word “contaminant” where it is clear that the level of the element originated, in whole or substantial part, from naturally occurring sources. See the redlined version of the Consultation for specific suggestions.

Health Effects of Constituents

In the section of the Consultation entitled “Contaminants of Concern,” ATSDR correctly states that uranium poses little or no health threat to humans and that natural and depleted uranium is not known to cause cancer. (Consultation at 19). Similarly, ATSDR recognizes that selenium and many of the other “contaminants” have either not been linked to health problems or are not present in the wells at a level that would cause reasonable concern. (Consultation at 18). We endorse and commend ATSDR’s recognition of the scientific consensus that uranium and selenium are not toxic except in extraordinarily large doses and that neither uranium nor selenium is a carcinogen. However, ATSDR should make the low level of risk clear from the beginning of the Consultation. As it is currently written, the early parts of the report may lead a

reader to believe that greater health risks exist than are actually present. (*E.g.*, Consultation at 2, 3, and 5)

For residents to understand the risks associated with their particular wells, it is important that they understand the benchmark metrics. Therefore, ATSDR should describe in the Consultation specifically how MCLs and MRLs are calculated and explain that they have significant built-in margins of safety, or “cushions.” As ATSDR knows, these metrics are not intended to be bright-line dividers between a level that will make someone sick and one that is safe. They are intended to protect the very young and the very old and are calculated with consideration of significant levels of exposure over a long period of time. ATSDR has explained MRLs in the following way in other documents:

[MRLs] are below levels that might cause adverse health effects in the people most sensitive to such effects. MRLs are generally based on the most sensitive end point considered to be a relevance to humans. Serious health effects (such as irreparable damage to the liver or kidneys, or birth defects) are not used as a basis for establishing MRLs. Exposure to a level above the MRL does not mean that adverse health effects will occur.

Agency for Toxic Substances and Disease Registry, Toxicological Profile for Uranium, Appendix A at 1 (1999), *available at* www.atsdr.cdc.gov/toxprofiles/tp150.html. Typically, an ATSDR MRL is derived by starting with an appropriate lowest-observed adverse effect level (LOAEL) and reducing this dose level with a variety of safety factors, sometimes ranging up to a factor of 1,000 (*i.e.*, 10 for use of a LOAEL, 10 for extrapolation from animals to humans, and 10 for human variability). Similarly, EPA has described how it calculates an MCL as follows:

After reviewing health effects studies, EPA sets a Maximum Contaminant Level Goal (MCLG), the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. MCLGs are non-enforceable public health goals. Since MCLGs consider only public health and not the limits of detection and treatment technology, sometimes they are set at a level which water systems cannot meet. When determining an MCLG, EPA considers the risk to sensitive subpopulations (infants, children, the elderly, and those with

compromised immune systems) of experiencing a variety of adverse health effects.

Once the MCLG is determined, EPA sets an enforceable standard. In most cases, the standard is a Maximum Contaminant Level (MCL), the maximum permissible level of a contaminant in water which is delivered to any user of a public water system. The MCL is set as close to the MCLG as feasible, which the Safe Drinking Water Act defines as the level that may be achieved with the use of the best available technology, treatment techniques, and other means which EPA finds are available, taking cost into consideration.

EPA, Setting Standards for Safe Drinking Water (2006), *available at* www.epa.gov/safewater/standard/setting.html.

Furthermore, ATSDR should clarify for readers that the MCL is a standard that applies under the federal Safe Drinking Water Act at the tap, and it applies only to public water systems that have at least fifteen service connections or regularly serve at least twenty-five individuals daily for at least sixty days of the year. 40 C.F.R. § 141.2 (2007). The wells at issue here are not part of a public water system. Even if the level of metals in an individual's well exceeds an MCL, ATSDR should be clear that it does not violate a standard or requirement of the Safe Drinking Water Act.

SPECIFIC COMMENTS

These comments are intended to be considered in conjunction with the redlined version of the Consultation. Please note that the page numbers listed below refer to the page numbers of the original report and not to the page numbers of our redlined version of the report.

Summary

- Page 1, paragraph 3. It is not accurate to link the "discovery" of groundwater contamination to the listing of the site on the National Priorities List ("NPL"). As noted in the redlined version, elevated levels of selenium were discovered in residential wells downgradient from the mill in September 1975. Homestake immediately provided bottled water to residents who

requested it at its own cost and continued to do so until 1985 when it paid for residential hookups to the Milan system, and then paid for the residences' water usage for an additional ten years. Homestake also entered into a Groundwater Protection Plan with NMED in early 1976, in which it committed to contain any seepage from the tailing ponds and restore selenium concentrations to background conditions.

- Page 2, paragraph 3. It is not clear what ATSDR means when it refers to the “lack of consistent monitoring.” Groundwater beneath residential areas near the mill has been closely monitored and subject to continuous intensive cleanup efforts since 1977 when the Grants Homestake groundwater collection and injection control system was implemented. The groundwater monitoring program conducted in the residential subdivisions by Homestake has always been done in cooperation with, and subject to the approval of, the NMED. If ATSDR intends to characterize the monitoring program as lacking consistency, it should also state that the monitoring program was approved by NMED.
- As mentioned above in the general comments regarding the site's designation as a public health hazard, ATSDR should insert the precise criteria or language it used to determine that the site is or may potentially be a public health hazard.

Section 1. Background

- This section should be updated to include an accurate summary of Homestake's ongoing and aggressive cleanup beginning in 1977.
- Page 2, paragraph 3. This paragraph should be consistent with page 12 and note that the reason the wells were not sampled from 1985 to 1995 is that residences were connected to the Milan water supply and that a monitoring program approved by NMED was followed to monitor conditions in the residential areas.

Section 2. Hydrology

- Tables 1, 2, 3, and 4. All tables in this section should include an additional column showing the established background concentrations as a reference point for comparison. Also, the word “contaminant” should be stricken from the titles for the reasons discussed in the general comments above.
- Page 5, paragraph 1. Homestake suggests that ATSDR strike the words “uranium plume” and replace it with “greater than MCL concentrations of uranium” to avoid the implication that the concentrations above the MCL are a result of activity at the mill.
- Pages 10-11, Table 5. Please insert a column that includes the dates of the most recent sample. The current layout mistakenly suggests that the wells have not been sampled in many years, if at all.
- Page 12, paragraph 1. ATSDR should state that these wells had not been sampled more recently because the residences where these wells were located had been connected to the Village of Milan pursuant to Homestake's agreement with EPA, and that a monitoring program approved by NMED was followed to monitor conditions in the residential areas.
- Pages 13 and 15. So that the public and the users of Well No. 16 are fully informed, we suggest ATSDR state that residents using Well No. 16 are connected to the Milan water supply and therefore elevated levels of constituents should not be a cause for concern in terms of a public health hazard.

Section 3. Contaminants of Concern

- Page 18, last paragraph. Strike “although some may be possible” from the last sentence. It does not seem appropriate to speculate in a health science document designed for lay public consumption.

- Page 19, paragraph 2. ATSDR should specify the amount of uranium exposure at which the studies have shown “chemical effects” to occur and stress how much more exposure was involved compared to the potential exposure from uranium levels actually present in any of the wells.² Further, it should be stressed that the kidney damage observed in the most heavily exposed individuals in the studies was readily reversible and apparently disappeared with the passage of time. M. Eisenbud & J.A. Quigley, *Industrial Hygiene of Uranium Processing*, 14 A.M.A. Archives of Industrial Health 12, 20 (1956).

Section 4. Exposure Scenario for Those Persons Still Using Their Wells

- Page 20, paragraph 1. There are institutional controls in the form of deed restrictions in Felice Acres, and there have been many quasi-institutional controls, such as notices to residents not to use well water for drinking water, multiple public meetings and outreach efforts toward area residents, and the provision of an alternate drinking water supply to residents in the affected area. Accordingly, the statement that “[n]o institutional controls have been put in place to restrict the use of well water so individuals have been able to use the water as they wish” is inaccurate and should be revised.
- Page 21, paragraph 2. It is unclear if the second sentence is referring to a well that is distinct from the sixteen wells referenced in the first sentence or if the well is one of the sixteen wells. If the second sentence is referring to one of the sixteen wells that ATSDR knows is being used for drinking water, it does not seem to make sense for ATSDR to state that it is

² For example, MCLs are based on reference doses (RfD). The uranium RfD (0.003 mg/kg/day) is given on USEPA’s Integrated Risk Information (IRIS) website at <http://www.epa.gov/ncea/iris/subst/0421.htm>. As described in the IRIS documentation, the U RfD was based on assessing experiments in rats, rabbits, and dogs eating uranium in food, and rabbits were found to be the most sensitive species. Based on histology of kidney tissues assessed at the end of the experiment, the LOAEL was determined to be 2.8 mg/kg/day. Because of extrapolation of results from animal species, a factor of 1,000 was used to extrapolate from the rabbit LOAEL to a human RfD for uranium.

“unknown if this well is being used as a potable supply of water.” We suggest ATSDR specify which wells are being specifically used for drinking water out of the 21 wells sampled in September 2005 and May 2006 and which residences are indeed connected to alternative water supplies.

- Page 21, paragraph 4. ATSDR should clarify that only a single well, No. 13, located in Felice Acres, has shown an upward trend in uranium concentrations.

Section 5. Community Concerns

- Page 22, paragraph 3. ATSDR should delete the statement that Homestake owns land near the well and that it has used fertilizer in the past. This is purely a speculative source.

Section 6. Conclusions

- Page 23, paragraph 4. ATSDR should strike the sentence stating that “adverse health effects in livestock would have been more likely to occur . . .” because the conclusion is speculative and unsubstantiated by data.
- Page 23, paragraph 5. ATSDR should clarify that only a single well, No. 13, located in Felice Acres, has shown an upward trend in uranium concentrations. Again, Homestake requests that ATSDR either remove its designation of Homestake mill site as a public health hazard because the site itself does not present the perceived health hazard or make it clear that the Consultation is reporting on the risk that constituents present in the aquifers pose, as distinguished from those present on Homestake property.

Section 7. Public Health Action Plan

- Page 24, last paragraph in this Section. Please specify when and at what frequency ATSDR intends to make future sampling and evaluations of the groundwater in the area and whether funding is currently available for the assessment and the source of such funding. If funding is not currently available, consider whether ATSDR should make such a commitment.

Health Consultation

San Mateo Alluvial and Chinle Aquifers

**Deleted: Homestake Mining
Company Mill Site**

Milan, Cibola County, New Mexico

May 19, 2008

Prepared by

**Agency for Toxic Substances and Disease
Registry Division of Health Assessment and
Consultation Atlanta, Georgia 30333**

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Summary

In 1958, the Homestake Mining Company (Homestake), located in Milan, New Mexico, opened a mill to process uranium. The mill operated for approximately 30 years, closing in 1990. Today, two tailings (waste) piles remain on the Homestake site. The tailings piles overlie an alluvial groundwater aquifer. Constituents from the larger of the two piles have migrated into the alluvial aquifer and constituents from the smaller of the piles may have done so as well. The southwesterly direction of the alluvial aquifer's groundwater flow resulted in the cross-contamination of underlying aquifers within the Chinle formation, as well as contamination of some private wells that are completed in the alluvial and Chinle aquifers.

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Elevated concentrations of selenium were first discovered in alluvial groundwater near the Homestake mill in 1975 during a joint EPA and New Mexico Environmental Department (NMED) study of groundwater conditions in the Grants mineral belt. Although the 1975 study did not conclude that the Homestake mill was the source of the selenium, Homestake immediately agreed to provide an alternate water supply to residents of Murray Acres and Broadview Acres, the affected communities. Homestake also voluntarily entered into a Groundwater Protection Plan with NMED, one of the earliest agreements of its kind, in which Homestake agreed to remediate the alluvial aquifer to background conditions and to contain any seepage from the tailings ponds to shallow groundwater. To accomplish the Plan's objectives, in 1977 Homestake installed the first in a series of collection wells to capture any seepage from the tailings ponds, and injection wells to introduce clean water and create a hydraulic barrier between the tailings ponds and the subdivisions. Homestake continued to supply alternative water to subdivision residents until 1985, when Homestake paid to connect all residences near the mill to municipal water from the Village of Milan.

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In September 1983, the United States Environmental Protection Agency (USEPA) placed the Homestake site on the National Priorities List (NPL). The USEPA was concerned about radon emissions from the piles. However, after monitoring indoor and outdoor radon concentrations in the subdivisions continuously for fifteen months, EPA concluded that the Homestake mill was "not contributing significantly to off-site radon concentrations." (USEPA Region 6 Record of Decision, Homestake Mining Company Radon Operable Unit, Cibola County, New Mexico, September 1989).

In December 1983, USEPA and Homestake entered into a consent decree under which Homestake committed to provide a permanent, alternative water supply to all existing residences in the subdivisions south of Homestake, which then included Felice Acres and Pleasant Valley Estates, as well as Murray Acres and Broadview Acres. Homestake was required to provide, potable water for household purposes, including drinking, cooking, washing and sanitary uses to the residences by connecting all the residences to the Village of Milan municipal water supply and to pay for such water usage for 10 years. Connections to the Village of Milan water supply were completed in April 1985, and Homestake paid the water bills until 1995.

Remediation of the contaminated aquifers has been ongoing since 1977, and over the years, contaminant levels have decreased. Selenium and uranium levels in some of the wells have, however, remained above their respective maximum contaminant level (MCL)—drinking water standards that apply to public drinking water systems. This is likely due primarily to the background concentrations of these constituents that occur in the alluvial and Chinle aquifers.

San Mateo Alluvial and Chinle Aquifers, Milan, Cibola County, New Mexico
Health Consultation

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Homestake's on-going groundwater restoration efforts include a network of collection, injection and monitoring wells and other measures designed to restore constituent levels to background concentrations. The groundwater collection and injection control system Homestake began in 1977 was one of the first and most sophisticated large groundwater cleanups in the United States and has expanded to include more than 600 wells. To augment this system, a large reverse osmosis unit was added in 1999 to treat a large amount of water with constituent concentrations above drinking water standards. This treatment system concentrates virtually all of the constituents into approximately 30 percent of the treated water stream, which is directed to an on-site evaporation pond; the balance of the treated water is cleaner than the naturally occurring water in the alluvial or Chinle aquifers, and is re-injected into those aquifers to promote the groundwater restoration. Dewatering of the Large Tailings Pile (LTP) was started in 1995 to reduce seepage from the pile into groundwater. A flushing program for the LTP started in 2000 has greatly reduced concentrations of constituents in the LTP water. An irrigation program was also initiated in 2000 to accelerate remediation in off-site areas where uranium and selenium concentrations are slightly above background levels. Homestake continues to closely monitor the site and evaluate even better ways to restore the groundwater affected by its operations.

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In 2005, USEPA and NMED initiated work to determine if area residents had access to uncontaminated potable drinking water. As part of that work, a well survey was conducted by USEPA and NMED in September 2005, which identified 5 of 34 well owners who were using their wells as a primary drinking water source, with the remaining 28 using the alternate water supply (Village of Milan). The September 2005 sampling event identified approximately two-thirds of the wells (22 out of 34) had uranium concentrations above the MCL, three wells had selenium concentrations above the MCL, and one had nitrate levels above the MCL. However, it is important to remember that the background levels of uranium and selenium exceed the MCL in the aquifers in which most of these wells are completed.

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Comment: It would be useful to specifically identify the wells and the constituent concentrations in a table.

USEPA and NMED conducted an additional round of well sampling in May 2006. Nine of the wells sampled in September 2005 were re-sampled, and an additional 19 wells were sampled that had not been previously. The May 2006 sampling event identified 16 of the 19 wells that were being used as a primary source of drinking water. It is unknown if six other well owners, who had their well sampled during this time, were using their wells. Seven wells were sampled in May 2007. One of these wells had been sampled previously (#20) and another is located where the residence has been connected to the alternate water supply.

ATSDR reviewed over thirty years of groundwater data from the aquifers and found that, because of Homestake's on-going remediation efforts and aquifer recharging, concentrations of uranium, arsenic, selenium, and molybdenum have declined in most of the wells, in some cases by two orders of magnitude. Arsenic concentrations were above the MCL in the past, but were below the MCL during the most recent sampling. Molybdenum does not have an enforceable standard, but it did exceed ATSDR's drinking water comparison value in the past. Molybdenum concentrations from the most recent sampling were below ATSDR's comparison value. Selenium and uranium concentrations in the mid-1970s, 1980s, and in some cases the 1990s were one to two orders of magnitude greater than the last three sampling rounds.

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Some of the wells, however, still have levels of metals above their respective drinking water standard and/or guideline because local background levels in this area are elevated, and could still have them after the remedial actions at the site are completed. It is estimated that the on-

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going remediation will lower the concentrations of metals down to background by 2015, but some of the metal concentrations will remain above their respective drinking water standard because of background levels. In accordance with accepted public health practice, ATSDR recommends that well owners who have obtained a connection to the alternate source of water continue to use this source of water. Also, individuals that are using their well as a source of potable water and have metal concentrations above the MCL need to contact the State of New Mexico's Environmental Department (NMED) to find out how to be connected to the alternate water supply. This will ensure that they are not exposed to levels of uranium and selenium above the MCLs in the alluvial and Chinle aquifers.

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The considerable concentration differences in wells within the same aquifer, the unknown usage of wells during the alternate water supply period, and anomalies with the sampling data are all factors that make past exposures an indeterminate health hazard. Sampling results from the past three years indicate that uranium and selenium concentrations are above drinking water standards in some private wells in the area, but in most cases concentrations are below local background levels for those constituents. Hence, these constituents will most likely continue to be above their respective drinking water standard upon completion of the remedial actions.

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1. Background

The Homestake Mining Company uranium mill, which opened in 1958, is located 5.5 miles north of the Village of Milan in northwest New Mexico. For approximately 30 years, Homestake milled uranium at the site. In 1975, USEPA and NMED conducted a study of groundwater conditions in the Grants mineral belt, including areas downgradient from the Homestake mill. Elevated levels of selenium were detected in some residential wells in Broadview and Murray Acres, two small subdivisions south of the mill. Even though the 1975 study did not conclude that the Homestake mill was the source of the selenium, Homestake voluntarily entered into a Groundwater Protection Plan with NMED, in which it agreed to remediate selenium until it reached background concentrations and to contain any seepage that may occur from the tailings ponds to shallow groundwater. To accomplish the Plan's objectives, in 1977 Homestake installed the first in a series of collection wells to capture any seepage from the tailings ponds and injection wells to introduce clean water and create a hydraulic barrier between the tailings ponds and the nearby residential subdivisions. Homestake also voluntarily agreed to provide clean water for potable uses on a regular schedule to any residents in the Broadview and Murray Acres subdivisions at its own cost during the time selenium levels were above the background levels. Homestake continued to provide this service until 1985 when, pursuant to a Consent Decree with USEPA, Homestake agreed to pay for all residences in the subdivisions south of mill to be connected to the Village of Milan water supply. In addition, Homestake agreed to pay for water for household purposes in those residences for ten years, until 1995.

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In September 1983, USEPA placed the Homestake site on the National Priorities List (NPL), because of the potential for radon emissions from the tailings piles. However, after monitoring indoor and outdoor radon concentrations in the subdivisions continuously for fifteen months, EPA concluded that the Homestake mill was "not contributing significantly to off-site radon concentrations," and that the principle cause of slightly elevated radon found in eight homes was related to local, native soil and was a function of the type and quality of housing construction.

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(USEPA Region 6 Record of Decision, Homestake Mining Company Radon Operable Unit, Cibola County, New Mexico, September 1989).

Deleted: Further investigations at the site identified groundwater contamination in on-site monitoring wells and some residential wells.

In 1990, the mill closed and was decommissioned and demolished. During 1993-1995, the Nuclear Regulatory Commission (NRC) oversaw surface reclamation activities at the site. Although the mill is gone, two tailings piles remain. The tailings piles are the result of waste products generated from the milling of uranium. The larger pile covers 200 acres and is approximately 100 feet high; the smaller pile covers 40 acres and is 25 feet high and was not used after 1962.

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In September 2005, the NMED and USEPA conducted a well survey in the subdivisions south of the mill site to verify that residents were not drinking contaminated well water. These two agencies collected samples from 34 private drinking water wells. The samples were analyzed for USEPA's target analyte list of compounds and radionuclides. In November 2005, USEPA Region 6 contacted the Agency for Toxic Substances and Disease Registry (ATSDR) and requested that ATSDR review the results and determine whether a public health hazard exists. Additional sampling was conducted in 2006 and 2007; this consultation includes ATSDR's review of those sampling results.

During its survey of the data ATSDR asked USEPA and NMED about any previous sampling that had been done in the area around Homestake. The NMED informed ATSDR of a database Homestake Mining Company generated some years ago containing data for private well sampling in the area. ATSDR obtained and analyzed the data; and incorporated this analysis into the health consultation.

The database included some wells that were sampled as far back as 1975, and others that were only sampled once or twice before September 2005 (USEPA 2005). Many of the wells were not sampled from 1985 through 1995 because the residences were connected to the Milan municipal water supply. Homestake continued to monitor groundwater in the subdivisions during this time pursuant to a monitoring plan approved by NMED.

The state of New Mexico's standard for uranium in groundwater was recently changed in June 2007 from 5,000 parts per billion (ppb) to 30 ppb (Court of Appeals State of New Mexico 2006, NMED). USEPA's MCL for uranium is 30 ppb and has been since 2000 (USEPA 2001).

1.1 Demographics

Approximately 200 people live within a mile of the tailings piles. Five residential subdivisions are located south and southwest of the mill site: Felice Acres, Broadview Acres, Murray Acres, Valle Verde, and Pleasant Valley Estates, along with a few residences located near the Pleasant Valley Estates. None of these subdivisions existed when the Homestake mill was constructed and began operating in 1958. Only Murray Acres and Broadview Acres had been developed before 1980. Within the subdivisions and farther south and west, the land is used for agriculture and livestock. The subdivisions are located between 0.5 mile to 2 miles from the tailings piles, with the nearest residence and drinking water well about 3,000 feet away. The well sample results are from the above five subdivisions and several residences east of State Route 605.

1.2 History

In 1958, milling operations began at Homestake's mill site. The operations involved the use of an alkaline leach-caustic precipitation process to extract and concentrate uranium oxide from

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uranium ores. The byproducts (waste) were either disposed above ground in the two tailings impoundments or recycled back into the milling process. Groundwater monitoring and remediation at the site began in 1977. Since then, over 600 wells have been installed at the Homestake site for groundwater injection, collection, and monitoring purposes.

Homestake began the state-approved groundwater restoration program in 1977 (CH2MHILL 2001). The program consists of a groundwater collection/injection system for the San Mateo alluvial aquifer and the Upper and Middle Chinle aquifers. Ongoing injection and extraction activities within the Upper and Middle Chinle occurs both within and outside of the subdivisions. The objective is to reduce concentrations of metals and other constituents down to background concentrations.

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Homestake and the USEPA signed a consent decree for an alternate water supply in December 1983. The decree required Homestake to provide an alternate water supply to nearby residences and to pay for water usage for 10 years. The alternate water supply hookups to residences were completed in April 1985, with Homestake paying for water usage until 1995. The soil cleanup and mill reclamation activities were completed in 1995 and approved by the NRC in 1999 (CH2MHILL 2001).

2. Hydrology

The tailings piles are located on alluvium, which is unconsolidated soil or sediment deposited by a river or other flowing water. The alluvium overlies the Chinle and San Andres aquifers, which subcrop with the alluvial aquifer at various locations near Homestake. Radioactive and nonradioactive contaminants within the tailings piles have leached and seeped downward through the soils, beneath the tailing piles into the groundwater. Site-derived contaminants within the alluvial ground water subsequently impacted the underlying Chinle aquifer through the subcrop areas.

Groundwater monitoring data indicate that contamination from tailings seepage at the mill site has affected the San Mateo alluvial aquifer and the Upper, Middle, and Lower Chinle aquifers. The San Mateo alluvial aquifer is the primary aquifer of concern because metal constituent concentrations are higher than in other aquifers and the majority of residential wells that were sampled are completed in the alluvial aquifer. The alluvial aquifer also mixes with the Chinle aquifers to some extent due to faulting and subcropping. The impacted wells are completed in one of the four aquifers. A few residential wells that were sampled are completed in the San Andres aquifer, which is not impacted by site-derived contaminants.

Uranium and selenium occur naturally in the various aquifers; this is referred to as the background concentration. The uranium and selenium background concentrations were determined for the different aquifers based upon samples collected between 1995 and 2005. Historic uranium milling and mining activities that occurred up gradient of the Homestake mill site may have also impacted the groundwater. It is important to note that the background concentrations for uranium and selenium are above their respective drinking water standard in some of the aquifers. Homestake is required to reduce the concentrations of selenium and uranium in each of the aquifers to their background concentrations, not to the drinking water standards. Consequently, even when Homestake's remediation is completed, groundwater in some of the aquifers will likely contain some constituents at concentrations greater than the drinking water standard.

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Background Concentrations

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Constituent	Aquifer				
	Alluvial	"Mixing zone"	Upper Chinle	Middle Chinle	Lower Chinle
Selenium (ppb)	320	140	60	70	320
Uranium (ppb)	160	180	90	70	20
Molybdenum (ppb)	100	100	100	100	100
Sulfate (ppb)	1,500,000	1,750,000	914,000	857,000	2,000,000
Chloride (ppb)	250,000	250,000	412,000	250,000	634,000
TDS (ppb)	2,734,000	3,140,000	2,010,000	1,560,000	4,140,000
Nitrate (ppb)	12,000	15,000	NA	NA	NA

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2.1 Current Groundwater Contamination

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During September 2005, the NMED and the USEPA sampled 34 wells in the previously mentioned subdivisions. Figure 1 depicts the locations of the wells within the five subdivisions. Several property owners have more than one well, and of the 28 well owners who consented to sampling, 22 have an alternate water supply—the Village of Milan (NMED 2005). The other six owners indicated that their residences are not connected to the Village of Milan water supply. Two of the wells (## 6, 7) are in the alluvium aquifer and the other four (##s 9, 10, 20, and 34) are completed in the Lower Chinle aquifer. The owners of well # 6 stated they were drinking bottled water and that they have a filter on their faucet to control water hardness. The owner(s) of well # 7 told NMED officials that they have a filter on their well. The type and efficiency of the filter is unknown.

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Sampling results indicated the presence of several constituents above federal drinking water standards, known as maximum contaminant levels (MCLs), and secondary MCLs (SMCLs). Most of the constituents, however, were not above their respective background concentrations, as indicated by the table above. MCLs are standards established under the federal Safe Drinking Water Act that apply to public water systems; these standards are not enforceable with respect to private wells like those at issue here. SMCLs are unenforceable guidelines that regulate for aesthetic effects (such as color, smell, and taste) and cosmetic effects (skin or tooth discoloration).

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Two separate, narrow areas of groundwater with uranium concentrations exceeding the MCL of 30 ppb extend from the tailings impoundments to the west and south. The greater-than-MCL concentrations of uranium to the west of the impoundments extends beneath the northern portion of Pleasant Valley Estates subdivision, past Valle Verde. The southward-extending area appears to originate beneath the east perimeter of the small tailings impoundment and extends under Highway 605, the Broadview Acres and Felice Acres subdivisions, and beyond Felice Acres to the southwest.

Other contaminants detected at levels above drinking water standards or comparison values include selenium and sulfate, but the source of these constituents has not been determined. One well had a high level of nitrates, however, this occurrence of nitrate is not attributed to the Homestake mill site and the origin of the nitrates is unclear, given that no other well had such

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high levels. Table 1 contains the list of contaminants and the concentration ranges found in the wells.

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2.1.1 Groundwater Contaminants

To screen contaminants and to determine which contaminants need further evaluation, ATSDR uses comparison values. These are doses (health guidelines) or substance concentrations (environmental guidelines) set well below levels known—or anticipated to result in—adverse health effects. In some instances the MCL was used as a comparison value; for other contaminants, an environmental media evaluation guideline (EMEG) was used. EMEGs are media-specific comparison values used to select chemical contaminants of potential concern at hazardous waste sites. These metrics are not predictors of adverse health effects, nor do they set cleanup levels. The following describe what each comparison value represents.

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EMEG - Environmental Media Evaluation Guides. EMEGs represent concentrations of substances in water, soil, and air to which humans may be exposed during a specified period (acute, intermediate or chronic) without experiencing adverse health effects.

MCL - Maximum Contaminant Level. The MCL is the highest level of a contaminant that is allowed in water delivered to any user of a public water system. MCLs are enforceable standards. MCLs are deemed protective of health during a lifetime (70 years) at an exposure rate of 2 liters per day (2 L/day). These levels are extremely conservative, as they are intended to protect the most vulnerable segments of a population and are therefore designed to include multiple margins of safety.

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MRL - Minimal Risk Level. A MRL is an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during a specified duration of exposure. They are set below levels that might cause adverse health effects in most people, including sensitive populations. MRLs are based on non-cancerous health effects only and are not based on a consideration of cancer effects.

RMEG - Reference Dose Media Evaluation Guides. If no Minimal Risk Level (MRL) is available to derive an EMEG, ATSDR develops RMEGs using USEPA's reference doses (RfDs) and default exposure assumptions, which account for variations in intake rates between adults and children. RMEGs apply to chronic (greater than 1 year) exposures.

Table 1 identifies the contaminants and the concentration range found in residential wells during the September 2005 sampling event. Table 2 lists the contaminant levels in those wells not connected to the alternate water source.

A portion of the groundwater sample results ATSDR reviewed for this consultation were presented as total metal concentrations and dissolved metal concentrations. Analyzing the samples in the lab this way helps identify how much of the metal in the sample is bioavailable (dissolved) portion compared to the total (dissolved and not dissolved) portion. Bioavailability is the proportion of total metals that are available for incorporation into biota (bioaccumulation). The two portions should be relatively similar regarding the concentration; the total should be slightly higher than the dissolved portion. Upon review of the groundwater monitoring data,

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ATSDR recognized that a few of the well sample results had higher dissolved concentrations than total concentrations. For these results, it is likely that the sample results were entered incorrectly. None of the sample results had concentrations vastly different from one another.

ATSDR used the dissolved portion results in the following tables. Total metal concentrations do not necessarily correspond with metal bioavailability. The dissolved portion is more readily available for the body to absorb the metal.

Table 1. Constituents found in residential wells during September 2005*

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<i>Constituent</i>	<i>Concentration range in parts per billion (ppb)</i>	<i>Comparison Value in ppb</i>	<i>Type of Comparison Value</i>	<i>Number of wells exceeding the Comparison Value</i>
Arsenic	<1 – 4	10	MCL	0
Lead	<2 – 34	15	MCL action level	4
Molybdenum	<1 – 82	50	RMEG	4
Nitrates	ND – 16,000	10,000	MCL	1
Selenium	<1 – 174	50	MCL; EMEG	3
Sulfate	193,000 – 1,390,000	250,000	USEPA drinking water advisory	33
Uranium	4.3 – 849	30	MCL	23

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* Sample results for May 2006 indicated none of the contaminants was outside of the ranges determined for the September 2005 sampling period.

ATSDR has not determined whether constituent concentrations that exceed the comparison values are naturally occurring, are the result of mining and milling operations, or both.

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Table 2. September 2005 metal levels found in residential wells not connected to the Village of Milan water supply

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Well #	Aquifer	Selenium (50)	Background Levels	Uranium (30)	Background Levels
6	Alluvium	32	320	40	160
7	Alluvium	40	320	47	160
9	Lower Chinle	25	320	10	20
10	Lower Chinle	9	320	4	20
20	Lower Chinle	24	320	22	20
34	Lower Chinle	12	320	10	20

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Concentrations are in ppb

Drinking water standard in parenthesis. **Bold numbers** indicate the levels are greater than the MCLs established for public drinking water systems. However, in the only two wells (## 6 & 7) with uranium concentrations above the MCL, the concentrations were well below background levels. No wells had selenium concentrations above the MCL.

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An open house was held in Grants, New Mexico during March 1-2, 2006 to discuss well sample results with those individuals who had their wells sampled in September 2005. Additional well owners who did not have their well sampled in September 2005 attended and requested that their wells be sampled. USEPA and NMED collected their names and addresses and notified them of when their well was to be sampled.

An additional round of sampling was conducted in May 2006 where 29 wells were sampled. Nine of the wells had been previously sampled in September 2005, but the remaining 22 had not. The well locations are also shown in Figure 2. Table 3 lists the constituent levels in the wells where the residence is not connected to the Village of Milan water supply.

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Figure 1. Locations of wells sampled in September 2005 and May 2006

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Table 3. May 2006 Constituent Levels in Wells Not on the Village of Milan Water Supply

Well #	Aquifer	Selenium (50)	Background Level	Uranium (30)	Background Level
6	Alluvium	27	320	32	160
7	Alluvium	38	320	54	160
9	Lower Chinle	26	320	11	20
20	Lower Chinle	26	320	23	20
34	Lower Chinle	13	320	9	20
37	Lower Chinle	13	320	16	20
38	Lower Chinle	8	320	18	20
39	Lower Chinle	6	320	7	20
40	Alluvium	24	320	37	160
42	Lower Chinle	18	320	6	20
43	San Andres	11		5	
44	Lower Chinle	9	320	17	20
45	Alluvium	54	320	46	160
46	San Andres	18		46	
47	Lower Chinle	11	320	16	20
49	Lower Chinle	101	320	25	20
50	Lower Chinle	3	320	9	20
51	Upper Chinle	2	60	25	90
52	Unknown	4		4	
53	Middle Chinle	ND	70	11	70
54	Unknown	5		4	

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Concentrations are in ppb

NOTE: The residences where wells 37, 38, 47 and 49 are located have been connected to the Village of Milan water system since May 2006.

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Drinking water standard in parenthesis **Bold numbers** indicate the levels are greater than the MCLs established for public drinking water systems. Note, however, that in all wells where the MCL was exceeded for selenium or uranium, the concentrations of those constituents was still below background levels.

ND - Non Detection

Seven wells were sampled in May 2007. One of these wells had been sampled previously (#20) and another well sampled is located where the residence has been connected to the alternate water supply. Table 4 lists the contaminant levels in those wells.

Comment: Only five wells, not seven, are listed in the table. Well 20 is not listed.
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Table 4. May 2007 Metal levels in wells not on the Village of Milan water Supply

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Well #	Aquifer	Selenium (50)	Background Level	Uranium (30)	Background Level
46	San Andres	21		55	
49	Lower Chinle	97	320	30	20
56	Unknown	11		9	
57	Lower Chinle	26	320	44	20
58	Alluvium	26	320	74	160

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Concentrations are in ppb

Drinking water standard in parenthesis. **Bold numbers** indicate the drinking water standard levels are greater than the MCLs established for public drinking water systems. Although Tables 2, 3, and 4 do indicate some levels of selenium or uranium above drinking water standards, only well 57 in May 2007 showed a concentration above both the MCL and background concentrations.

2.2 Past Groundwater Contamination

The sampling conducted in September 2005 identified arsenic, lead, molybdenum, nitrates, selenium, sulfate and uranium present in groundwater from the wells sampled at that time. All of these constituents occur naturally in the groundwater in this area. Sampling conducted in May 2006 and May 2007 identified selenium and uranium present in groundwater from the wells sampled at those points in time. Again, these are naturally occurring elements and in all cases the concentrations of selenium were below background. Uranium concentrations exceeded background levels in two of the fifty-eight wells sampled.

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Comment: It is difficult to determine the total number of wells sampled. 58 comes from table 5. It would be helpful to state this and to show results for all wells sampled, regardless of whether the well was sampled in more than one sampling event.

To determine any contaminant-level trends in the private wells, ATSDR wanted a better idea of what the contamination levels were in the past. ATSDR reviewed the historical database compiled by Homestake and provided by USEPA, which contained samples dating back to 1975 for some of the wells (USEPA 2005). Table 5 contains the list of wells that were sampled in one of the last three sampling rounds (with the exception of well #3) and their sampling history. Well #3 was included to give a comprehensive history of all wells sampled over time.

Table 5. Well sampling history

Well number	Aquifer	Last sample date (update with latest sample – see specific comments)	Residence connected to Milan Water Supply
1	Middle Chinle	2005	Yes
2	Middle Chinle	1998	Yes
3	Upper Chinle	2004	Yes
4	Alluvium	1995	Yes
5	Alluvium	1983	Yes
6	Alluvium	NA	No
7	Alluvium	2002	No
8	Alluvium	1995	Yes

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Well number	Aquifer	Last sample date (update with latest sample – see specific comments)	Residence connected to Milan Water Supply
9	Lower Chinle	NA	No
10	Lower Chinle	NA	Yes
11	Alluvium	NA	Yes
12	Alluvium	2004	Yes
13	Middle Chinle	2004/2005	Yes
14	Upper Chinle	2004/2005	Yes
15	Alluvium	1994	Yes
16	Alluvium	2004/2005	Yes
17	Lower Chinle	1991	Yes
18	Alluvium	1996	Yes
19	Alluvium	1996	Yes
20	Lower Chinle	2001	No
21	Alluvium	1996	Yes
22	Middle Chinle	2005	Yes
23	Alluvium	1997	Yes
24	Middle Chinle	1998	Yes
25	Alluvium	2003	Yes
26	Middle Chinle	2003	Yes
27	Alluvium	2004	Yes
28	Alluvium	2004/2005	Yes
29	Alluvium	1995	Yes
30	Alluvium	1995	Yes
31	Alluvium	1994	Yes
32	Alluvium	2002	Yes
33	Alluvium	1995	Yes
34	Lower Chinle	NA	No
35	Middle Chinle	1981	Yes
36	Unknown	NA	Yes
37	Lower Chinle	1994	Yes
38	Lower Chinle	NA	Yes
39	Lower Chinle	1996	No
40	Alluvium	1995	No
41	Middle Chinle	1998	Yes
42	Lower Chinle	1996	No
43	San Andres	1996	No
44	Lower Chinle	NA	No
45	Alluvium	1995	No
46	San Andres	1995	No
47	Lower Chinle	1994	Yes
48	Middle Chinle	2002	Yes
49	Lower Chinle	2003	Yes

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Well number	Aquifer	Last sample date (update with latest sample – see specific comments)	Residence connected to Milan Water Supply
50	Lower Chinle	1994	No
51	Upper Chinle	2005	No
52	Unknown	NA	No
53	Middle Chinle	1995	No
54	Unknown	NA	No
55	Lower Chinle	1983	Yes
56	Unknown	1995	Yes
57	Lower Chinle	1998	No
58	Alluvium	NA	No

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Many of the wells sampled in September 2005 hadn't been sampled previously for ten years or more. The additional wells sampled in May 2006, that hadn't been sampled in September 2005, had no prior sampling data. Additionally, sampling between 1985 and 1995 was limited because these residences had been connected to the Village of Milan municipal water supply, and the NMED approved a more limited groundwater monitoring plan for the subdivisions.

Comment: Specify which wells and clarify that the reason they were not sampled is that residences had alternative water supplies.

Deleted: this was the timeframe during which many residences were provided the alternate water supply by Homestake.

This sampling variability over different periods made analyzing the results difficult. Determining potential adverse health effects from exposure is dependent upon what concentrations people were exposed to, for how long they were exposed, and other factors. The different aquifers and varying concentrations of metals within those aquifers, as well as the depths of the individual wells, must be taken into account when determining what an individual's exposure dose may have been. Wells sampled once only tell us what was in the well at the time of sampling. Compared to past concentrations, these one-time samples could have been higher, lower, or similar.

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Other than the three most recent sampling events, many of the wells (#s 5, 7, 19, 20, 21, and 23) in the database had only been sampled a few times.

Some of the wells (#12 (1981), #13 (1984), #14 (1984), #16 (1975), and #28 (1977)¹ were sampled consistently throughout the 1980s and 1990s. The residences where these wells are located are connected to the Village of Milan water supply.

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To determine any trends in the makeup of the groundwater, ATSDR used the results from the wells that had been sampled consistently from the mid-1970s through May 2007. Using the wells that were sampled consistently gave us an indication of what the constituent levels were over time. The following wells had enough samples to complete the evaluation of trends in the sample data:

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Alluvium: well #'s 12, 16, and 28

Upper Chinle: 3, 14

Middle Chinle: 13, 26

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¹ The year in parentheses is when the well was first sampled.

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Lower Chinle: 17

2.2.1 Trends in the data

Alluvium wells:

Well #12, which is located in Felice Acres, and Well #28 which is in Broadview Acres, are located immediately south of the small tailings pile. Despite their proximity and their location in the alluvium, the constituent concentrations in the two wells are considerably different:

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- Uranium concentrations in well #12 were four times greater than those in well #28.
- Molybdenum concentrations are still above comparison values in well #12, but are barely detectable in well #28.

The residences these wells serve are connected to the Village of Milan water supply.

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#12

#28

Well #16 is located in Murray Acres.

#16

The residence where this well is located is connected to the Village of Milan water supply. Selenium concentrations have varied throughout this well over the past thirty years. From the mid -1970s until the mid -1980s the concentrations were well above the MCL, with the highest concentration (370 ppb) detected in 1981. Concentrations dropped in the late-1980s and then increased in the early 1990s. Since November 1999, the concentrations have been below the MCL and the most recent sampling indicated the level was the lowest since that time.

Uranium concentrations have been elevated above MCLs in this well since 1992 with the highest concentrations occurring between 1996 and 2002. The maximum concentration of 1,960 ppb occurred in 2001 and the September 2005 sample contained 837 ppb.

Molybdenum concentrations do not appear to have been a problem in this well.

Upper Chinle wells

#3

The residence where this well is located is connected to the Village of Milan water supply. Selenium concentrations were between 10 and 60 ppb during the late 1970s and throughout the 1980s. In 1996, the selenium concentration reached a maximum of 147 ppb and concentrations have decreased ever since. Since June 2004, selenium concentrations have been below the detection limit of 5 ppb.

The maximum uranium concentration (237 ppb) was detected in this well in June 1975. Uranium concentrations fluctuated between 8 and 85 ppb throughout the 1980s and 1990s. Since 2001, the concentrations dropped below the MCL and are currently around 6 ppb.

Molybdenum concentrations reached a maximum of 50 ppb in 1983. Since then, concentrations have been below the detection limit of 30 ppb.

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The residence where this well is located is connected to the Village of Milan water supply. Selenium concentrations have varied over time in this well, with a maximum concentration of 70 ppb in 1986. Since 2000, concentrations have been in the 20-30 ppb range.

Since 1984, concentrations of uranium in this well have dropped consistently. In that year, uranium was detected at 916 ppb. By 1986 the concentrations were in the 500-600 ppb range. Since 1989, the concentration has varied between 200-400 ppb. In 2005, the uranium levels were in the high 100-ppb to low 200-ppb range.

The maximum molybdenum concentration (310 ppb) was detected in well 14 during 1984. From 1985 until 1995 concentrations dropped, and since 1995 they have remained below 100 ppb.

Selenium, uranium, and molybdenum concentrations have declined over the years, but uranium levels remain above the MCL of 30 ppb.

Middle Chinle wells

#13

The residence where this well is located is connected to the Village of Milan water supply. Since October 1990, selenium concentrations in this well have been above the MCL and above the chronic 50-ppb EMEG. In October 1999, the maximum selenium concentration of 261 ppb was detected. Sample results from the September 2005 sampling indicated a concentration of 171 ppb. This well was not sampled in May 2006 or May 2007.

By contrast, over the years uranium concentrations in this well have increased. Between 1984 and 1988, uranium was below the 10-ppb detection limit. Between 1989 and 2002, the concentrations fluctuated from 17 ppb to 56 ppb. From 2003 until 2005, the concentrations increased to over 100 ppb and a maximum of 185 ppb in February 2005.

Molybdenum levels in this well have remained below the comparison value.

#26 Sample data was lacking from 1984 to 1994 and from 1996 to 2002 because the residence was connected to the Village of Milan water supply in 1985.

The residence where this well is located is connected to the Village of Milan water supply. From 1979 through 1983, selenium levels in this well ranged from as high as 800 ppb (1980) to 90 in 1983. From 1994 until 1995 they were below the comparison value.

Molybdenum levels were much greater in this well compared to well #13 even though they are in the same aquifer. They have continued to decline over the years (two orders of magnitude). A maximum 2,350 ppb was detected in 1982 and the level in the most recent sampling was 65 ppb.

Uranium levels in this well were as high as 6,530 ppb in 1980 and decreased to 180 ppb in September 2005.

In the Middle Chinle aquifer, lead is not at a level that would be considered a public health problem. Uranium levels increased in well #13, but have declined in well #26.

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Lower Chinle wells

The Lower Chinle has the lowest levels of contaminants of any of the aquifers. Historically, selenium and molybdenum have not exceeded comparison values. Only two wells (#17 and #20) have any prior sampling data. Well number 17 lacks sampling data from 1992 until 2005. Well number 20 was only sampled in 2001. Nitrates are elevated in this well, but no other constituents were above comparison values or drinking water standards. Nitrate is also considered to be a site-related contaminant, although it is uncertain where this source is originating.

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Comment: What is meant by "site-related," and what is the basis for this statement?

In 1976, the maximum uranium concentration in well #17 (84 ppb) was detected. Since then, concentrations have varied until the most recent sampling, when 82 ppb was detected.

In 1981, arsenic levels exceeded the comparison value, but ever since the arsenic levels have remained below the comparison value.

ATSDR reviewed over thirty years of sampling results and found that the ongoing remediation has greatly reduced the levels of contaminants. During this time, the levels of some of the contaminants have decreased by two orders of magnitude. ATSDR is concerned, however, about increasing concentrations of uranium in well #13 in the Middle Chinle aquifer, and the elevated levels of uranium in well # 16 located in the alluvial aquifer. Although uranium concentrations are decreasing in this well, they are quite elevated compared to the other wells within this aquifer. However, because these residences are already connected to the Village of Milan water supply, ATSDR does not believe a significant risk to the occupant's health exists.

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Table 6 lists the historical concentrations found in wells screened in the various aquifers.

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Table 6. Historical metal concentration ranges in parts per billion (ppb).

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<i>Aquifer</i>	<i>Arsenic</i>	<i>Lead</i>	<i>Molybdenum</i>	<i>Selenium</i>	<i>Uranium</i>
Alluvial	ND-310*	ND-100	ND-2, 120	ND-3,650	ND-1,510,000
Upper Chinle	ND - 14	3	ND-310	ND-147	162 – 916
Middle Chinle	ND-28	ND-100	ND-4,930	ND-1,600	ND-12,300
Lower Chinle	ND-10	ND-34	ND-30	ND - 34	ND- 84.8
Comparison Value	3 Chronic EMEG (child)	15 USEPA Action Level	50 Child RMEG	50 Chronic EMEG(child)	30 MCL

* - Sample result may be an anomaly.

3. Constituents of Concern

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The following are contaminants of concern—that either exceeded the MCL or exceeded a comparison value.

Arsenic

Arsenic is an element that occurs naturally in soil and minerals and is widely distributed in the earth's crust. It may enter the air, land and water from windblown dust and may also enter the water from runoff and leaching. In the environment, arsenic usually bonds with other elements such as oxygen, chlorine, and sulfur. This form of arsenic is known as inorganic arsenic. Arsenic combined with carbon and hydrogen is known as organic arsenic. The organic forms of arsenic are usually less harmful than the inorganic forms. But the specific form of arsenic to which a person may be exposed is not always known—the analytical methods used by scientists to determine the levels of arsenic in the environment generally do not distinguish between organic and inorganic.

The concentration of arsenic in natural surface and groundwater is generally about 1 part in a billion parts of water (1 ppb), but it may exceed 1,000 ppb in mining areas or in areas where arsenic levels in soil are high (ATSDR 2000a). The maximum arsenic concentration was detected in well # 28 in 1977 at 310 ppb, but this reading may be an anomaly because samples from this well that were analyzed by different labs the day before and the day after show concentrations at 31 ppb and less than 10 ppb, respectively. The sample results from this well in 1981 show arsenic levels at 20 ppb and the September 2005 sample identified a concentration of less than 1 ppb. Arsenic was detected in another well (# 8) in 1977 with the next highest concentration at 40 ppb. In 1978, the well was sampled again and the concentration was equal to 10 ppb. Arsenic concentrations have remained below 10 ppb in this well ever since 1978. The majority of the wells had a concentration of 10 ppb or less and ATSDR used 10 ppb to calculate an exposure dose.

The resulting exposure doses were compared to the MRL of 0.0003 mg/kg/day for chronic duration (365 days or more) of oral exposure to arsenic. The MRL was calculated from a study

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in which 17,000 people had no symptoms after exposure to an average total daily intake (i.e., from water plus food) of 0.0008 mg As/kg/day (Tseng et al. 1968). Because estimated exposure doses at Homestake are less than 0.0008 mg As/kg/day, nearby residents are not expected to experience adverse health effects due to this level of arsenic. None of the wells sampled during the past 3 sampling rounds had concentrations of arsenic above the MCL.

Lead

Like arsenic, lead is a naturally occurring element and is a known toxin. But unlike arsenic, lead is bluish-gray in color and occurs in smaller quantities in the earth's crust. The main target for lead toxicity in both adults and children is the nervous system. Children, however, are more sensitive to the effects of lead than are adults. Low levels of lead exposure can affect children's mental and physical growth.

ATSDR has not derived MRLs for lead, nor has the US EPA developed a reference concentration (RfC) for lead. USEPA also deemed as inappropriate the development of a reference dose (RfD) for inorganic lead (and lead compounds). Some health effects associated with exposure to lead occur at blood lead levels so low as to be essentially without a threshold (IRIS 1999).

The lead concentration in the areas around the Homestake site has historically been below the USEPA action level of 15 ppb. The most recent sampling in May 2007 did not identify any of the wells with lead concentrations at or above 15 ppb.

ATSDR calculated exposure doses based on the maximum concentration (34 ppb) found in wells during the September 2005 sampling. The estimated exposure doses are below the lowest observed adverse effect level (LOAEL) of 0.02 mg/kg/day. The five wells that are used as primary residential water sources revealed a complete absence of lead. None of the wells sampled in May 2006 and May 2007 had dissolved concentrations of lead above comparison values. Consequently, the lead levels in wells sampled around Homestake are not sufficient to cause adverse health effects.

Molybdenum

Molybdenum is another naturally occurring element found in various ores and is considered an essential trace element. The Food and Nutrition Board (FNB) of the Institute of Medicine has found little evidence that in generally healthy people any molybdenum excess was associated with adverse health outcomes. The FNB determined the tolerable upper intake level for molybdenum in children and adults (FNB 2001):

- For children 1 to 3 years of age, it is equal to 0.3 mg/kg/day;
- children 4 to 8 years of age (0.6 mg/kg/day);
- children 9 to 13 years of age (1.1 mg/kg/day);
- adolescents 14 to 18 years of age (1.7 mg/kg/day); and
- adults (2.0 mg/kg/day).

ATSDR calculated a dose based on the highest concentration (174 ppb) detected during the September 2005 sampling round at Homestake and found the exposure doses to be below 0.3 mg/kg/day by an order of magnitude (i.e., 0.0174 mg/kg/day). These doses are not sufficient to

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cause adverse health effects in people. None of the wells sampled in May 2006 and May 2007 had any molybdenum levels above the comparison value.

Selenium

Selenium is one more naturally occurring, solid element that is widely but unevenly distributed in the earth's crust. Selenium is an essential nutrient for humans and animals. Insufficient selenium intake can cause heart problems and muscle pain. People receive the majority of their daily intake of selenium from eating food, and to a lesser extent, from drinking water.

In some parts of the United States, especially in the western states, some soils naturally contain high levels of selenium compounds. Still, no human populations in the United States have been identified with long-term selenium poisoning, including populations in the western part of the country where, as stated, in-soil selenium levels are naturally high. Most of the selenium that enters the body quickly leaves, usually within 24 hours. Some studies have shown that if mildly excessive amounts of selenium are eaten over long periods, brittle hair and deformed nails can develop (ATSDR 2003). The LOAEL whereby nail damage was seen was equal to 0.023 mg/kg/day.

Although selenium levels in the Lower Chinle aquifer were not above the MCL (50 ppb), they were above the MCL in the Middle Chinle and Upper Chinle aquifers, but this is likely due to background levels. Results from the May 2006 sampling identified a maximum concentration equal to 105 ppb. This concentration was found in a well that is used for domestic purposes and the residence is not connected to the alternate water supply. ATSDR used this concentration to calculate an exposure dose. The exposure dose based on this concentration was above the chronic MRL of 0.005 mg/kg/day, but was below the No Observed Adverse Effect Level (NOAEL) of 0.015 mg/kg/day for nail disease.

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Uranium

Throughout the world uranium is a natural and common radioactive element. Rocks, soil, surface and ground water, air, plants, and animals all contain varying amounts of uranium. The area around Homestake has high concentrations of naturally occurring (background) uranium in the soil and is much higher than other areas of the country. For nearly three decades (1951-1980), the Grants uranium district in northwestern New Mexico produced more uranium than any other district in the world (McLemore and Chenoweth 1989). New Mexico ranks second behind Wyoming as the state with the most uranium reserves in the United States (EIA 2001). The background concentrations of uranium in the groundwater are also much higher than other areas of the country, and in some of the aquifers the background concentrations are above the current drinking water standard.

Uranium is a chemical substance that is also radioactive. Scientists have never detected harmful radiation effects from low levels of natural uranium. Natural uranium is radioactive but poses little radioactive danger—it releases only small amounts of radiation. Moreover, unlike other types of radiation, the alpha radiation released by natural uranium cannot pass through solid objects, such as paper or human skin. Few human data are available that adequately describe the dose-response toxicity of uranium after an oral exposure. The data regarding human exposure to uranium via the oral route are mainly for acute (i.e., less than or equal to 14 days) exposures (ATSDR 1999).

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Scientists have seen chemical effects in people that have ingested large amounts of uranium. Kidney disease has been reported in both humans and animals that were exposed to large amounts of uranium. The available data from studies on (the more important) soluble and the insoluble uranium compounds are sufficient to conclude that uranium has a low order of metallotoxicity in humans. In view of the high levels of exposure reported in these studies, the negative findings regarding renal injury among workers exposed over long periods to insoluble uranium compounds are particularly significant (Eisenbud and Quigley 1955).

Comment: Consider specifying the amount used in these studies.

Natural and depleted uranium are only weakly radioactive and are not likely to cause cancer. No human cancer of any type has ever been seen as a result of exposure to natural or depleted uranium. The National Academy of Sciences determined that bone sarcoma is the most likely cancer from oral exposure to uranium; its report noted, however, that this cancer has not been observed in exposed humans and concluded that exposure to natural uranium may have no measurable effect (BEIR IV).

The maximum uranium concentration detected from the September 2005 sampling was 849 ppb. The residence where this concentration was detected is connected to the Village of Milan water supply. This well was not sampled in May 2006. ATSDR recommends that this well not be used. The highest concentration detected in wells at residences not connected to the Milan water supply during September 2005 was 46.7 ppb. If people were exposed to this concentration on a daily basis, children and infants expected exposure dose would exceed the MRL of 0.002 mg/kg/day for an intermediate-duration oral exposure. The MRL is based on a LOAEL of 0.05 mg U/kg/day for renal effects in rabbits. The MRL level for intermediate-duration oral exposure is also protective for chronic-duration oral exposure—the renal effects of uranium exposure are more dependent on the dose than on the duration of exposure.

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In May 2006, the maximum uranium concentration detected was 287 ppb. The residence where this was detected is connected to the Milan water supply. The maximum concentration found in private wells not connected to the Milan water supply was detected in May 2007 at 74 ppb. People exposed at this concentration would exceed the MRL, but the estimated dose would be below the LOAEL of 0.05 mg U/kg/day. [not clear how many wells are being discussed here – need to clarify] For systemic effects the LOAEL in humans was equal to 131 mg/kg/day (ATSDR 1999). This level is much higher than the estimated exposure doses calculated for uranium concentrations in well water around Homestake.

Other Constituents

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The USEPA has established National Secondary Drinking Water Regulations which set non-mandatory water quality standards for 15 constituents. These non-enforceable standards are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor. These standards are also used as guidelines regarding constituents that may cause cosmetic effects (such as skin or tooth discoloration). These constituents are not considered to present a risk to human health at the secondary maximum contaminant level (SMCL) (USEPA 1992).

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Many of the wells sampled contained elevated levels of total dissolved solids (tds), sulfates, iron, and chloride which exceeded USEPA's SMCLs. A few wells exceeded the SMCL for manganese. The following contaminants were found to exceed the SMCL in the well samples:

Manganese

Three wells contained manganese levels above USEPA's SMCL of 50 ppb. The residences where these three wells are located are connected to the Village of Milan water supply. Manganese is an essential nutrient, and eating a small amount of it each day is important to stay healthy. Too much manganese may also cause serious illness. Manganese miners or steel workers exposed to high levels of manganese dust in air may have mental and emotional disturbances, and their movements may become slow and clumsy. This combination of symptoms is a disease called "manganism".

It is not certain whether eating or drinking too much manganese can cause symptoms of manganism. In one report, people who drank water with above-average levels of manganese seemed to have a slightly higher frequency of symptoms such as weakness, stiff muscles, and trembling hands. However, these symptoms are not specific for manganism and might have been caused by other factors. Another study in adults over 40 years old who drank water with high manganese levels for at least 10 years reported no changes in behavior and no symptoms which commonly occur in people exposed to excess levels of manganese. Two studies reported that children who drank water and who ate food with higher-than-usual levels of manganese did more poorly in school and on specific tests that measure coordination than children who had not eaten above-average amounts of manganese. However, these studies included several limitations; it is not clear whether the adverse effects in the children were caused only by eating too much manganese (ATSDR 2000b).

Sulfates

Many of the wells sampled had elevated sulfate concentrations. The maximum sulfate concentration detected in May 2006 was 2,340 ppm. USEPA's SMCL is equal to 250 ppm and the state of New Mexico's water quality criteria is 600 ppm. Consumption of drinking water with sulfate levels above 600 ppm can cause laxative effects, including diarrhea. Dehydration can result from persistent diarrhea. Infants and children are more susceptible to diarrhea induced dehydration than healthy adults because of their smaller size and more frequent turnover of water and electrolytes. The elderly and people who are already ill are also at a higher risk of dehydration resulting from persistent diarrhea.

4. Exposure Scenario for Those Persons Still Using Their Well(s)

The three most recent sampling events identified several homeowners who are using their well(s) as a source of drinking water. In addition, there are homeowners who had their well(s) tested, but it is uncertain if they are using their well(s) as a source of drinking water.

The September 2005 sampling identified five well owners whose residences were not connected to the Village of Milan water supply. In September 2005 and May 2006, uranium concentrations in well #6 and well #7, both located within the alluvium, were above the MCL, but below background levels.

The additional round of sampling conducted in May 2006 identified sixteen additional well owners who are using their wells for drinking water. One well sampled during this timeframe contained uranium at 265 ppb. It is unknown if this well is being used as a potable supply of water. ATSDR recommends that this well not be used as such. It is uncertain if six other wells that were sampled are being used as a source of drinking water.

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Comment: Please specify which of the residences serviced by the wells referenced have been connected to the Village of Milan municipal water supply

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Sampling in May 2007 identified one well with selenium concentrations above the MCL, but below background levels, uranium concentrations equal to the MCL, and sulfates above the SMCL. The one well that has had nitrate concentrations in excess of the MCL in the past still has them. Three additional wells have uranium concentrations above the MCL, one of which also is above background, and sulfate concentrations above the SMCL.

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Remedial actions are expected to continue until 2015. Even when the remedial actions are complete, uranium levels will still be above the drinking water standard because of background levels. ATSDR is concerned about the increasing concentrations of uranium in one well, No. 13, the Middle Chinle aquifer and believes well owners that have a well completed in the Middle Chinle should not use well water for potable purposes, although use for other purposes such as lawn watering, livestock, etc. is acceptable. In order to be protective of the public's health, ATSDR recommends that well owners refrain from using their well(s) for potable purposes if uranium, selenium, or nitrates are above their respective MCL. ATSDR recognizes that deed restrictions prohibit Felice Acres residents in from tapping into shallow aquifers and that other controls, such as public meetings and this report, are in place to raise awareness of the groundwater quality throughout the subdivisions.

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5. Community Concerns

During the meetings held on March 1-2, 2006, ATSDR noted several concerns from the community regarding the use of well water. Included among those concerns, many residents have horses and grow alfalfa for feed and are concerned that the constituents in the water could contaminate the alfalfa and the horses.

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Other residents were concerned about growing vegetables in their gardens and then consuming them. Both selenium and uranium occur naturally in the soil in New Mexico. Hence, any vegetables grown in the yards around Milan would be exposed to both in the soil. Additional exposure could occur if well water containing selenium and uranium are used to water the vegetables. Unfortunately, no vegetable or soil samples were collected and analyzed during the well monitoring event. Therefore, ATSDR does not know what levels of selenium and uranium were in the vegetables. However, because removing the root and washing the vegetable will remove most or all of the uranium, this is not a significant concern.

Scientific research has shown that uranium transports poorly from soils to plants (Dreesen et al. 1982; Moffett and Tellier 1977). In fact, uranium uptake by plants may be limited to the outer membrane of the root system and may not occur at all within the interior of the root (Van Netten and Morley 1983; Sheppard et al. 1983). That said, because of the higher root sorption of uranium, the consumption of radishes and other root vegetables grown in soils containing uranium may be a source of human exposure, but a thorough cleaning of the plant exterior—especially if performed in conjunction with removal of the outer membrane—may remove most or all of the uranium (Van Netten and Morley 1983).

Some plants can build up selenium to levels that harm livestock feeding on them. A condition referred to as “blind staggers” has been repeatedly observed in cattle feeding on vegetation in areas with high selenium content in the soil. Blind staggers is a symptom of several unrelated animal diseases, in which the affected animal walks with an unsteady, staggering gait and seems to be blind. These neurological effects however, have not been replicated in experimentally exposed cattle receiving doses of selenium sufficient to induce hoof lesions. Thus, the

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neurological signs associated with "blind staggers" may be due to other compounds found within the vegetation (ATSDR 2003). At Homestake, ATSDR spoke with several residents who raised cattle in areas near the site; none had observed any "blind stagger" behavior in cattle.

The Agricultural Research Service, within the United States Department of Agriculture (USDA), conducted studies on the bio-transfer possibilities of selenium from plants used in phytoremediation (USDA 2002). Phytoremediation is the use of plants to remediate soils and water that are contaminated with organic or inorganic pollutants. One of the studies involved the feeding of selenium enriched canola or alfalfa to sheep, rabbits, and dairy cows to determine the bio-transfer capability. Results from the study indicated that the levels of selenium did increase in the animal tissues. The effects of the transfer did not appear to be hazardous, and may even have been beneficial for increasing selenium content in different biological systems (USDA 2002). The transfer of selenium to the milk of the cow was too low to pose a potential health hazard to human health or to be detected. A limitation of the study is the fact that the cows were only fed the selenium enriched feed (canola and alfalfa) for 14 days.

Several other residents stated they had moved into the area after the alternate-water consent decree had been issued and consequently did not know about contamination in the residential wells. USEPA and NMED collected the name of every resident who came to the public meeting and their well number. Those who did not have their wells sampled in September 2005 provided their names and addresses to USEPA and NMED. Those individuals had their well sampled in May 2006 and some in May 2007.

One homeowner's well, which is one of the wells farthest from the site, contained nitrates at 25.3 ppm in May 2006. This level is above the drinking water standard of 10 ppm. All other wells were below the standard. Sampling of the well in May 2007 identified a concentration of 16 ppm. The Homestake mill is not considered to be a source of the nitrates, and the source is unknown. Potential sources of nitrate contamination are normally from runoff due to fertilizer use or leaching from septic tanks or sewage. NMED is currently working with this well owner to determine the source of the nitrates.

6. Conclusions

1. During the 1970s, 1980s, and 1990s, uranium, selenium, and molybdenum concentrations in several private wells near the Homestake site were at levels much greater than those found during September 2005, May 2006, and May 2007. A drinking water standard specific to uranium was not enacted until 2000. Uranium, selenium, and molybdenum concentrations were sometimes as much as 100 times greater than those found in the past three years. The considerable concentration differences in wells within the same aquifer, the unknown usage of wells during the alternate water supply period, and anomalies with the sampling data are all factors that make past exposures an indeterminate health hazard.
2. In 1985, all existing residences within the subdivisions proximate to the Homestake mill site were connected to a permanent alternate water supply (Village of Milan). Residents who used the Milan water as their sole source of water eliminated their potential exposure to water with constituents above MCLs or SMCLs. These residents are still using this source of water. If residents continued to use their well water for drinking, showering, watering gardens and

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Comment: To imply Homestake's past fertilization accounts for nitrate concentrations is pure speculation.
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lawns, they were potentially exposed to water with constituents above MCLs or SMCLs. ATSDR has not determined whether any residents did, in fact, continue to use well water rather than Village of Milan municipal water as a drinking water source. Whether a health hazard existed based on drinking water exposure during this period of time cannot be determined without additional information about well water usage.

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3. ATSDR did not have any vegetable or soil sample results to determine what the contaminant levels were in the vegetables, and therefore doesn't know what levels people may have been exposed to via this route. The amount of uranium, selenium, and molybdenum ingested would depend upon how often they consumed vegetables, if they used contaminated well water to irrigate the vegetables, and if the vegetables were thoroughly cleaned prior to eating them.

4. Because no institutional controls have been established, residents have had the option of using the contaminated groundwater for irrigation purposes and to provide water for their livestock (e.g., cattle, horses, pigs, and sheep). At the public meeting in March 2005, residents did not indicate to ATSDR any "blind stager" activity or other adverse health effects occurring in the livestock.

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5. Analysis of individual well monitoring results over time has shown decreasing molybdenum, selenium, and uranium concentrations; with the exception of one well in Felice Acres (well No. 13) completed in the Middle Chinle aquifer, in which uranium concentrations are trending higher. The three most recent sampling events identified several well owners with selenium and uranium levels above the MCL but, in most cases, below background levels, and they may continue to have them above the MCL in the future because of background levels of these metals. Some of these owners are using the Village of Milan water supply and there are others that are using their well(s); and it is unknown if several other owners are using their well(s). Residential wells that have selenium or uranium concentrations above the MCL should not be used for potable purposes. Many of the wells also exceed USEPA's drinking water advisory for sulfates and total dissolved solids. These constituents are more of an aesthetic (color, smell, or taste) problem than a health problem, but could pose a problem to the very young, very old, and those that are already ill. ATSDR concludes the potential for exposure to uranium or selenium is at levels and duration that do not pose a public health hazard. More aggressive institutional controls should be implemented to reduce the potential for exposure to well water with constituents above MCLs as much as possible.

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Comment: make consistent with comment on p.2 is the whole are a health hazard?]

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7. Public Health Action Plan

Homestake continues to operate the groundwater extraction/injection system to dewater the large tailings impoundment and to clean up groundwater contaminated by the tailings seepage. Today Homestake operates more than 600 collection, injection and monitoring wells in the area. In an area between the tailings impoundments and the northern edge of the subdivisions, the natural southwest groundwater flow direction has been reversed. This created a capture zone for recovering contaminated groundwater and for preventing further migration of contaminants toward the subdivisions. (Hydro-Engineering 2001). In addition, Homestake has requested

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additional evaporation capacity, which would hasten the groundwater cleanup. Homestake is awaiting NMED and NRC regulatory approval for the expanded evaporation capacity.

Groundwater restoration is expected to continue until 2015. Although ongoing remediation efforts have helped decrease the level of contaminants in the various aquifers, even upon completion of the remediation, the levels of uranium and selenium will be above drinking water standards, because of background levels of these constituents.

Comment: This should be noted as Homestake is continuing to improve our remediation efforts to hasten groundwater cleanup. Regulatory permitting for the added capacity has now been ongoing for 2 years.

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The large tailings pile is currently capped, with a radon barrier and erosion-protection cover on its sides and an interim soil cover on its top. A final radon barrier will be constructed after the tailings are dewatered. The small tailings pile is also capped by an interim soil cover. Once the groundwater restoration is complete, a final radon barrier will be constructed.

The NMED is currently working with individual well owners so their residence can become connected to the Village of Milan water supply. This water supply is routinely checked and is a cleaner source of potable water.

As approved funds may allow, ATSDR hopes to continue to work in collaboration with the USEPA and the NMED to evaluate future sampling results.

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8. Recommendations

1. Advise residents who have moved to the area since 1995 of the levels of metals and other constituents present in the aquifers beneath the subdivisions and advise those who are using well water to have their water supply tested before using that water for household purposes.
2. Advise residents who are not using the alternate source of drinking water to have their wells sampled, to use bottled water if concentrations are greater than the MCL, or arrange for connection to the Village of Milan water supply.
3. Advise residents who have vegetable gardens to wash the vegetables thoroughly before cooking or eating them. This is especially true for root vegetables, given their high root sorption of uranium.
4. Determine why uranium concentrations are increasing in well No. 13 in the Middle Chinle aquifer.
5. Because of increasing concentrations of uranium in the Middle Chinle aquifer, anyone who has a well in this aquifer should refrain from using the well for potable purposes if the levels are greater than the MCL.

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**MEMORANDUM OF AGREEMENT
BETWEEN HOMESTAKE MINING COMPANY OF CALIFORNIA AND THE NEW
MEXICO ENVIRONMENT DEPARTMENT**

**Agreement Regarding Provision of Access to
Drinking Water System**

Memorandum of Agreement ("MOA") between the Homestake Mining Company of California ("Homestake") and the New Mexico Environment Department ("NMED").

The Parties to this MOA enter into agreement according to the following provisions as set forth in this document and its attachments:

INTRODUCTION

1. Homestake is the owner and operator of the Grants Uranium Mill ("Mill") located approximately four miles north of Milan, New Mexico.

2. Homestake operated the Mill under a license from the State of New Mexico in accordance with the State's status as an NRC agreement state until June 1, 1986. Through a Ground Water Discharge Plan, the State required Homestake to undertake long-term restoration of the aquifers from which property owners in nearby subdivisions obtain water from wells.

3. In September 1983, EPA placed the Mill site on the Superfund National Priorities List at the request of the State. In November 1983, EPA entered into a Consent Decree with Homestake that provided for extension of and connections to the Village of Milan public water system for the property owners living in the subdivisions at that time.

4. On June 1, 1986, the NRC began regulating activities at the Mill site under a source and byproduct material license issued in accordance with 10 CFR Part 40.

5. On December 14, 1993, the NRC and EPA signed a Memorandum of Understanding ("MOU") delineating agency responsibilities in regulating activities at the Mill site. The MOU provides that the NRC will act as lead regulatory agency for the byproduct material disposal area reclamation and closure activities and EPA will monitor such activities and provide comments to the NRC to attain applicable or relevant and appropriate requirements under the Comprehensive Environmental Response Compensation and Liability Act of 1980 ("CERCLA"), 42 U.S.C. §9601, outside the byproduct material disposal site.

6. The MOU provides that both agencies will be responsible for assuring compliance with its specific regulatory requirements. The MOU also provides that the Mill site will be considered for deletion from the National Priorities List only after completion of the closure of the disposal area and other remedial measures are taken in full compliance with 10 CFR Part 40 and EPA and the State of New Mexico determine whether all required response actions with respect to the Mill site have been successfully implemented.

7. NMED, EPA, and NRC, collectively "the Regulatory Agencies" have determined that NMED is the lead agency for the actions to be conducted pursuant to this Memorandum of Agreement. EPA technical staff have committed to NMED to provide technical assistance, such as to review and comment upon work plans, reports, test results, and other documents, as requested by NMED.

8. EPA requested that the Agency for Toxic Substances and Disease Registry ("ATSDR"), an agency within the federal Center for Disease Control, complete and distribute a Health Consultation to property owners in the Area of Concern ("AOC") identified by NMED. Once ATSDR issues a report, NMED will retain the report in its site repository for public review.

9. Pursuant to the New Mexico Water Quality Act, NMSA 1978, §§ 74-6-1 through 74-6-17, in 1983 NMED issued three ground water discharge permits, one of which expired in 1989 or 1990, to Homestake for ground water remediation activities at the Mill site. The two remaining ground water discharge permits are currently active.

10. As part of this Agreement, NMED has designated an Area of Concern ("AOC") around the Mill site, as depicted on map Attachment A to this agreement.

11. This Agreement is entered into expressly for the purpose of establishing Homestake's voluntary commitment to provide access to safe drinking water for current Property Owners listed in Attachment B, except for the provision of potable water to Elizabeth Marie Estates, Block 1, Lot 4, that will be addressed by the Parties in a separate document no later than November 2, 2009.

12. On or about August 2005, NMED and Homestake mutually agreed to undertake a water sampling program in the vicinity of the Mill site of some private domestic wells.

13. The Regulatory Agencies approached Homestake in May 2006 to express their concern that several private residential wells within the AOC used as primary drinking water sources contain contaminants that exceed federal maximum contaminant levels (MCLs) and should not be used for drinking water purposes. Three of these residential wells have contaminant concentrations that exceed background levels accepted by the regulatory agencies and are primary drinking water sources for these properties. Of the three wells not currently

connected to the Village of Milan water system, two have an exceedance of Secondary MCLs and one well has an exceedance of a Primary MCL. All Parties agree that it is not certain that the exceedance of the Primary MCL is related to Homestake's historical operations. NMED requested that Homestake voluntarily connect certain of the properties listed in Attachment B to the Village of Milan water system.

14. Since the initial meetings, NMED has defined the AOC, and the Parties have determined the properties listed in Attachment B, and negotiated the terms and conditions contained in this MOA.

I. AUTHORITY

15. NMED is an executive agency of the State of New Mexico created pursuant to the Department of Environment Act, NMSA 1978, §9-7A-4 (1991). NMED has authority to regulate water quality and enter into agreements pursuant to the New Mexico Water Quality Act NMSA 1978, §§74-6-1 through 74-6-17.

16. Homestake is a California corporation authorized to do business in New Mexico.

II. DEFINITIONS

17. Unless otherwise expressly provided herein, a term used in this Agreement shall have the following meaning:

A. "Advisory" means NMED's "Health Advisory for Private Wells in the San Mateo Creek Basin."

B. "AOC" means the Area of Concern designated by NMED in Attachment A to this Agreement.

C. "EPA" means the U.S. Environmental Protection Agency.

D. "Homestake" means Homestake Mining Company of California.

E. "Milan" means the Village of Milan.

F. "Mill site" means the Homestake Grants Uranium mill site.

G. "MOA" and "Agreement" mean this Agreement, including any attachments and modifications.

H. "NMED" means the New Mexico Environment Department.

- I. "NRC" means the U.S. Nuclear Regulatory Commission.
- J. "OSE" means the New Mexico Office of the State Engineer.
- K. "Parties" means collectively Homestake and NMED.
- L. "Primary MCL" means a constituent standard for which federal and state standards have been established for drinking water.
- M. "Secondary MCL" means a constituent for which an aesthetic federal and state standard has been established.
- N. "Water service connection" means all actions necessary to physically connect existing main water lines of the Milan water system to a residence.
- O. "Main water lines" means the drinking and fire suppression water distribution infrastructure of the Village of Milan water distribution system that is installed in a public right-of-way.

III. DRINKING WATER PROJECTS

18. Water Service Connections.

A. In accordance with the terms of the MOA, Homestake will voluntarily provide water service connections from the Milan main water lines in accordance with Milan engineering specification and requirements to eligible current property owners ("Property Owners") within the AOC listed in Attachment B. In accordance with the terms of the MOA, Homestake also will reimburse certain eligible Property Owners listed in Attachment B for charges already incurred for water service connections to the Milan main water line system from January 1, 2004 to the effective date of the MOA.

B. Homestake shall have 60 days from the execution date of this MOA to notify certain Property Owners listed in Attachment B of their opportunity to be connected to the existing Village of Milan water system. The Property Owners shall have 120 days from such notification to agree to the water service connection terms set forth in this MOA. NMED and Homestake agree that neither Party can require a Property Owner to agree to connect to the Milan water system and the purpose of this MOA is to provide the Property Owners listed in Attachment B with the opportunity to do so.

C. Homestake will enter into an agreement with the Village of Milan to finance the completion of the water service connections for participating Property Owners. Homestake will commence discussions with the Village of Milan to accomplish connections

within 30 days of the execution of the MOA and will use its best efforts to put the financing portion of the project into place within 160 days of the execution of the MOA. Homestake shall notify NMED if these activities extend beyond the original time periods specified in this Agreement.

D. Homestake will use its best efforts to reimburse certain Property Owners who paid their own costs to connect to the Village of Milan water system listed in Attachment B within 60 days of the execution of this MOA. Homestake shall notify NMED if these activities extend beyond the original 60 days.

19. **Advisory.** NMED shall issue a health advisory for private wells ("Advisory") to all property owners in the AOC and publish the advisory in two newspapers of general circulation in Cibola and McKinley Counties. NMED shall use its best efforts to obtain a signature from Property Owners listed in Attachment B acknowledging that they have received a copy of the Advisory. NMED shall request that the OSE issue the Advisory to every person who applies for a well permit within the area referenced in the drinking water advisory. NMED also shall record the Advisory with the Cibola County clerk's office.

20. **Abandonment of Existing Wells.** Homestake will plug and abandon water wells in accordance with 19.27.4 NMAC for property owners within the boundaries of the AOC who request in writing that their well(s) be plugged. Pursuant to this Paragraph, Homestake will notify all property owners within the boundaries of the AOC in writing of the offer to plug their wells. Homestake also will publish a public notice of this offer in two newspapers of general circulation in Cibola and McKinley Counties. Property Owners shall have 120 days from the published public notice to notify Homestake as set forth in the public notice of the Property Owner's intent to have their well(s) plugged. Homestake will arrange for such well plugging on a reasonable schedule and in accordance with obtaining the necessary permits and approvals from the OSE.

IV. REPORTS

21. Within thirty (30) days of the execution of an agreement between Homestake and the Village of Milan for Homestake's financing of water service connections, Homestake shall submit a written report to NMED of such agreement. Thereafter, Homestake shall provide NMED semi-annual reports on the progress by the Village of Milan on completing such water service connections and Homestake's completion of agreements to reimburse certain Property Owners listed in Attachment B who are eligible for reimbursement for connecting to the Village of Milan water system. Homestake also will notify NMED of any wells that have been plugged pursuant to this MOA. Homestake will notify NMED that the activities described in this MOA have been completed and Homestake's reporting requirements hereunder shall be concluded.

V. RELEASE

22. The Parties have negotiated this Agreement for the sole purpose of relieving Homestake of any future obligation to provide access to drinking water services to property owners in the AOC under the New Mexico Water Quality Act, except for the property referenced in paragraph 11. Homestake agrees not to install any wells on Elizabeth Marie Estates, Block 1, Lot 4, prior to November 2, 2009, or as otherwise agreed to in writing by the Parties and attached as an amendment to this Agreement. This Agreement does not relieve Homestake of any liability or responsibility that may exist under federal or state law for further ground water remediation or any other obligation. Furthermore, if NMED becomes aware of data that indicate adverse ground water impacts from Mill site contamination within the San Andres aquifer or outside of the AOC, NMED reserves the right to seek additional action by Homestake to provide safe drinking water to property owners within such areas that are identified.

23. The Agreement shall neither constitute nor be construed as an admission or acknowledgment of liability by Homestake. Nothing in this Agreement shall be construed to create any rights in or grant any cause of action to any person not a signatory to this Agreement. The preceding sentence shall not be construed to waive or nullify any rights that a person not a signatory to this Agreement may have under any law or regulation. The Parties expressly reserve all rights, defenses, claims, demands, and causes of action that they may have against each other with respect to any matter, transaction, or occurrence relating to the Mill site and AOC that is not addressed in this Agreement. Homestake expressly reserves all rights and defenses that it may have to any claim, demand, or cause of action related to the Mill site and AOC that is not addressed in this Agreement. Nothing in this Agreement shall be construed as a waiver of privilege by any Party.

24. Nothing herein shall prevent the Parties from taking an action to address conditions at the Mill site or in the AOC that constitute an emergency or that present an immediate threat to public health or the environment.

VI. COMPLIANCE WITH APPLICABLE LAWS

25. This Agreement shall not affect, change, amend, or relieve any obligation that Homestake may have pursuant to a plan, permit, Consent Decree, or other agreement with NMED, EPA, or NRC. Homestake shall undertake the projects described in this Agreement in accordance with applicable federal, state, and local laws and regulations. This Agreement is not a permit and nothing in this Agreement shall relieve Homestake of its responsibility to comply with all federal, state and local laws, regulations, and permits.

VII. DISPUTE RESOLUTION

26. **Informal resolution.** Should any Party determine that there has been a violation or deficiency in the actions of the other Party under this Agreement, including attachments to this Agreement, that Party shall notify the other Party in writing of the violation or deficiency and propose a plan to correct the violation or deficiency. If the other Party fails to respond within thirty (30) days of receipt of the complaint, the complaining Party may seek enforcement of this Agreement pursuant to Paragraph 29.

27. The Parties agree that the laws of New Mexico shall govern the construction and interpretation of this Agreement. The Parties agree that any dispute regarding this Agreement that could not be resolved through the informal resolution process described in Paragraph 28 shall be resolved in the district court for Santa Fe County. The Parties agree that the district court for Santa Fe County shall have exclusive jurisdiction over the Parties for the purpose of interpreting and enforcing this Agreement, and waive any right to challenge such jurisdiction in any forum.

VIII. COSTS

28. Homestake shall be responsible for its own costs of performance under this Agreement. Nothing in this Agreement shall be used or interpreted to prevent NMED from seeking cost recovery from Homestake pursuant to statutory authority or other agreements. NMED on its own behalf or on behalf of the State of New Mexico, shall not assume liability for Homestake's performance of any obligation under this Agreement.

IX. DELAY OR OMISSION

29. No delay or omission in the exercise of any right or duty under this Agreement shall impair such right or duty nor shall it be construed as a waiver of or acquiescence to a breach or default of this Agreement. No Party shall construe the conduct, delay, or omissions of another as altering in any way its own agreements as set forth in this Agreement. Any waiver, allowance, or approval of any claimed breach or default under this Agreement must be in writing and no Party shall raise unwritten waiver or estoppel as affirmative defenses to such claimed breach or default.

X. BINDING EFFECT

30. This Agreement shall be binding on the Parties and their officers, directors, employees, agents, subsidiaries, successors, assigns, trustees, or receivers.

XI. INTEGRATION AND MODIFICATION

31. This Agreement merges all prior written and oral communications between the Parties concerning the subject matter of this Agreement, and contains the entire Agreement between them. This Agreement shall not be modified without the express written consent of all Parties.

XII. RESERVATION OF RIGHTS AND DEFENSES

32. Other than provided herein, this Agreement shall not be construed to prohibit or limit in any way NMED from requiring Homestake to comply with any state or federal law applicable to the Mill site and AOC, or from seeking any relief authorized by state or federal law applicable to the Mill site and AOC. This Agreement shall not be construed to prohibit or limit in any way Homestake from raising any defense, other than provided herein, to an action by NMED seeking relief for alleged violations or enforcement of legal obligations.

XIII. DISCLOSURE TO SUCCESSORS-IN-INTEREST

33. Homestake shall disclose this Agreement to any successor-in-interest and shall advise such successor-in-interest that the Agreement is binding on the successor-in-interest until the Agreement expires or is terminated by written agreement of the Parties or Homestake's successor-in-interest.

XIV. EFFECTIVE DATE

34. This Agreement shall become effective upon full execution by the duly authorized representatives of the Parties.

XV. TERMINATION OF AGREEMENT

35. This Agreement shall remain an enforceable document until NMED determines in response to a written letter by Homestake that Homestake has complied with all provisions of this Agreement.

XVI. HEADINGS

36. Section and paragraph headings in this Agreement are provided solely as a matter of convenience to the reader and shall not be construed to alter the meaning of any provision of this Agreement.

XVII. SEVERABILITY

37. If any provision or authority of this Agreement is held by a court of competent jurisdiction to be invalid, if that provision or authority is severable from the remainder of this Agreement, the remainder of this Agreement shall remain in force and shall not be affected by the court's order and ruling. If the application of this Agreement to any party or circumstance is held by a court of competent jurisdiction to be invalid, the application of this Agreement to the other party or circumstances shall remain in force and shall not be affected thereby.

XVIII. NOTICE

38. Whenever this Agreement requires a Party to provide notice or submit a document to another Party, the notice or document shall be sent to the following persons in electronic format (.pdf) unless the size or other characteristic of the notice or document requires submission of a hard copy. A Party shall notify all other parties of changes to this list:

For Homestake

Homestake Mining Company
Al Cox
P.O. Box 98
Grants, New Mexico 87020
Phone: (505)287-4456
Fax: (505)287-9289
Email: acox@barrick.com

Ted Grandy, Esq.
Barrick Gold Corporation
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Salt Lake City, Utah 84147-2410
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Jon J. Indall, Esq.
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Fax: (505) 988-2987
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For NMED

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Gerard A. Schoeppner, Project Manager
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Email: leslie.barnhart@state.nm.us

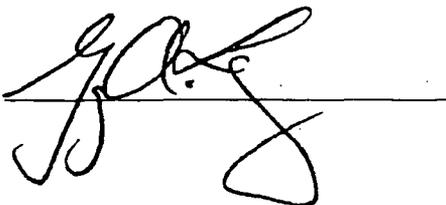
XIX. AUTHORITY OF SIGNATORIES

39. The persons executing this Agreement represent that they have the authority to bind their respective parties to the Agreement, and that their representation shall be legally sufficient evidence of actual or apparent authority to bind their respective parties to the Agreement.

XX. SIGNATURE AND COUNTERPART

40. This Agreement may be executed in multiple counterparts, each of which shall be deemed an original, but all of which shall constitute one and the same agreement.

HOMESTAKE MINING COMPANY



Date: 01/12/09

NEW MEXICO ENVIRONMENT DEPARTMENT



RON CURREY, SECRETARY

Date: 1/12/09

ATTACHMENT B
 Memorandum of Agreement
 Property Listing

Offer to Reimburse for Cost of Hookup to Village of Milan Water System

State Well ID Reference No.	Property Description			
	Subdivision	Block / Lot	Assessor Parcel No.	Assessor Map Code
RW-44			TBD*	TBD*
NA			10-08348	2-056-067-225-320
RW-42			21-01596	2-057-066-465-492
RW-43	La Siembra Estates	Block 1, Lot 21		
RW-46	La Siembra Estates	Block 2, Lot 1		
RW-40	Valle Verde Estates	Block 4, Lot 14		
RW-6	Valle Verde Estates	Block 3, Lot 2		
RW-45	Valle Verde Estates	Block2, Lot 6		
RW-57	Valle Verde Estates	Block 5, Lot 12		
RW-58	Valle Verde Estates	Block 3, Lot 3		

Offer to Reimburse for Past Cost of Current Service Hookup with Village of Milan Water System

State Well ID Reference No.	Property Description			
	Subdivision	Block / Lot	Assessor Parcel No.	Assessor Map Code
RW-47			10-15997	2-057-066-055-248
RW-37			10-00858	2-057-066-025-265
RW-38			10-03406	2-057-066-046-202
RW-49			10-03205	2-056-066-260-512
RW-7	Valle Verde Estates	Block 2, Lot 5		
RW-56	Valle Verde Estates	Block 4, Lot11		

* = To Be Determined

**Grants Reclamation Project
Evaluation of Years 2000 Through 2007
Irrigation with Alluvial Ground Water**

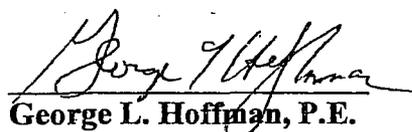
For:

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

By:

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

April, 2008


**George L. Hoffman, P.E.
Hydrologist
Hydro-Engineering, L.L.C**
7/25/08

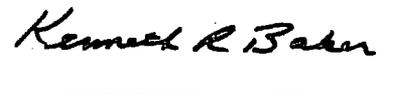

**Kenneth R. Baker, Ph.D.
Health Physicist
Environmental
Restoration Group, Inc.**

TABLE OF CONTENTS

Page Number

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.....	6
3.1 Background Soil Concentrations	6
3.1.1 1998 Investigation	7
3.1.2 Background Determinations during Ongoing Investigation.....	7
3.1.3 Mean Background Soil Concentrations.....	8
3.2 Constituents in Treated Soil.....	13
3.2.1 Section 33 Center Pivot.....	17
3.2.2 Sections 33 and 34 Flood Areas	20
3.2.3 Section 28 Center Pivot.....	23
3.2.4 Comparison of Predicted and Measured Soil Concentrations.....	24
3.2.4.1 Uranium	24
3.2.4.2 Selenium.....	26
3.2.5 Summary of Soil Concentration Comparison	27
4.0 Hay Concentrations and Constituent Uptakes	28
4.1 Measured Hay Concentrations.....	28
4.1.1 Section 33 Center Pivot.....	29
4.1.2 Sections 33 and 34 Flood Areas	29
4.1.3 Section 28 Center Pivot.....	29
4.1.4 Background Concentrations in Hay and Special Study.....	30
4.1.5 Summary of Hay Concentrations	31
4.2 Measured Uranium Uptake in Alfalfa.....	31
5.0 Radiation Dose from Eating Beef.....	33
5.1 Vegetation to Livestock Uptake.....	33
5.2 Beef to Human Uptake.....	34
6.0 Conclusion	34

TABLE OF CONTENTS
(continued)

Page Number

7.0 References..... 35

Figures

1.	Location of Irrigation Areas with Soil Sample Locations From The 1998 Investigation.....	37
2.	1999 and 2000 Irrigation Areas with Irrigation Wells and Soil Sample Locations	38
3.	2001 Irrigation Areas with Irrigation Wells and Soil Sample Locations	39
4.	2002 Sections 33 and 34 Irrigation Areas with Irrigation Wells and Soil Sample Locations.....	40
5.	2003 Sections 33 and 34 Irrigation Areas with Irrigation Wells and Soil Sample Locations.....	41
6.	2004 Sections 33 and 34 Irrigation Areas with Irrigation Wells and Soil Sample Locations.....	42
7.	2005 Sections 33 and 34 Irrigation Areas with Irrigation Wells and Soil Sample Locations.....	43
8.	2006 Sections 33 and 34 Irrigation Areas with Irrigation Wells and Soil Sample Locations.....	44
9.	2007 Section 33 and 34 Irrigation Areas with Irrigation Wells And Soil Sample Locations.....	45
10.	2002 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations	46
11.	2003 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations.....	47
12.	2004 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations.....	48
13.	2005 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations.....	49
14.	2006 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations.....	50
15.	2007 Section 28 Irrigation Area with Irrigation Wells and Soil Sample Locations.....	51

TABLE OF CONTENTS
(continued)

Page Number

Figures (continued)

16.	Uranium Concentrations Versus Time for Section 33 Center Pivot Soil Samples.....	52
17.	Uranium Concentrations Versus Time for Sections 33 and 34 Flood Soil Samples ..	53
18.	Uranium Concentrations Versus Time for Section 28 Center Pivot Soil Samples.....	54
19.	Selenium Concentrations Versus Time for Section 33 Center Pivot Soil Samples	55
20.	Selenium Concentrations Versus Time for Sections 33 and 34 Flood Soil Samples .	56
21.	Selenium Concentrations Versus Time for Section 28 Center Pivot Soil Samples	57

Tables

1.	2000 through 2007 Sections 33/34 Irrigation Supply Concentrations.....	3
2.	2002 through 2007 Section 28 Irrigation Supply Concentrations.....	5
3.	Pre-Operations and Background Soil Sample Results for Section 33	9
4.	Pre-Operations and Background Soil Sample Results for Section 34	10
5.	Pre-Operations and Background Soil Sample Results for Section 28	12
6.	Irrigation Soil Analyses, 2000 through 2007	14
7.	Summary of Irrigation Soil Analyses, 2000 through 2007	18
8.	Uranium Applied in Irrigation Water.....	25
9.	Measured Uranium in Soil at the End of 2007 Growing Season for Treated Soils, Mean Background Concentrations.....	26
10.	Selenium Applied in Irrigation Water.....	26
11.	Comparison of Measured Versus Applied Selenium.....	27
12.	Summary of Hay Analyses	30
13.	Average Uranium Concentrations in Soil and Hay.....	31
14.	Transfer Coefficient from Soil to Hay (mg/kg-hay/mg/kg-soil).....	32

Appendix

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

Executive Summary

This report characterizes changes in uranium and selenium concentrations in four alfalfa (*Medicago sativa*) hay fields supplied with irrigation water from groundwater with elevated levels of uranium and selenium. From 2000 through 2007, 270 to 394 acres were irrigated with this water. Uranium and selenium concentrations have been measured in the applied irrigation water and the affected soils each year and each hay crop since 2000.

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) and 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 7042 acre feet (ac-ft), ranging from 695 to 1034 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 the soil. 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 life of the 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: 0.55, 0.53, and 0.51, averaging 0.53 milligrams per kilogram (mg/kg).
- Section 33: 0.78, 0.69, and 0.71, averaging 0.73 mg/kg.
- Section 34: 1.96, 1.45, and 1.15, averaging 1.52 mg/kg

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 71 to 138 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 63 to 148 percent. The percentages above 100 are likely attributable to variability of solid characteristics as well as analytical accuracy capabilities at the low levels observed.

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

Uranium concentrations in the treated soils in Section 28 were essentially constant and similar to background from 2003 through 2005. The most recent (2007) concentrations exceeded mean background by factors of 2.07 (0-1 ft), 1.91 (1-2 ft), and 1.80 (2-3 ft).

Uranium concentrations in the treated soils in Section 33 started to exceed background in 2003 (2002 not considered). The most recent (2007) concentrations exceeded the mean background by factors of 2.14 (0-1 ft), 1.94 (1-2 ft) and 1.83 (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. Steady state had appeared to have occurred in 2003 in the lower interval but the 2007 value shows an increase.

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 2007 results exceed background by factors of 2.56 (0-1 ft at 5.02 mg/kg), 2.10 (1-2 ft at 3.05 mg/kg), and 1.52 (2-3 ft at 1.75 mg/kg).
- The concentration in the upper interval appears to have been increasing at a relatively constant rate since 2000.
- The concentration in the middle interval appeared to have been in a steady state since 2000 until an increasing rate was observed in 2007.
- The concentration in the lower interval appears not to have stabilized. The most recent measurements are 1.21 (2006) and 1.75 (2007) mg/kg, respectively which indicate a start of a possible increasing trend.

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

Uranium is being retained in the upper layers of treated soil. 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.

The 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 to soil is not retarding the movement of selenium through the soil. In addition, selenium and chloride --the latter a conservative constituent in terms of fate and transport-- are being retained at similar levels in varying soil types.

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 alfalfa (*Medicago sativa*) hay fields supplied with irrigation water from impacted groundwater sources near the Homestake Grants Reclamation Project.

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 2007 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 was irrigated in 2005 through 2007. Fields in Sections 33 and 28 were irrigated using a center pivot irrigation system, whereas the field in Section 34 was irrigated by flooding. Additionally, 24 acres were flood irrigated in Section 33 in 2004 and 2005, 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, 2005 and 2006 growing seasons (see ERG and HYDRO, 2005, 2006 and 2007).

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 three exceptions, measured uranium and selenium concentrations have been below these limits since inception of the irrigation program through 2007. The exceptions occurred with two early 2005 uranium concentrations in Section 28 and one late 2001 selenium concentration in Section 33/34. Adjustments were made in the usage of new irrigation supply wells in early 2005. The average 2007 uranium and selenium concentrations for Section 28 water were 0.36 mg/l and 0.08 mg/l, respectively.

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. The pipeline supplied water to one of the two major fields at a time. Irrigation of the 24 flooded acres in Section 33, which occurred only during the 2004 and 2005 growing seasons, was 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. Figures 2 through 9 show the irrigation supply well locations and supply lines for the 2000-2007 years.

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 2000-2007 irrigation water. Yearly averages are also presented in the table.

Average uranium and selenium concentrations were approximately 0.26 and 0.09 mg/l, respectively, over the eight growing seasons. The May 14, 2003 result for uranium (0.03 mg/l) is not included in the uranium average, because it is one order of magnitude lower than all other observations. Thus, it is assumed to be a laboratory artifact.

With one exception, the average concentrations of TDS and molybdenum were essentially constant from 2000 to 2007. The 2007 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 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 concentration ranged from 561 to 1020 mg/l. Chloride levels have been increasing slowly, and in 2007 were approximately 26 percent greater than initial measurements. Chloride concentrations have ranged from 94 to 247 mg/l in the seven years of monitoring.

Table 1. 2000 through 2006 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 2007 Sections 33/34 Irrigation Supply Concentrations (cont'd)

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	

Notes:

* Indicates datum not used.

2.2 Section 28 Irrigation

Section 28 was irrigated from 2002 through 2007. Figures 10 and 11 show the locations of the four wells installed to supply water to the center pivot system in the first two years. Figures 12, 13 and 14 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 (see Figure 15). 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. Chloride and molybdenum were omitted as analytes in 2002 and one sample in 2004, 2006 and 2007.

The concentrations of TDS and sulfate were essentially constant from 2002 through 2007. The TDS concentration was 2,070 mg/l in 2002 and 2003 and averaged 2115, 2109, 1986 and 2122

mg/l in 2004, 2005, 2006 and 2007. The annual average sulfate concentrations varied from 881 to 936 mg/l.

The annual average concentrations of chloride and molybdenum varied from 171 to 185 mg/l and less than 0.03 to 0.04 mg/l, respectively.

Uranium concentrations increased gradually in Section 28 irrigation water. They were 0.23 mg/l in 2002, 0.24 mg/l in 2003, 0.27 mg/l in 2004, and stabilized in 2005 through 2007 at 0.35 to 0.36 mg/l.

The six-year average uranium concentration of 0.30 mg/l is assumed to be the average of the reported mean concentrations for the six years, 2002 through 2007 (0.23, 0.24, 0.27, 0.35, 0.35 and 0.36 mg/l).

Table 2. 2002 through 2007 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	

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 2007 selenium concentrations were similar to the 2002 value. Thus, the five-year average selenium concentration of 0.08 mg/l is assumed to be an average of the mean concentration reported from 2002 through 2007.

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.

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) are essentially background areas until they are 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, Homestake Mining Corporation (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 were analyzed for uranium and selenium from Section 33. 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.

All soil samples were analyzed by ACZ Laboratories, Inc. Uranium concentrations were determined using U.S. 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 and 2007.

Selenium concentrations in samples collected from 1999-2001 were determined using 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 U.S. EPA Method 6020 ICP-MS, with an MDL of 0.8 mg/kg. The samples were then re-analyzed twice: first by way of U.S. 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 U.S. 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 and 2007. 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 will be used to calculate uptake of a constituent in the treated areas. Figures 16, 17 and 18 show the data used to calculate the mean uranium background concentrations for Section 33, 34 and 28 respectively. Figures 19, 20 and 21 give the mean background plots for selenium.

As of 2007, mean background uranium concentrations for the three Section 33 intervals are 0.78 (0-1 ft), 0.69 (1-2 ft), and 0.71 mg/kg (2-3 ft). The corresponding mean background concentrations for selenium and chloride are 0.14, 0.15, and 0.12 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 2007. 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), 1.45 (1-2 ft), and 1.15 (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 0.55 (0-1 ft), 0.53 (1-2 ft), and 0.51 (2-3 ft) mg/kg. Table 5 presents the results for the Section 28 area.

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 86 percent.

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

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium		Selenium mg/kg	Chloride (mg/kg)	Comment	
				(pCi/g)	mg/kg				
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	ߒ	
	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	
				Mean	0.53	0.78	0.14	24	
				SDV	0.14	0.20	0.10	17	
			CV	26.24	26.24	72.29	69		

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium		Selenium mg/kg	Chloride (mg/kg)	Comment	
				(pCi/g)	mg/kg				
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	
				Mean	0.47	0.69	0.15	37	
				SDV	0.11	0.16	0.12	25	
			CV	22.92	22.92	83.60	68		

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium		Selenium mg/kg	Chloride (mg/kg)	Comment
				(pCi/g)	mg/kg			
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
				Mean	0.45	0.71	0.12	30
			SDV	0.13	0.21	0.11	20	
			CV	28.05	29.66	85.58	66	

* = 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		Selenium (mg/kg)	Chloride (mg/kg)	Comment	
				(pCi/g)	mg/kg				
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	
	34I	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	
				Mean	1.33	1.96	0.34	55	
				SDV	0.53	0.78	0.23	36	
				CV	39.98	40.00	67.91	66	

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	@393	@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	
				Mean	0.98	1.45	0.26	67	
				SDV	0.36	0.53	0.21	51	
				CV	37.03	36.37	80.57	76	

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

Interval (ft)	Location ID	Area	Depth (in)	Natural Uranium		Selenium (mg/kg)	Chloride (mg/kg)	Comment
				(pCi/g)	mg/kg			
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	
			Mean	0.78	1.15	0.27	62	
			SDV	0.37	0.55	0.17	53	
			CV	47.63	47.55	61.27	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		Selenium mg/kg	Chloride (mg/kg)	Comment
				(pCi/g)	mg/kg			
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
				Mean	0.37	0.55	0.13	17
			SDV	0.14	0.21	0.07	10	
			CV	37.36	37.38	52.03	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
				Mean	0.36	0.53	0.11	15
			SDV	0.14	0.20	0.08	7	
			CV	37.95	37.83	71.14	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
			Mean	0.35	0.51	0.09	16	
			SDV	0.15	0.22	0.08	8	
			CV	41.90	41.82	84.87	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 2007 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 and in this report.

Figures 2 through 9 show the locations of the Section 33 and Section 34 sampling sites for 2000, 2001, 2002, 2003, 2004, 2005, 2006 and 2007. Figures 10 through 15 present the locations of soil samples collected in Section 28 in 2002, 2003, 2004, 2005, 2006 and 2007. Figures 16 through 21 present uranium and selenium soil concentrations for the irrigation areas.

Composite samples were prepared from locations indicated within each irrigation area and in 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 2007, 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 2007. 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, 2000-2007

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	0.3	<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
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	0.3	<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	0.3	<1	7.7	5.300	19.60	11.00	37.00	9.46	187	900
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	0.1	<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	0.3	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
BG-1	12/7/2000	1.14	0.2	<1	7.6	1.240	9.07	2.64	0.64	0.26	18	<50
	6/20/2001	0.98	0.1	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
BG-2	6/20/2001	0.76	0.2	<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
	BG-3	6/20/2001	0.83	0.3	<1	7.9	0.385	2.41	1.12	0.48	0.36	41
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
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
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	0.4	<1	7.8	3.070	16.90	6.58	13.00	3.79	63	390
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	0.2	<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	0.4	<1	7.7	2.010	11.50	4.06	7.97	2.86	52	470

Table 6. Irrigation Soil Analyses, 2000-2007 (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 (continued)												
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
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	0.2	<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
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
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
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
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	7.60	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	5.28	24.2	6.25	32.7	8.38	337	1700
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
	BG-2	8/8/2001	1.92	0.20	2	7.5	4.730	7.94	2.60	4.53	1.97	120
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
BG-3		8/8/2001	0.79	0.20	<1	7.6	8.200	6.35	2.12	2.77	1.35	120
	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

Table 6. Irrigation Soil Analyses, 2000-2007 (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 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
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
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	0.7	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	1.8	118	420
	10/21/2006	1.06	0.08	2	7.8	3.58	15.20	8.21	26.00	7.6	37	670
	11/10/2007	0.92	0.25	<1	7.8	3.46	16.30	8.70	20.60	5.83	37	540
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
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	0.6	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	<0.5	1	7.8	0.53	2.22	0.95	0.89	0.7	14	<50
	11/10/2007	0.91	0.24	<1	7.6	0.95	5.95	2.18	1.45	0.71	26	99
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	0.8	0.25	<1	7.7	0.88	4.99	1.84	1.76	1.95	30	120

NOTE: 2000 Sample: 1 = 0 - 6 inches, 2 = 6 - 18 inches and 3 = 18 - 36 inches
 2001 through 2007 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, 2002, 2003, 2004, 2005, 2006 and 2007 for 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 seven latter years (2001 to 2007) 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, 2005, 2006 and 2007.

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 (2007) concentrations observed in the treated area were 1.67 (0-1 ft), 1.34 (1-2 ft) and 1.30 (2-3 ft); this compares to the corresponding mean background values of 0.78 (0-1 ft), 0.69 (1-2 ft) and 0.71 mg/kg (2-3 ft). The concentrations of uranium in the upper three feet of treated soil exceeded the mean background by factors of 2.14 (0-1 ft), 1.94 (1-2 ft) and 1.83 (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 16).

Table 7. Summary of Irrigation Soil Analyses, 2000-2007

Section	Yearly Data	Uranium (mg/kg)		Selenium (mg/kg)	
		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	
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	

Table 7. Summary of Irrigation Soil Analyses, 2000-2007 (concluded)

Section	Yearly Data	Uranium (mg/kg)		Selenium (mg/kg)	
		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	
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	

Notes:
 2000 Sample: 1 = 0 - 6 inches, 2 = 6 - 18 inches and 3 = 18 - 36 inches
 2001 through 2007 Sample: 1 = 0 - 1 ft, 2 = 1 - 2 ft and 3 = 2 - 3 ft

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 (2007) concentrations observed in the treated area are 0.44 (0-1 ft), 0.30 (1-2 ft), and 0.39 (2-3 ft) mg/kg; and in the mean background are 0.14 (0-1 ft), 0.15 (1-2 ft) and 0.12 (2-3 ft) mg/kg. The selenium concentrations in the top three feet of treated soil exceeded the mean background by factors of 3.14 (0-1 ft), 2.00 (1-2 ft) and 3.25 (2-3 ft). The 2007 selenium data from the treated and untreated areas both increased significantly resulting in questionable selenium results for 2007 (see Figure 19).

Generalized findings for other parameters are as follows:

The data in Table 6 show an overall increase in conductivity, SAR, calcium, magnesium and sodium concentrations in both treated and untreated soils in Section 33. 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 fairly similar over the period of years. The changes 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 and 2007 (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 and 2007 (see Figures 2 through 9 for sample locations). Uranium and selenium concentration data for Section 33 and 34 flood irrigation areas are presented in Figures 17 and 20, 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 2007 mean background are as follows:

- 2000: Average 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: Concentrations in the treated area at 0-1 ft (2.72 mg/kg) are a factor of 1.39 greater than the 2007 mean background (1.96 mg/kg). The value of treated soil at 1-2 ft (1.88 mg/kg) exceeds the mean background (1.45 mg/kg) by a factor of 1.30.
- 2002: Concentrations decreased dramatically in the treated and untreated areas when compared to the 2001 values. Uranium concentrations observed in 2002 are not thought to be representative of this area.
- 2003: Concentrations 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 1-2 ft uranium level treated soil (1.90 mg/kg) exceeded the mean background by a factor of 1.45. The 2-3 ft interval treated uranium value was essentially the same as the mean background.
- 2004: Concentrations in the treated area at 0-1 ft (4.43 mg/kg) exceeded the 2007 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 (1.45 mg/kg) by a factor of 1.57, whereas the bottom interval was similar to mean background.
- 2005: Concentrations in the treated area at 0-1 ft (3.94 mg/kg) exceeded the untreated mean background (1.96 mg/kg) by a factor of 2.01, while the concentration of the second interval indicated no increase and the third interval indicated an anomalous increase.
- 2006: Concentrations in the treated area at 0-1 ft (4.88 mg/kg) exceed the untreated mean background (1.96 mg/kg) by a factor of 2.49. The concentration from 1-2 ft (2.25) is only 1.55 times the mean background of 1.45 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.
- From 2001 to 2007, in Section 34 Flood, uranium concentrations increased in the 0-1 ft layer from 2.72 to 5.02 mg/kg, a factor of 1.84. The average uranium concentration in the first 3 feet of soil increased from 1.91 to 3.27 mg/kg, a factor of 1.71.
- Average uranium concentrations in deeper layers of treated soils were generally lower than those in the surface samples.
- 2002 uranium concentrations in both treated and background areas were consistently lower than those observed in 2001, 2003, 2004, 2005, 2006 and 2007. This anomaly is likely due to a systemic analytical bias and not representative of actual concentrations.

A comparison of the 2001, 2003, 2004, 2005, 2006 and 2007 results indicates that uranium is accumulating in the treated areas of Section 34, primarily in the upper and middle intervals. In

the 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: The 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: The selenium concentration at all depths in the treated and mean background area was 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: The 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: The 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: The 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: The 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: The selenium 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 (0.26 mg/kg) by a factor of 3.62. The increased selenium in 2007 should be used with caution because the background selenium values also increased.

A comparison of the 2001, 2003, 2004, 2005, 2006 and 2007 results indicates that the selenium has accumulated in the treated areas of Section 34. The concentration of selenium peaked in the upper layer in 2004 and had gradually declined in 2005 followed by small increases in 2006 and 2007. The selenium concentration at 1-2 ft was 61% of those in the upper layer in 2007. 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 33 Flood area, there have been decreases in sodium, SAR, conductivity, magnesium and chloride, whereas levels of sulfate have been increasing in the treated soils. Calcium levels have been variable. In untreated areas of Section 33, the concentrations of all constituents have declined except for sulfate, which is increasing in the lower two feet (1-2 and 2-3 ft). The treated area of Section 34 is exhibiting an increase in conductivity, SAR, and concentrations of calcium, magnesium, sodium, chloride, and sulfate. The concentrations and ratios also increased in untreated soils. The exception is conductivity, which has varied but has a generally decreasing trend.

3.2.3 Section 28 Center Pivot

Twelve locations were sampled in the treated area of Section 28 in 2002, 2003, 2004, 2005, 2006 and 2007 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 10 for the five background locations that were composited for the three depths for 2002 and Figures 11 through 15 for the 2003 through 2007 locations). Graphical presentations of uranium and selenium concentrations are included in Figures 18 and 21 respectively.

Generalized findings for uranium from Table 7 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 2007 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, 2004, 2005, 2006 and 2007. The most recent (2007) concentrations of uranium observed in the treated area were 1.14 (0-1 ft), 1.01 (1-2 ft) and 0.92 (2-3 ft); and 0.55 (0-1 ft), 0.53 (1-2 ft) and 0.51 mg/kg (2-3 ft) for the mean background. The treated intervals exceed the mean background by factors of 2.07 (0-1 ft), 1.91 (1-2 ft) and 1.80 (2-3 ft). All three interval concentrations of uranium in the treated area exceed background by an average factor of 1.93. Thus, uranium concentrations are essentially twice that of background and appear to have become fairly steady.

Generalized findings for selenium are as follows:

- Selenium concentrations in composite samples collected from the treated area and background area for the year 2002 were all below the relatively high MDA of 0.6 mg/kg and are not useful in trend analysis. In 2007, the selenium concentrations observed in the treated area were 0.47 (0-1 ft), 0.34 (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 3.62 (0-1 ft), 3.09 (1-2 ft) and 2.78 (2-3 ft). In 2007, the average concentration of selenium in the treated area exceeded the mean background by a factor of 3.21, indicating that selenium was retained in the Section 28 soils in 2007. 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:

Data for Section 28 in Table 6 show general decreases in conductivity, SAR and calcium, magnesium, sodium and sulfate concentrations in both treated and background soils from year 2003 to 2006 with some increase in 2007. The chloride and sulfate results in the untreated area are more variable.

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 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 = $\Sigma_{2000-2007}[(\text{average concentration in water, mg/l}) (\text{volume of water in ac-ft}) (28.3 \text{ l/ft}^3) (43,560 \text{ ft}^2/\text{ac})]$

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

c = 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/ft³).

The above-background concentrations of uranium in each section, in mg/kg, are: Section 33 Center Pivot (2.13); Section 33 Flood (0.19); Section 34 (5.26); and Section 28 (1.48). 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 (0.71), 33 Flood (0.49), 34 (1.38), and 28 (0.76).

In Sections 33 Pivot and Section 28, 29 percent and 24 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, all of the uranium applied to Section 34 is indicated to be retained in the upper three feet and this is attributed to the presence of clay soils. The measured amount of uranium being 38 percent larger than the applied amount questions the accuracy of the uranium values. The measured concentrations in Section 33 Flood are too close to background to consider the value of 49 percent to be reliable.

Accumulating uranium concentrations for each layer in each irrigation area are shown in Figures 16 (Section 33 Center Pivot), 17 (Sections 33 and 34 Flood), and 18 (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

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

Notes:

NA = not irrigated

Table 9. Comparison of Measured Versus Applied Uranium

	Section			
	28 Pivot	33 Flood	33 Pivot	34 Flood
Applied Mass of Uranium (mg), a	346976649	16402452	797082529	815625525
Sum of 3-ft Measured Concentrations Minus Background (mg/kg), c	3.07-1.59= 1.48	4.75-4.56= 0.19	4.31-2.18= 2.13	9.82-4.56= 5.26
Mass of Soil (kg), b	533958480	128150035	800937720	640750176
Measured Mass of Uranium (mg), d	263419517	8116169	568665781	1123448642
Ratio of Measured to Applied Masses, e	0.76	0.49	0.71	1.38

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 (0.72); Section 33 Flood (0.38); Section 34 (5.26); and Section 28 (1.48). 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 (0.63), 33 Flood (3.35), 34 (1.48), and 28 (1.14). The selenium results should be considered questionable with three of the ratios being above one for 2007.

Table 10. Selenium Applied in Irrigation Water

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

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			
	28 Pivot	33 Flood	33 Pivot	34 Flood
Applied Mass of Selenium (mg), a	114280671	4846179	306122147	292042932
Sum of 3-ft Measured Concentrations Minus Background (mg/kg), c	1.06-0.33= 0.73	1.25-0.87= 0.38	1.13-0.41= 0.72	2.90-0.87= 2.03
Mass of Soil (kg), b	533958480	128150035	800937720	640750176
Measured Mass of Selenium (mg), d	129929897	16232338	192225053	433574286
Ratio of Measured to Applied Masses, e	1.14	3.35	0.63	1.48

In Section 33 Pivot, 37 percent of the applied selenium is unaccounted for, respectively. The 2007 selenium results should be used with caution because their quantities are larger than the total amount of selenium applied.

Actual selenium measurements are also shown in Figures 19 (Section 33 Center Pivot), 20 (Sections 33 and 34 Flood), and 21 (Section 28 Center Pivot). As in Figures 16 through 18, each figure is subdivided into upper, middle, and lower intervals. The horizontal line on each figure represents the mean background concentration.

There are indications that selenium, when retained, is parted to the dissolved phase, rather than absorbed in soils. A review of Figures 19 through 21 indicates that the retention of selenium appears to be independent of time, implying that absorption to soil is not retarding the movement of selenium through the soil. In addition, selenium and chloride—the latter a conservative constituent in terms of fate and transport—had been retained at similar levels in varying soil types. Only 5, 17 and 52 percent of the chloride concentration applied was measured in the soil in 2007 for Sections 28, 33 and 34 areas respectively. These are similar percentages that were observed for selenium in 2006 and likely reasonable estimates of the true 2007 selenium percentages.

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. 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 2007 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 2007 results also indicate selenium is being retained but these results need to be confirmed with future measurements.

The uranium concentrations for the 2007 treated soil samples within the irrigation areas ranged from 0.92 to 5.02 mg/kg. The laboratory reported uranium MDL and PQL for the year 2003 and 2004 data were 0.03 and 0.1 mg/kg, respectively and 0.05 and 0.3 mg/kg for 2005, 2006 and 2007. The selenium concentrations in the irrigated areas for 2007 ranged from 0.25 to 1.32 mg/kg. The laboratory reported selenium MDL and PQL for the soil analysis was 0.05 and 0.3 mg/kg.

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

4.0 Hay Concentrations and Constituent Uptakes

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 2007. 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. 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. 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. Twelve, seven, and 12 samples were collected from the first, second and third cuttings, respectively, in 2003. Twelve and six samples were analyzed for the first and second cuttings in 2004 and 2005, while 10 and six samples were collected for the first and second cuttings in 2006. Six samples were collected from the first cutting in 2007. Table 12 presents the average concentrations of uranium and selenium for Section 34. 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 and 2007. 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 an alfalfa seeding. Twelve samples were collected from each of the three cuttings in 2003 through 2007. The 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 2007 hay from Section 28 were similar to those observed in 2006. Table 12 presents the summary of the uranium and selenium concentrations in the Section 28 cuttings.

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
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

Notes:

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

4.1.4 Background Concentrations in Hay and Special Study

In 2000, a composite sample was prepared from 10 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 the year 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.

4.1.5 Summary of Hay Concentrations

Table 12 presents the summary of the hay concentrations for the 2000 through 2007 cuttings. No trends for uranium or selenium exist from the years 2003 to 2007. The data indicate a slight decrease in uranium concentration from the first cutting to the third cutting. No trend is evident for selenium. The average uranium concentrations for the 2007 hay cuttings ranged from 0.90 to 1.60 mg/kg. The laboratory reported an MDL and PQL for the year 2007 data of 0.03 and 0.1 mg/kg, respectively.

The average selenium concentrations in hay for 2007 ranged from 0.90 to 1.50 mg/kg. The laboratory reported MDL and PQL for the hay selenium analysis were 0.2 and 0.3 mg/kg. Prior years' results show a similar range of values for the upper limit. Recent studies have shown that selenium in cattle diets has a very 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 Alfalfa

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.

Table 13. Average Uranium Concentrations in Soil and Hay

Year	Avg. Uranium Soil Concentration (mg/kg)			Avg. Uranium Hay Concentration (mg/kg)		
	Section 33	Section 34	Section 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
				Average:	0.89	

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.

The calculated uranium transfer coefficients have a mean of 0.78 and standard deviation of 0.53. This is significantly higher than the published transfer coefficient of 0.017. The fact that the uranium uptake is higher than that 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
	Mean	0.78	
	SDV	0.53	

Six hundred twenty-two pounds of uranium were applied in 2002, based on the 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 very 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 pound. This shows that much less than 1% of the uranium that was supplied to the field in 2002 (622 pounds) 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 here, we have used the average uranium in hay measurements from the 2000 through 2007 (Table 13 average concentration 0.89 mg/kg = 603 pCi/kg). The measured natural concentrations of uranium and selenium in hay grown in the region were 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 = is the 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} = is the 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) = 603 pCi/kg
- F_h = is the fraction of the total annual feed requirement not from irrigated hay, = 0.5. Assumed 50% not grown on irrigated area.
- C_{hi} = is the uranium concentration in the other fraction of feed not grown on the irrigated area = 0

$$C_{bi} = 27 \text{ kg/day } (2.0E-4) \{ (0.5) (603) + (0.5) (0.0) \} = 1.6 \text{ pCi/kg meat}$$

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:

$$I_i = \text{annual intake rate (pCi/y)}$$

$$U_{bk} = \text{ingestion rate of beef for an adult} = (0.16 \text{ kg/d})(365 \text{ d/y})$$

$$C_{bi} = \text{concentration in meat (pCi/kg)}$$

$$I_i = (1.6 \text{ pCi/kg meat}) (0.16 \text{ kg/d}) (365 \text{ day/y})$$

$$I_i = 93 \text{ pCi/y}$$

This annual intake of uranium from eating beef that feeds on the irrigated hay is very small. The ingestion dose is calculated from the following equation:

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

Where:

$$I_{(ing)} = \text{ingestion dose mrem/y}$$

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

$$I_{(ing)} = (93 \text{ pCi/y}) (1E-6 \mu\text{Ci/pCi}) (5 \text{ rem}/10 \mu\text{Ci}) (1E3 \text{ mrem/rem}) \\ = 0.05 \text{ mrem/y}$$

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. 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.

The 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 to soil is not retarding the movement of selenium through the soil. In addition, selenium and chloride --the latter a conservative constituent in terms of fate and transport-- are being retained at similar levels in varying soil types.

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

7.0 References

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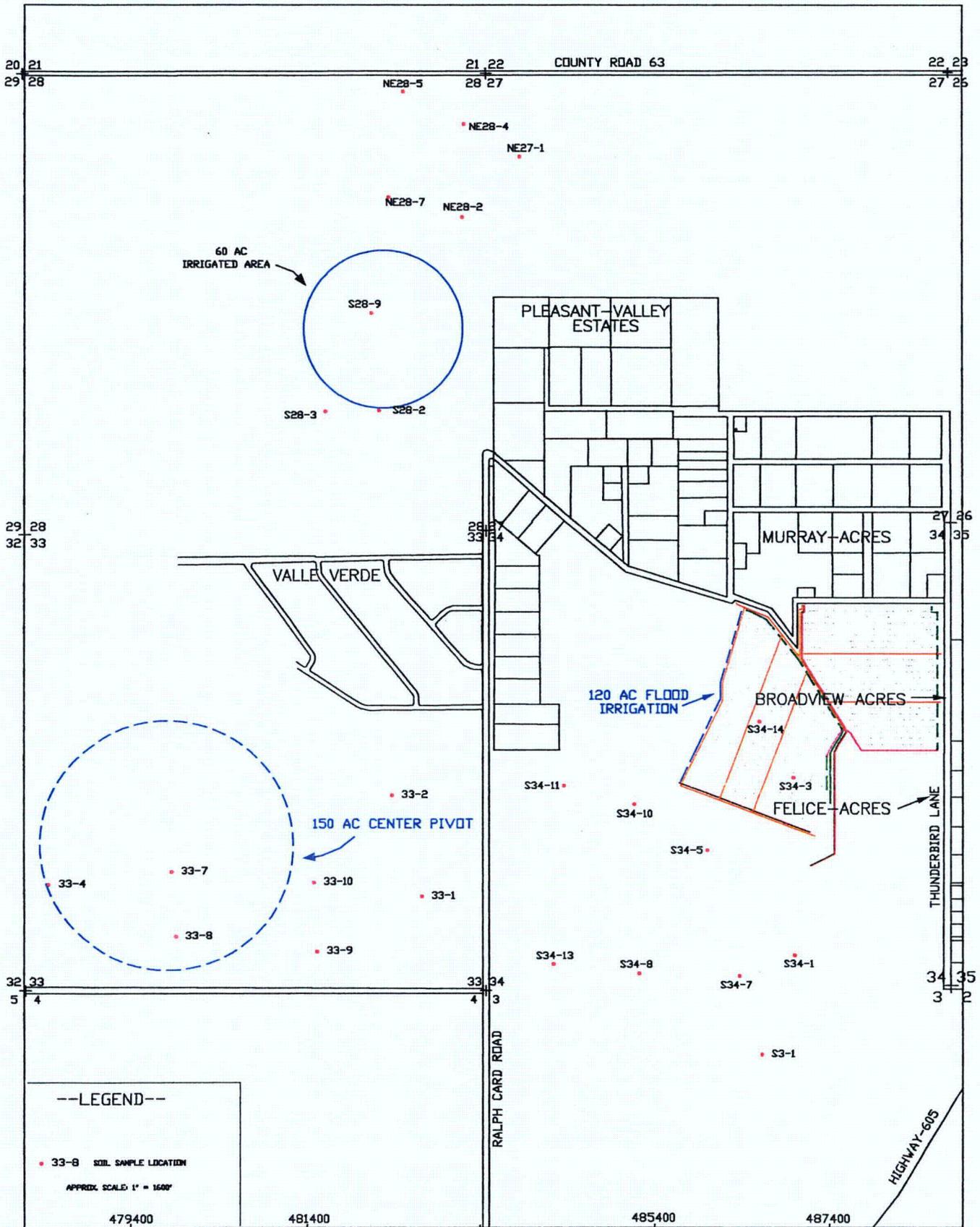


FIGURE 1. LOCATION OF IRRIGATION AREAS WITH SOIL SAMPLE LOCATIONS FROM THE 1998 INVESTIGATION

DATE: 05/23/06

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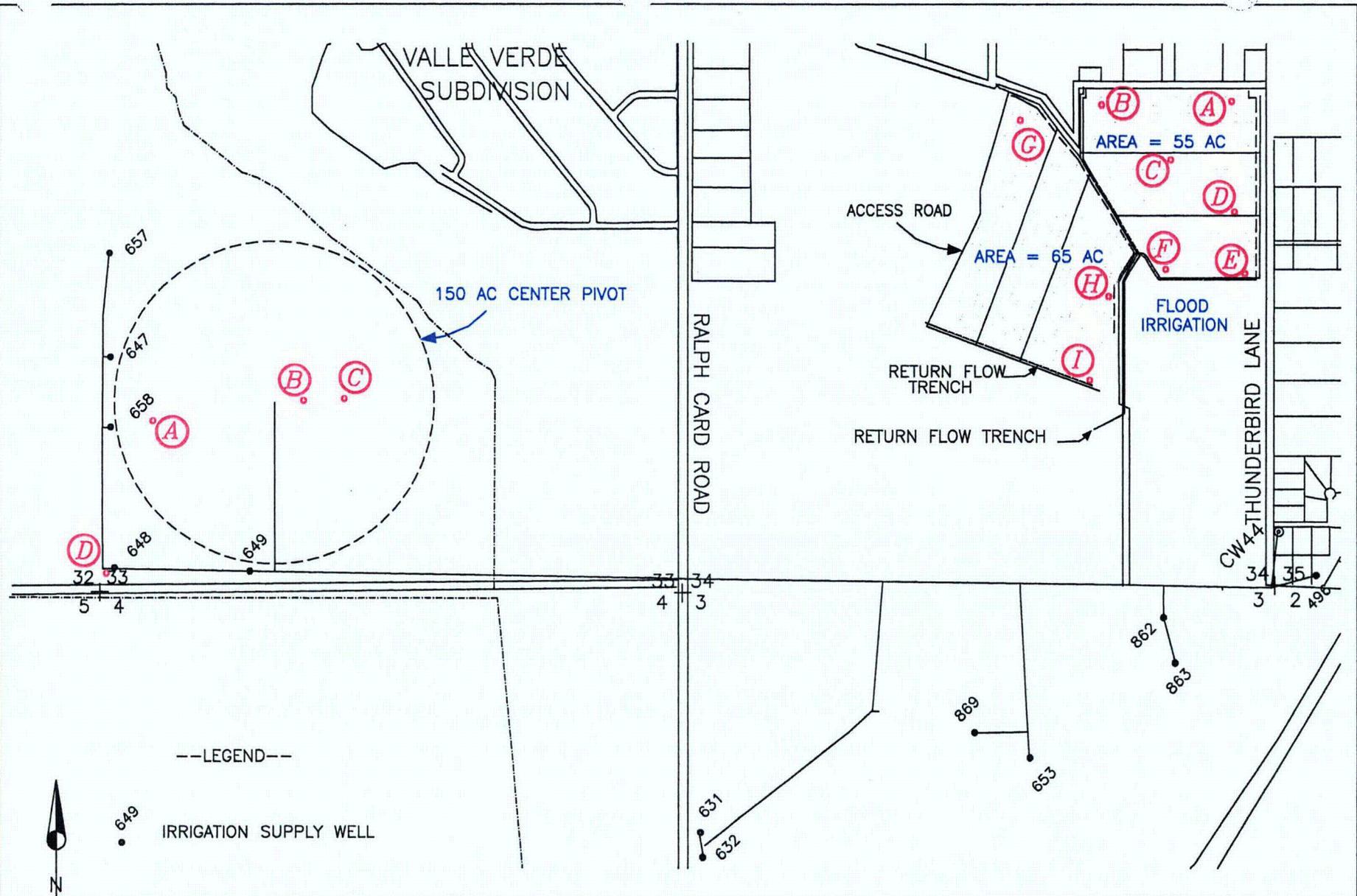


FIGURE 2. 1999 AND 2000 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

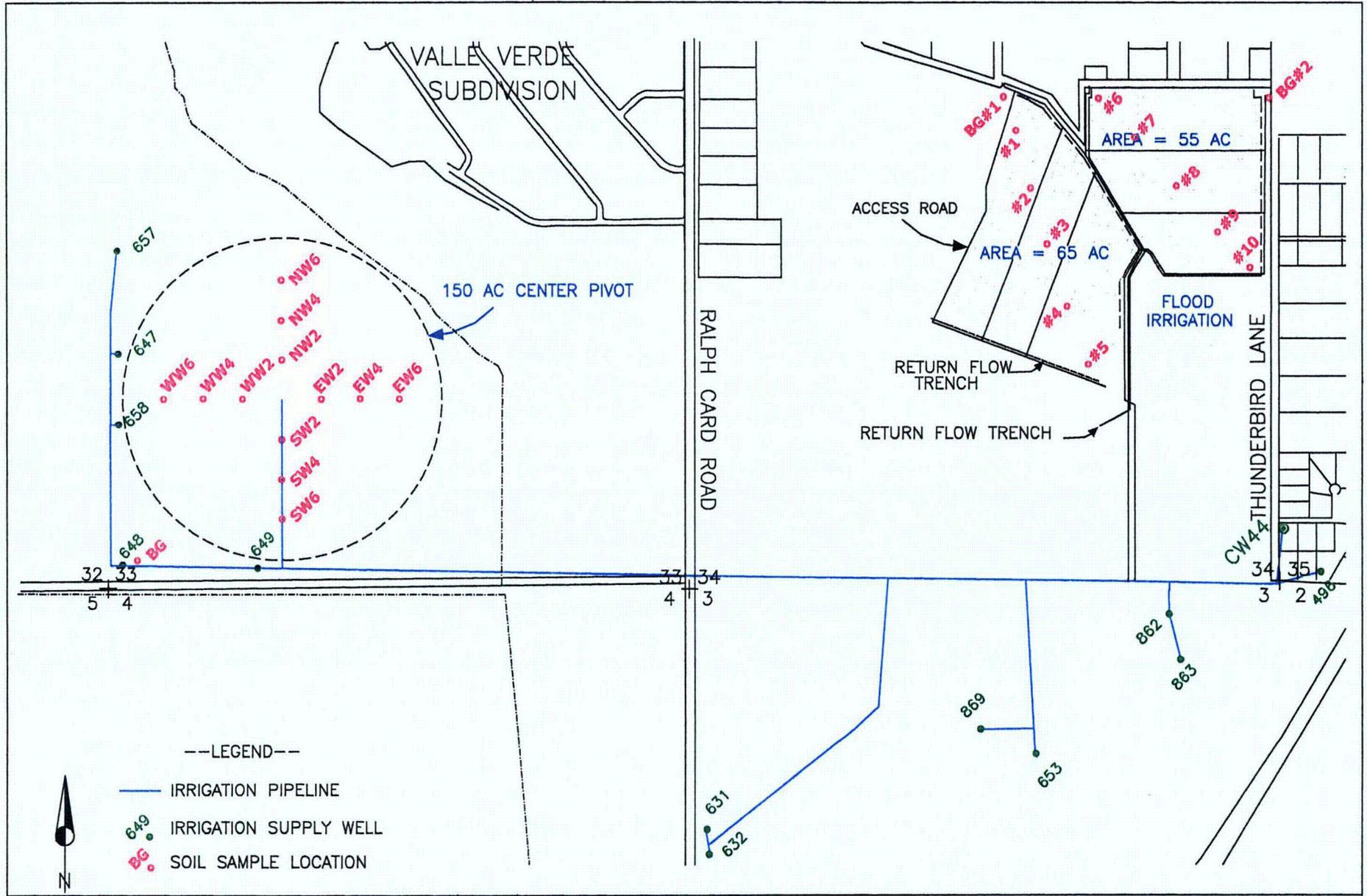
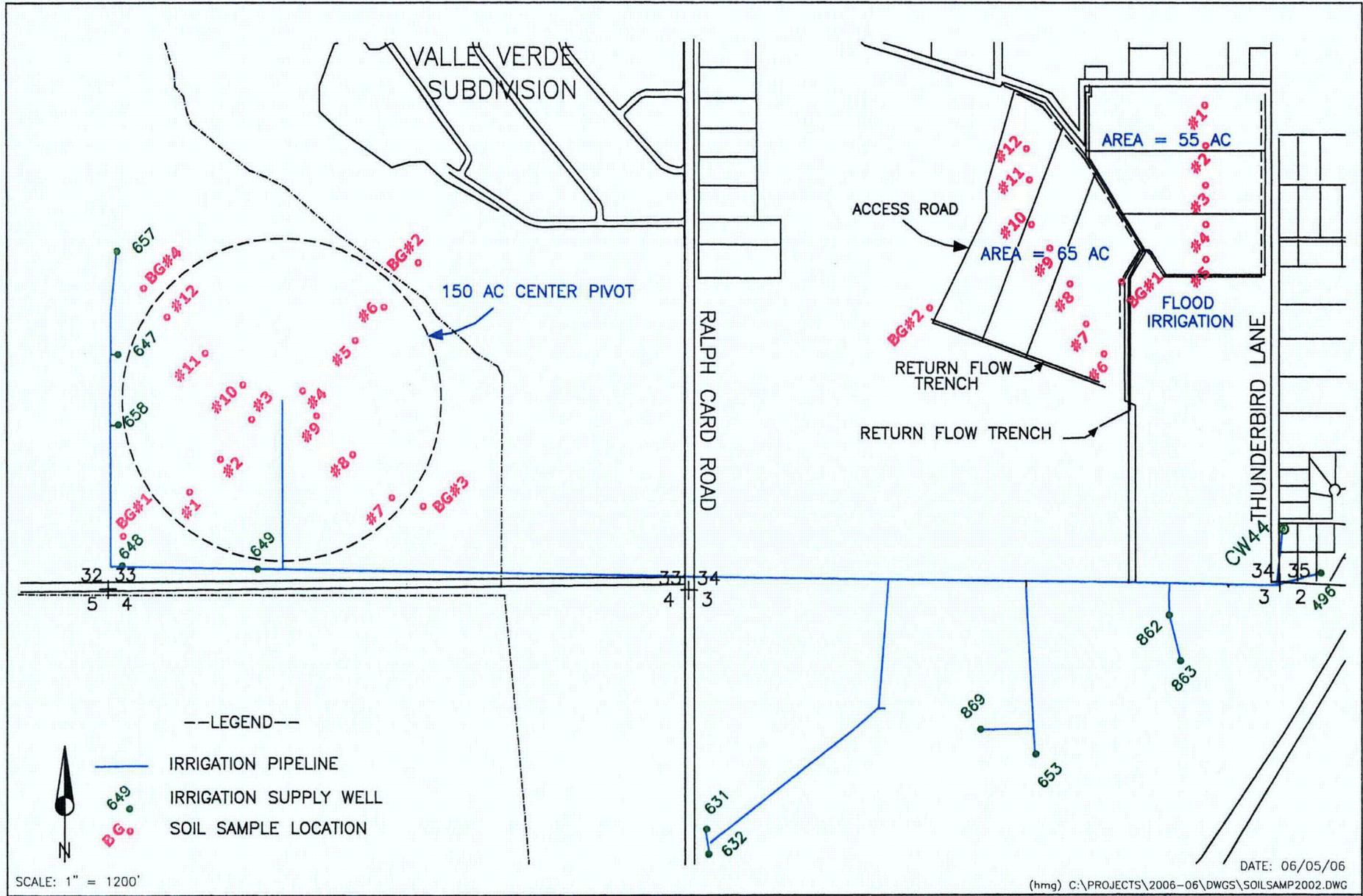


FIGURE 3. 2001 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS



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

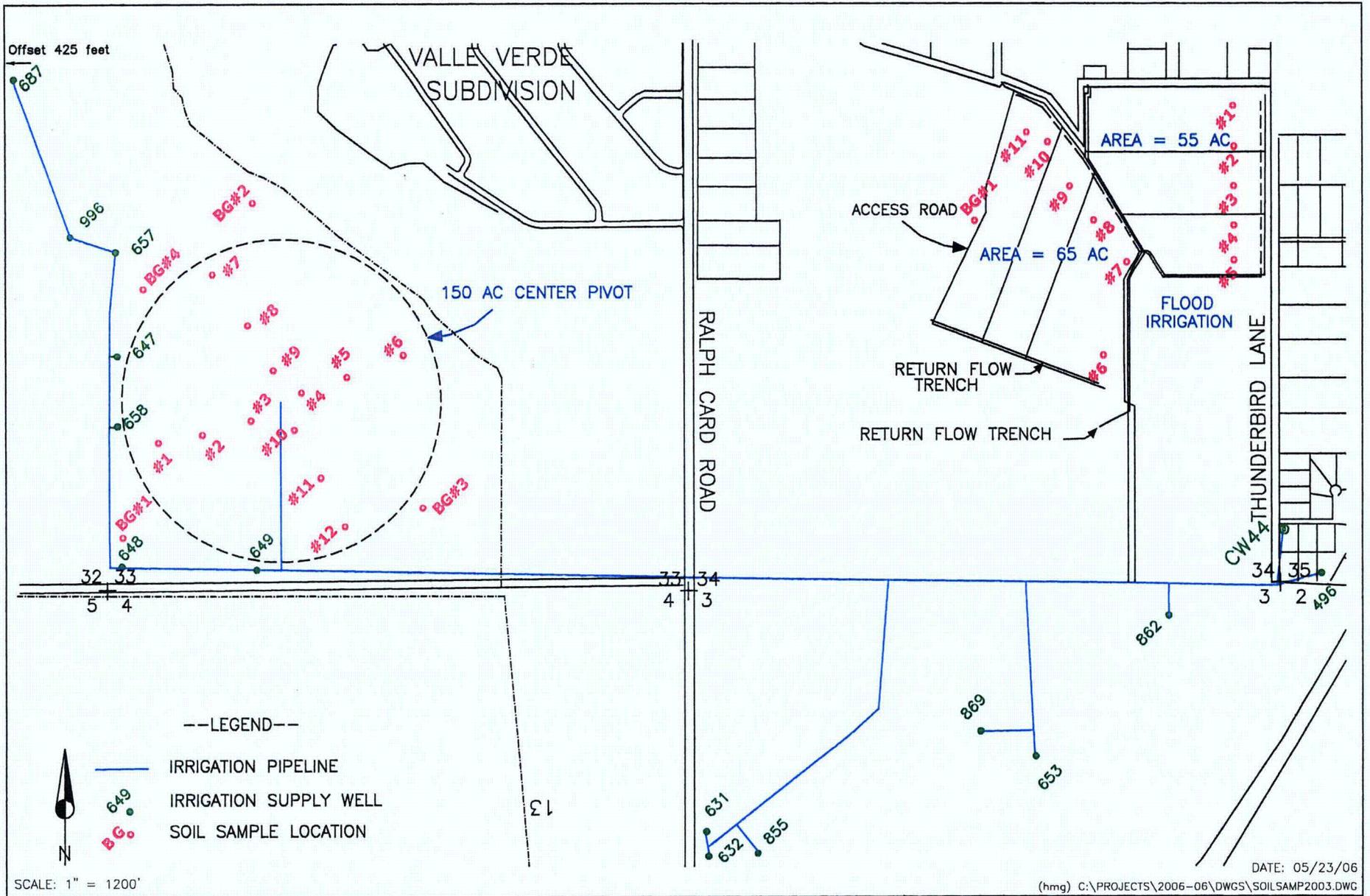
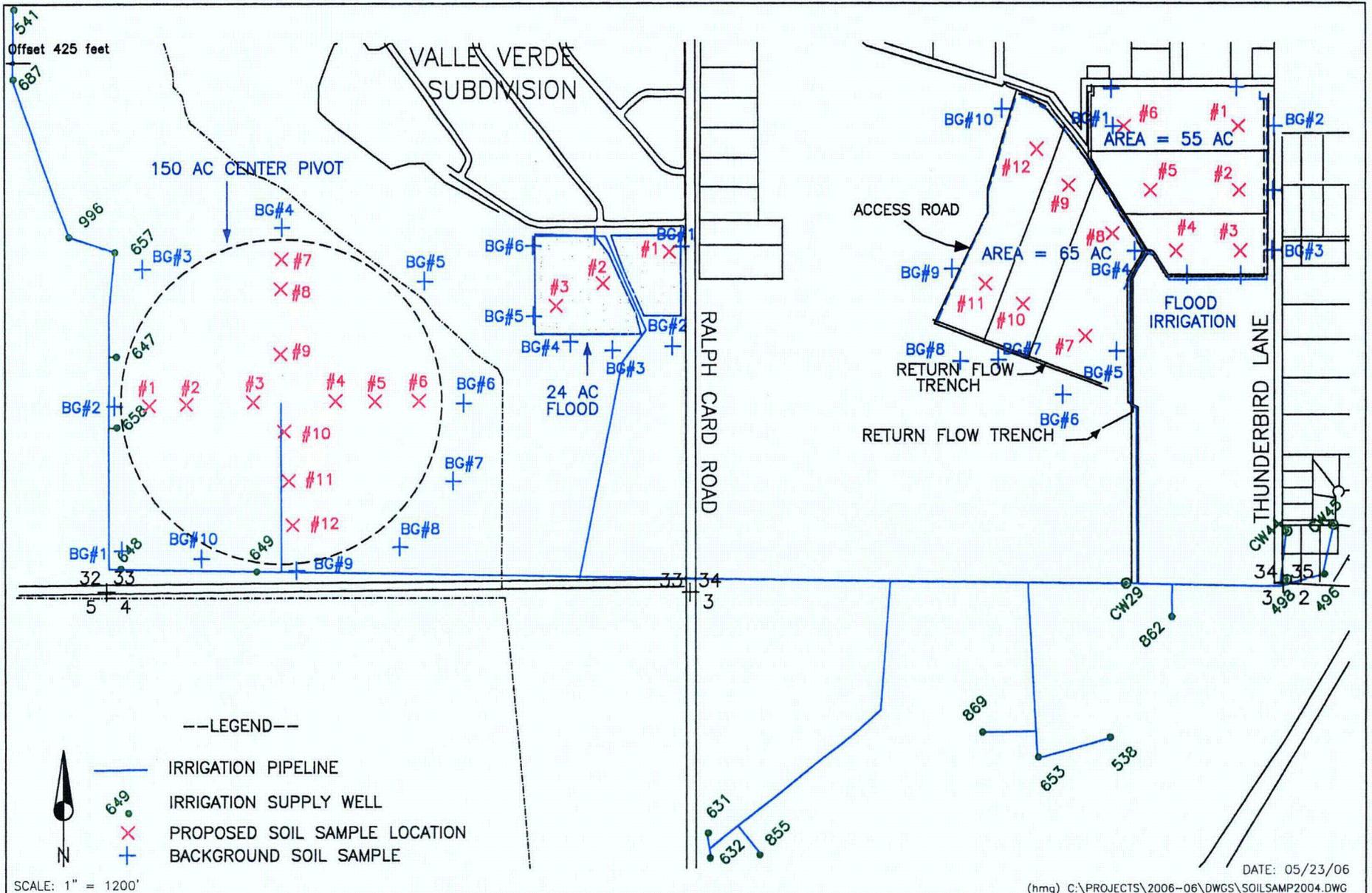


FIGURE 5. 2003 SECTIONS 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS



DATE: 05/23/06

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

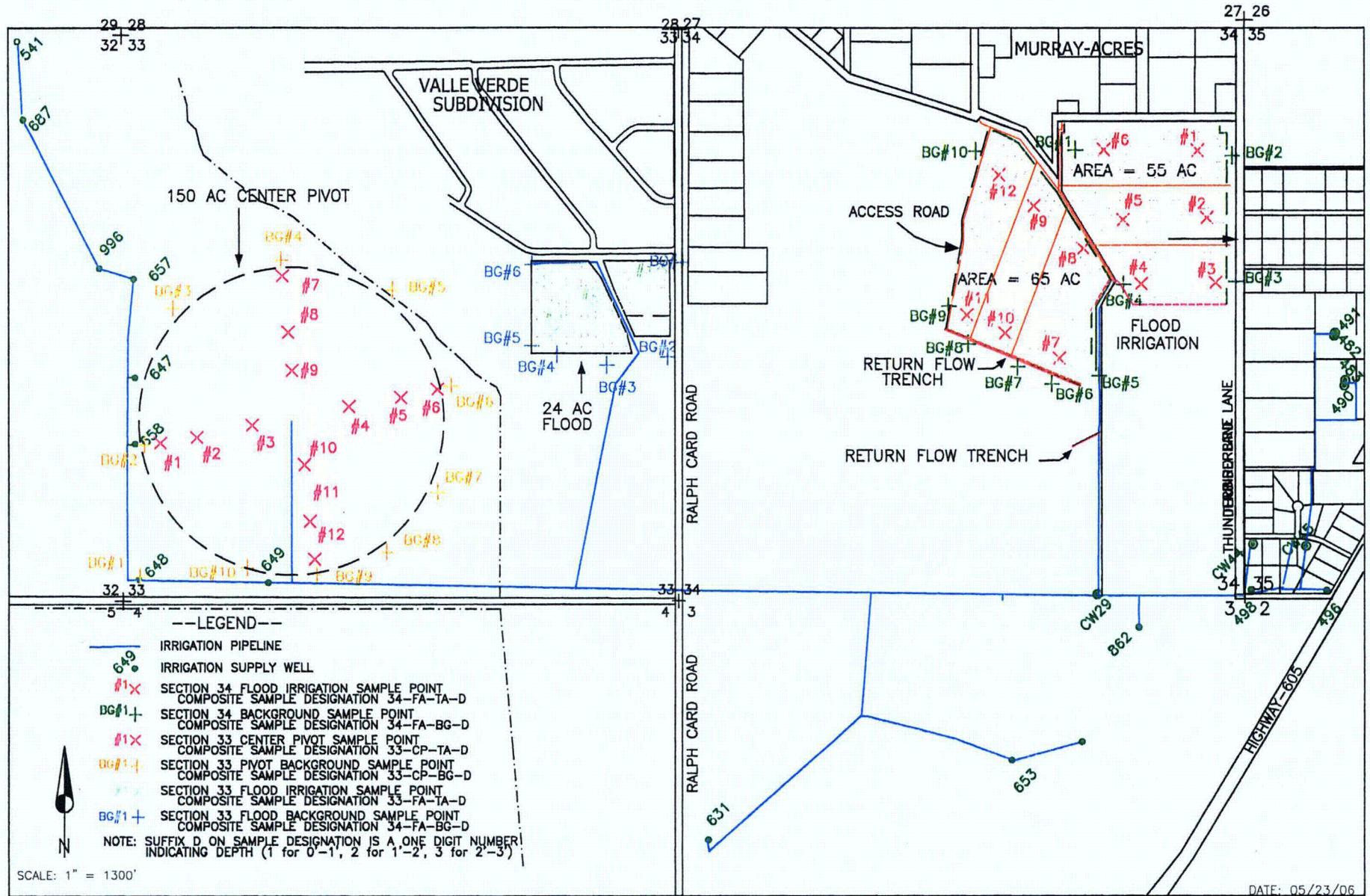


FIGURE 7. 2005 SECTIONS 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

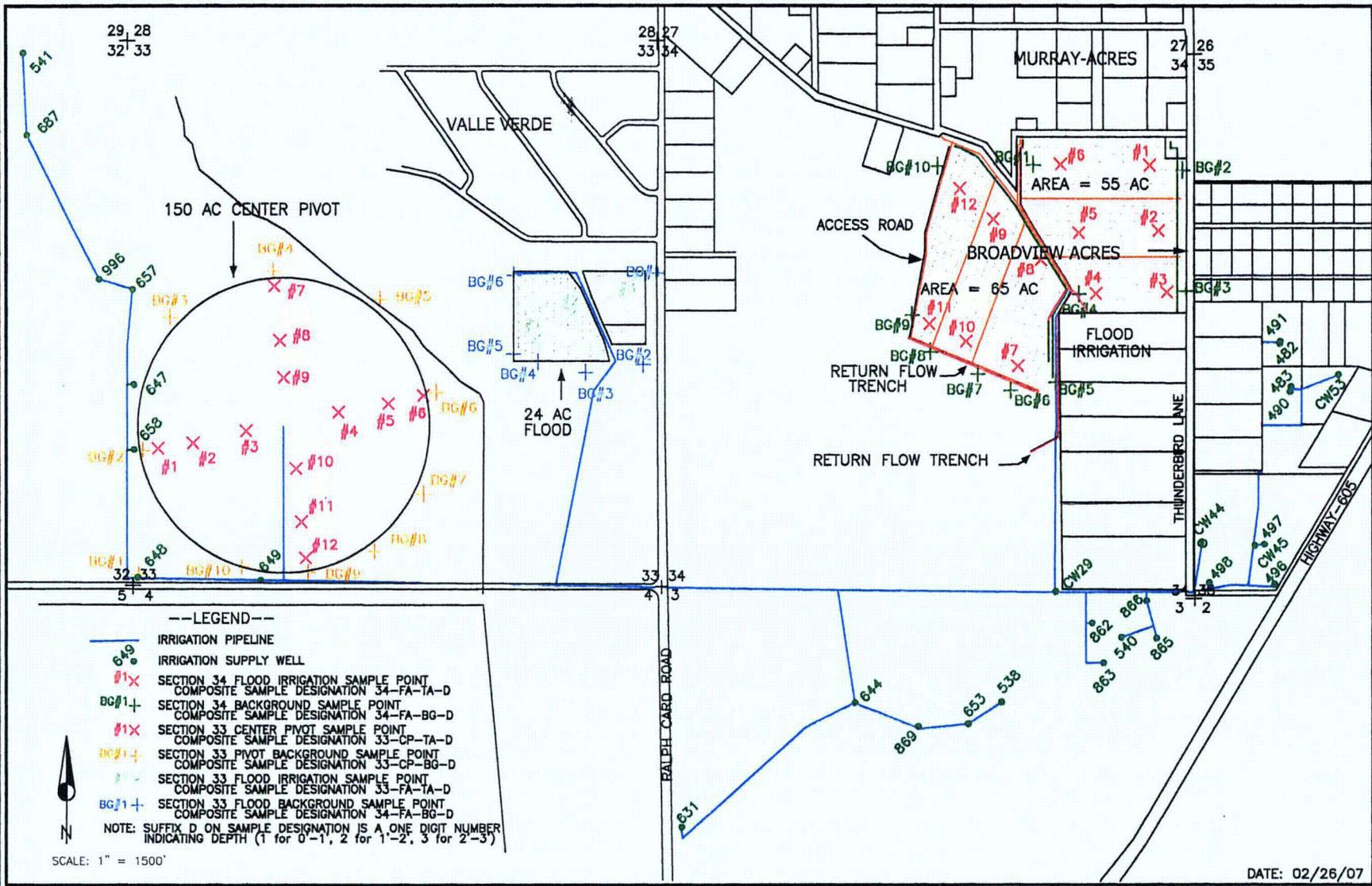
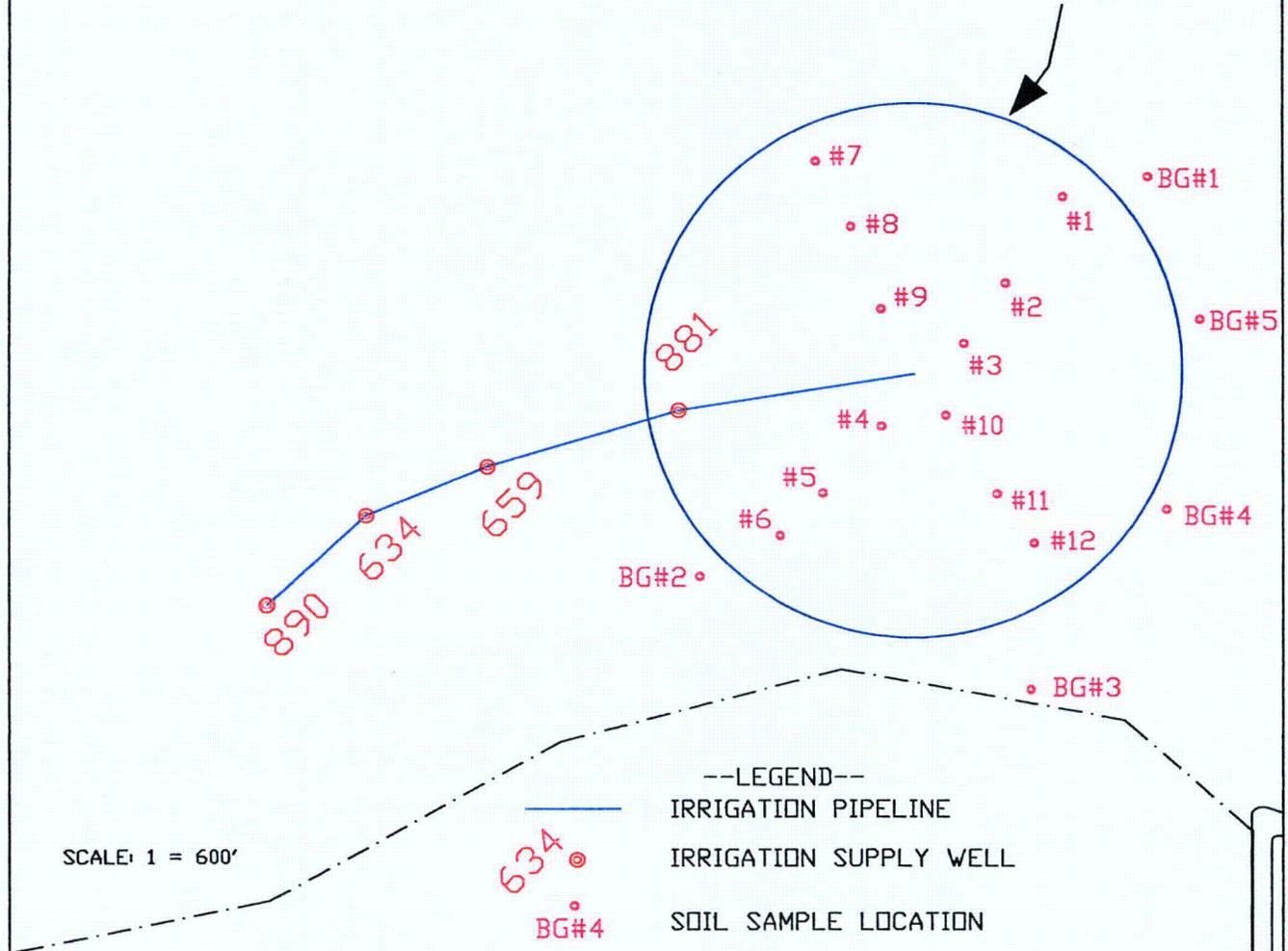


FIGURE 8. 2006 SECTION 33 AND 34 IRRIGATION AREAS WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

COUNTY ROAD 63 21 22

28 27

914' RADIUS
IRRIGATED AREA
= 60 AC



SCALE: 1 = 600'

634
BG#4

--LEGEND--
IRRIGATION PIPELINE
IRRIGATION SUPPLY WELL
SOIL SAMPLE LOCATION

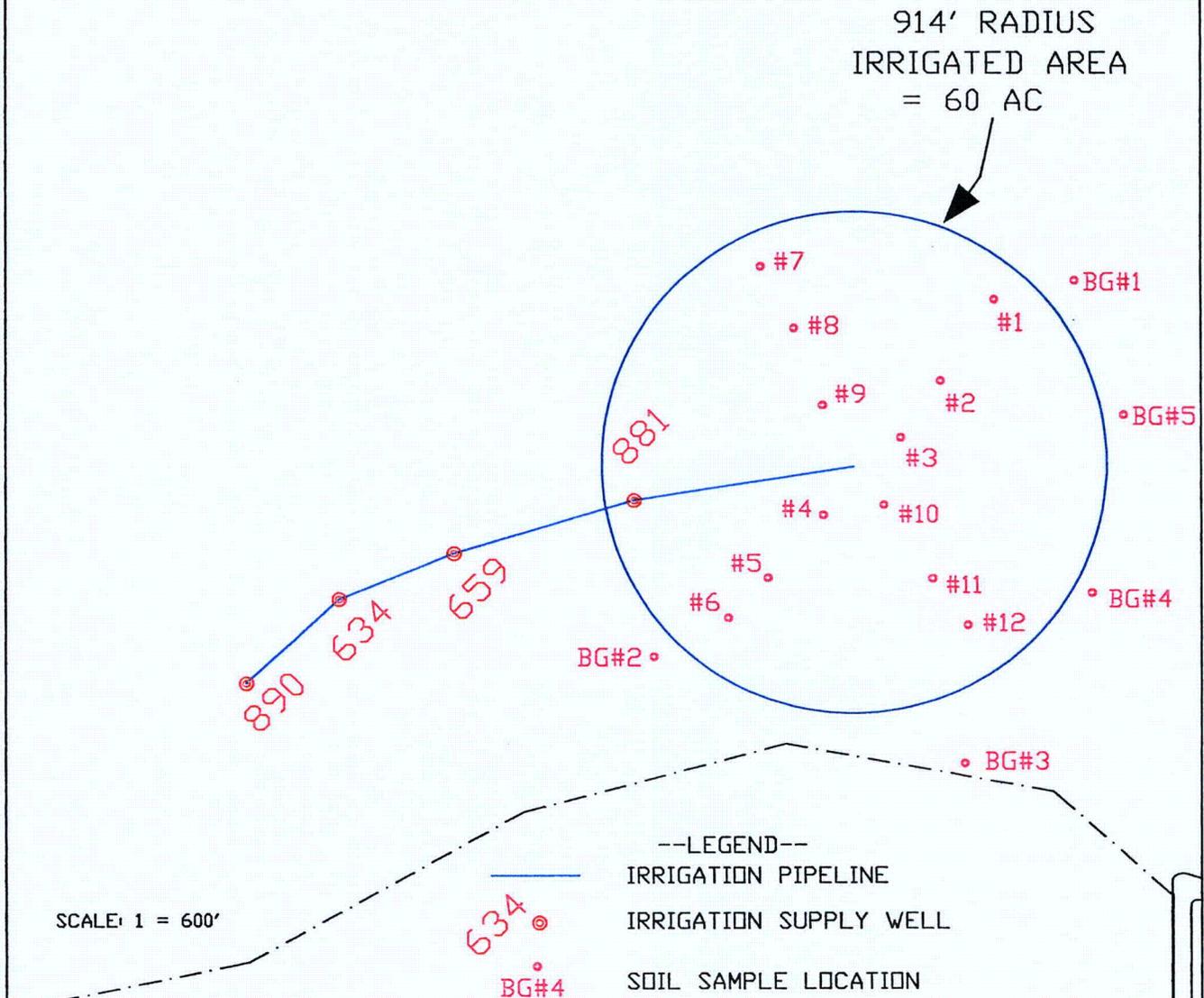
FIGURE 10. 2002 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

28 27
33 34

(hmg) C:\PROJECTS\2007-06\DWGS\28CP2002

COUNTY ROAD 63 21 22
28 27

914' RADIUS
IRRIGATED AREA
= 60 AC



SCALE: 1 = 600'

--LEGEND--
IRRIGATION PIPELINE
IRRIGATION SUPPLY WELL
SOIL SAMPLE LOCATION

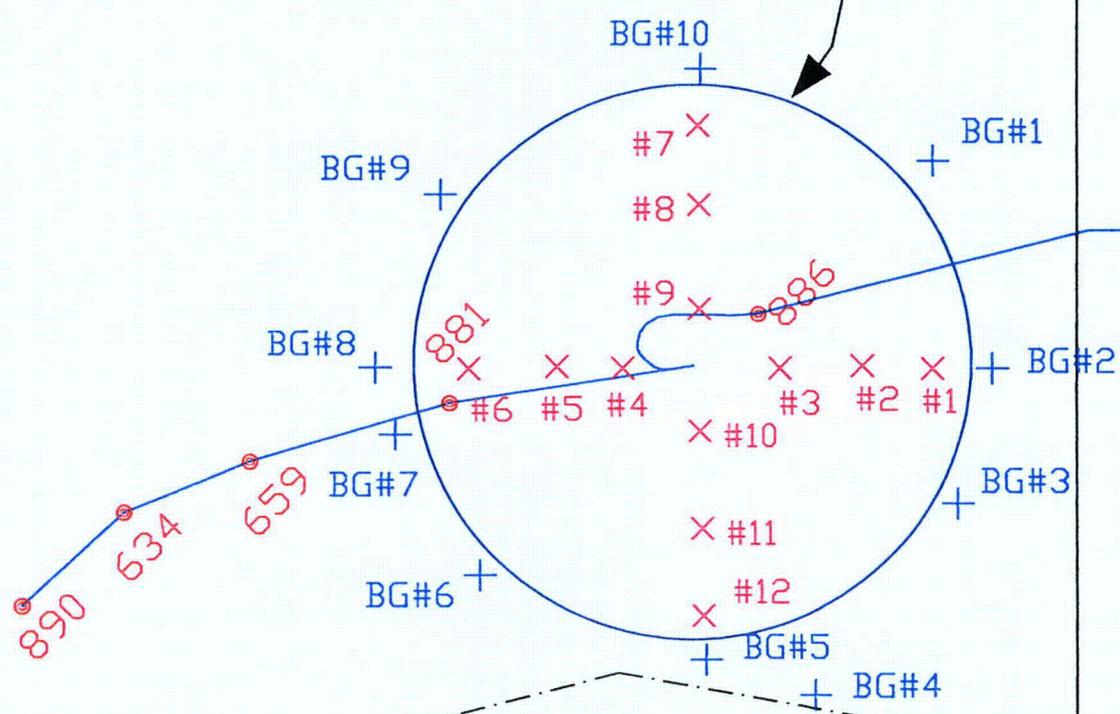
FIGURE 11. 2003 SECTION 28 IRRIGATION AREA WITH
IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS
(hmg) C:\PROJECTS\2007-06\DWGS\28CP2003

28 27
33 34

COUNTY ROAD 63 21 22

28 27

914' RADIUS
IRRIGATED AREA
= 60 AC



SCALE: 1 = 600'

- LEGEND--
- IRRIGATION PIPELINE
 - IRRIGATION SUPPLY WELL
 - PROPOSED SOIL SAMPLE LOCATION
 - BACKGROUND SOIL SAMPLE

28 27
33 34

FIGURE 12. 2004 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

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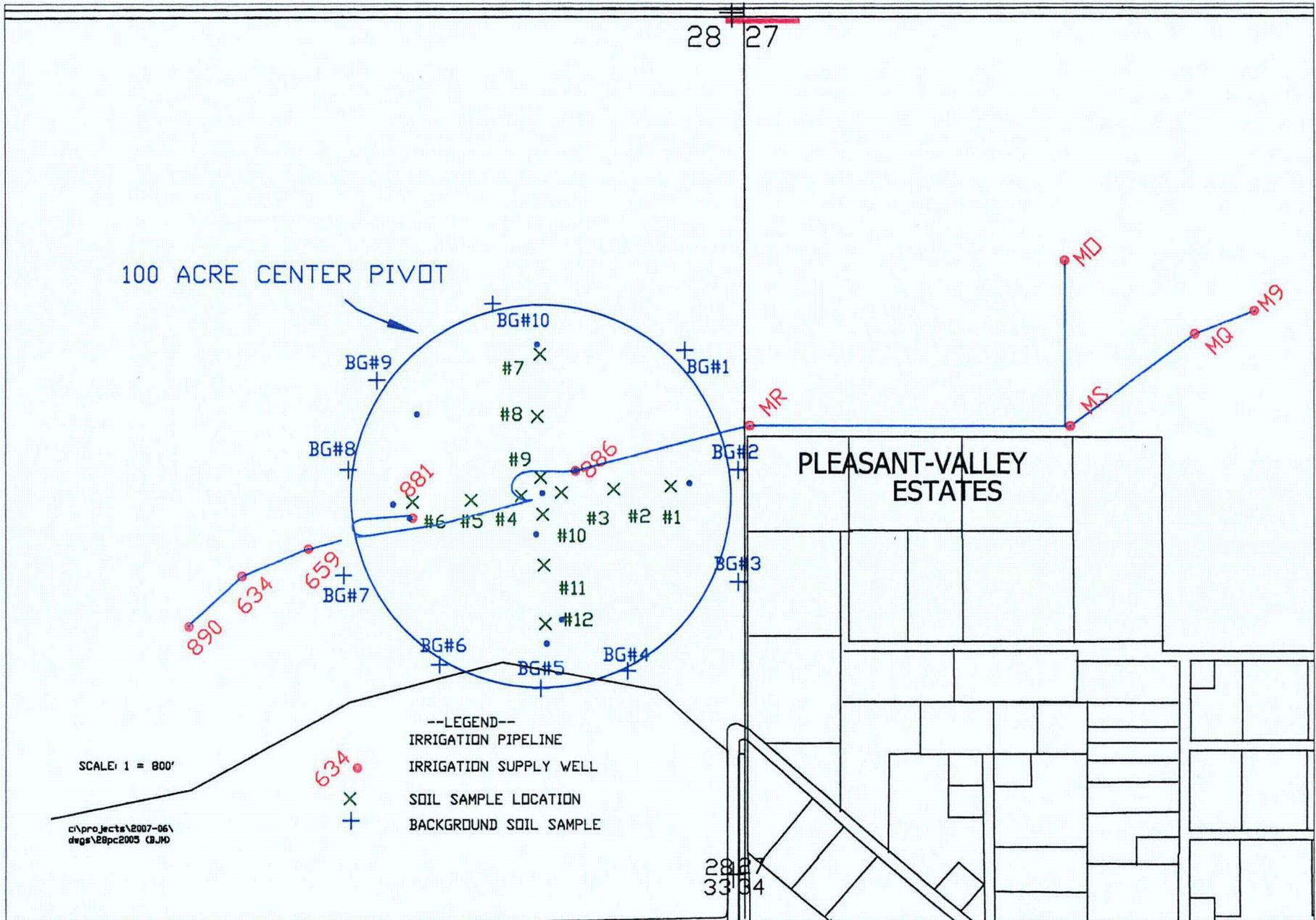


FIGURE 13. 2005 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

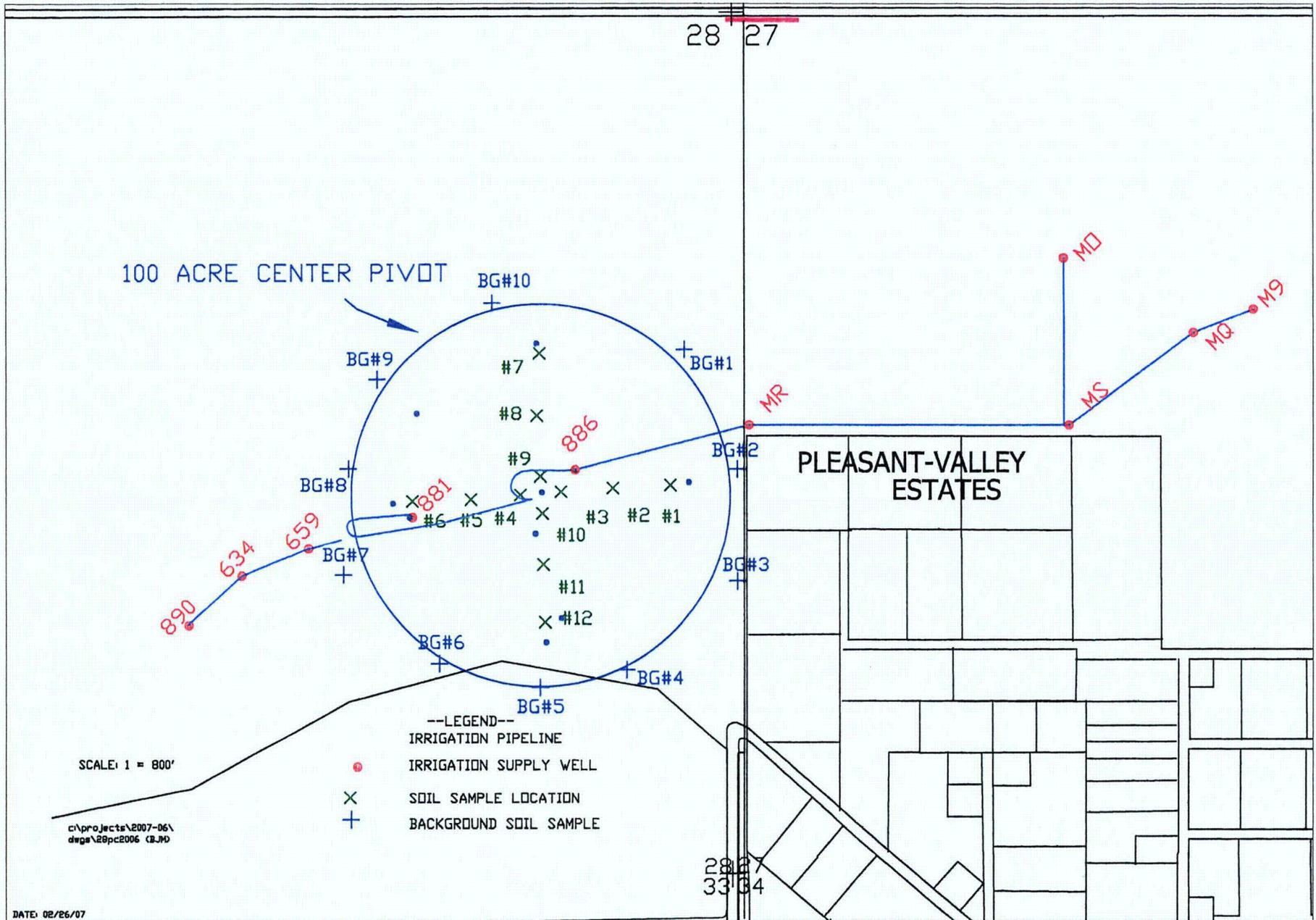


FIGURE 14. 2006 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

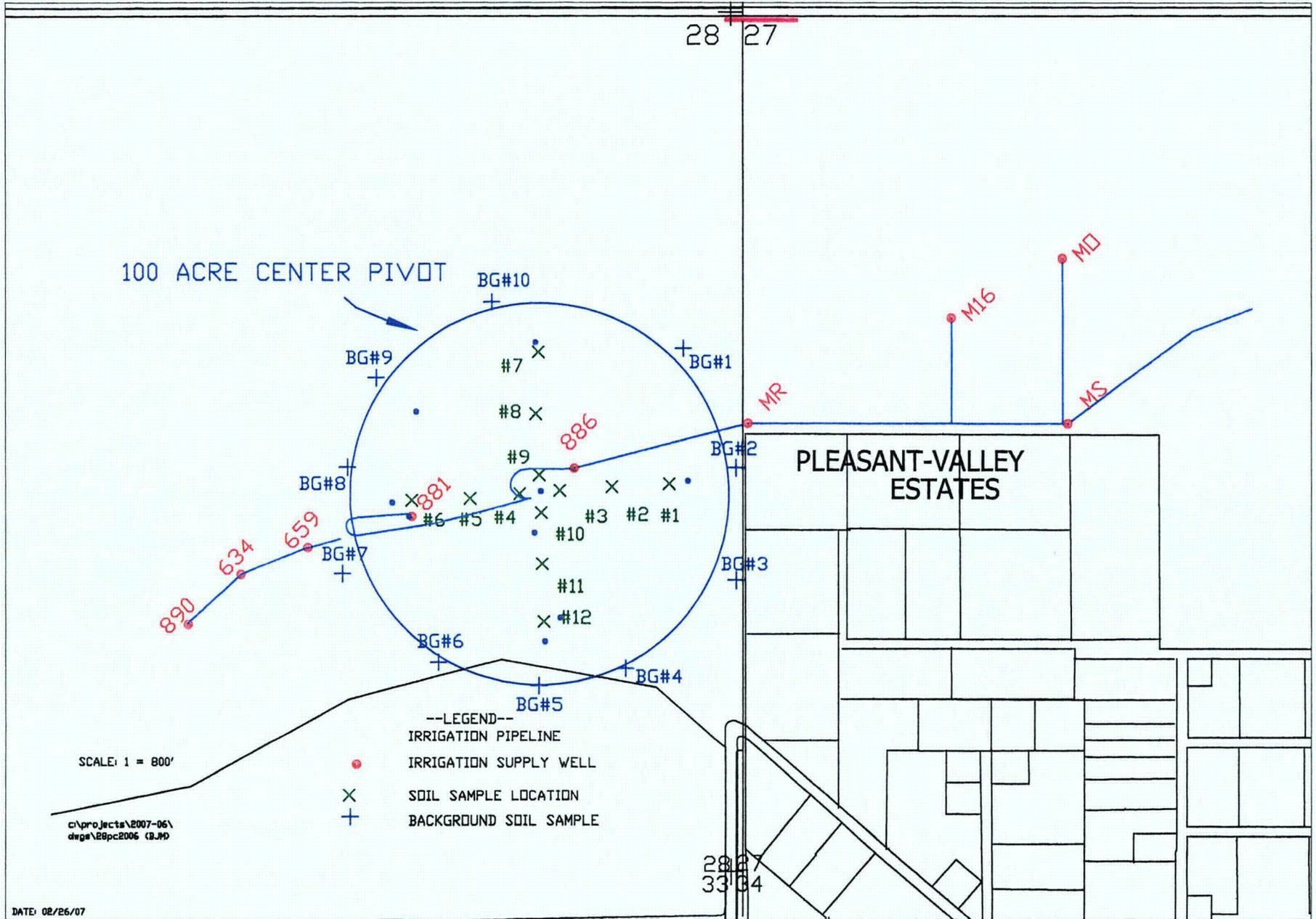


FIGURE 15. 2007 SECTION 28 IRRIGATION AREA WITH IRRIGATION WELLS AND SOIL SAMPLE LOCATIONS

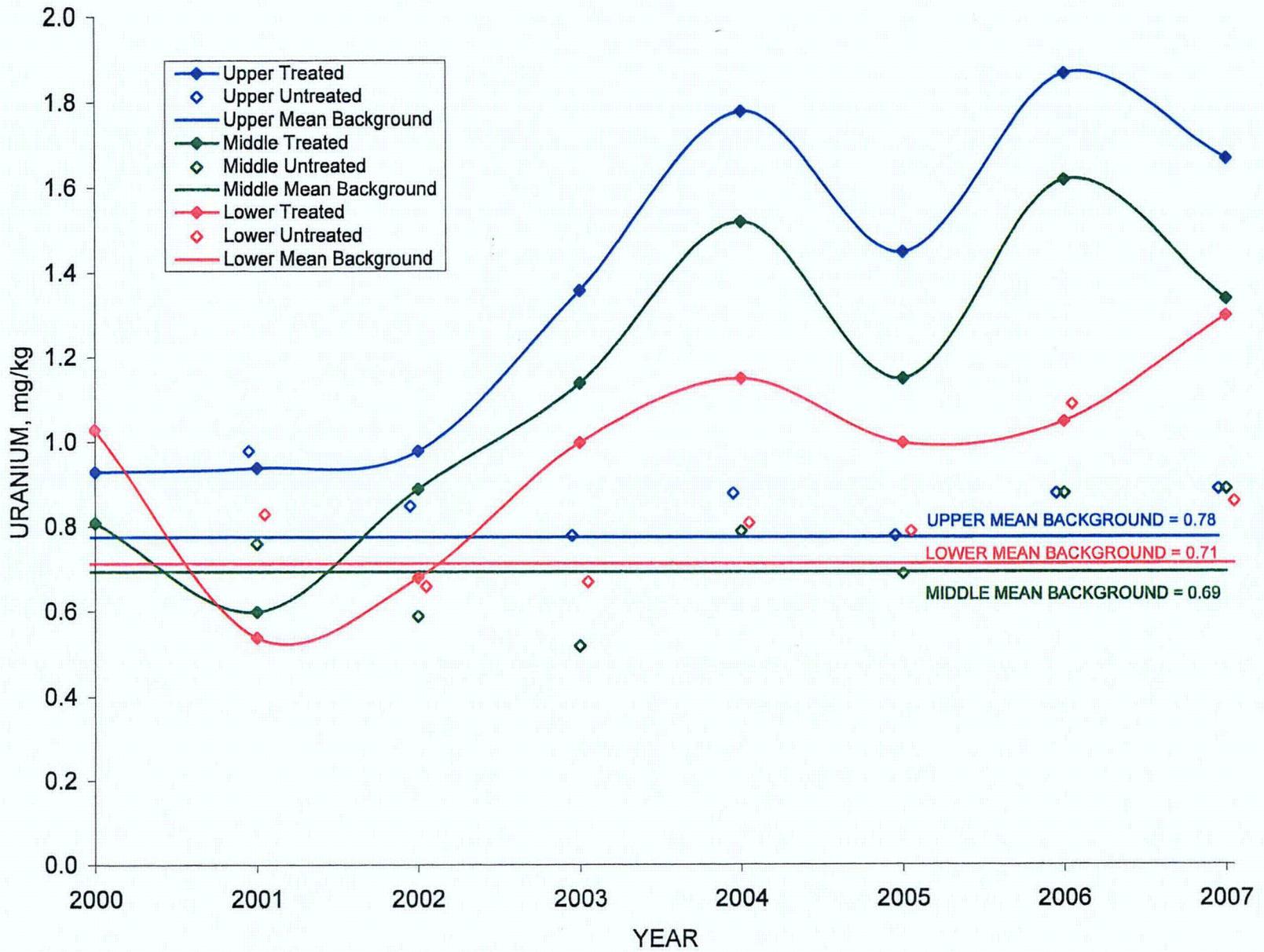


FIGURE 16. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTION 33 CENTER PIVOT SOIL SAMPLES

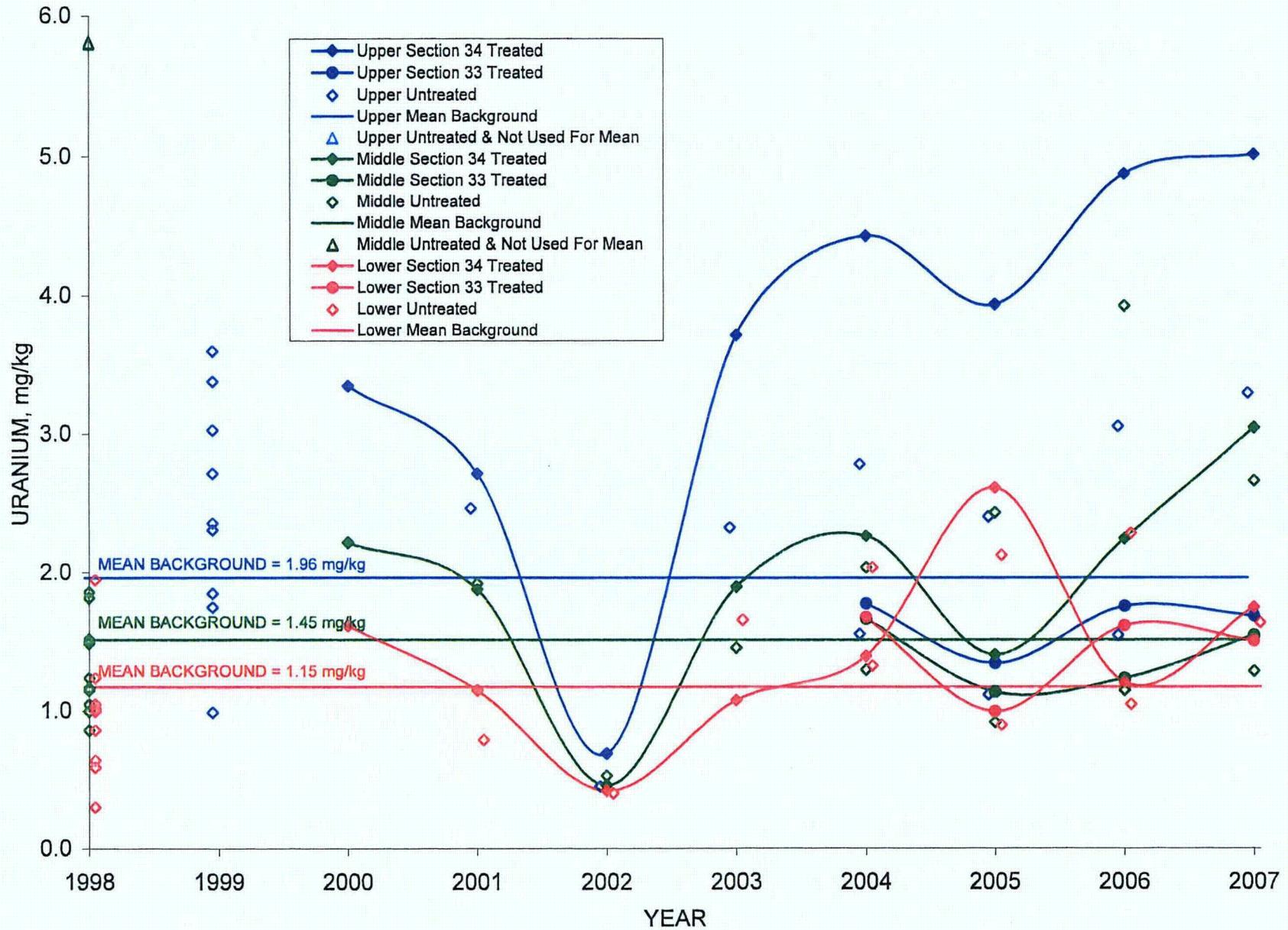


FIGURE 17. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTIONS 33 AND 34 FLOOD SOIL SAMPLES

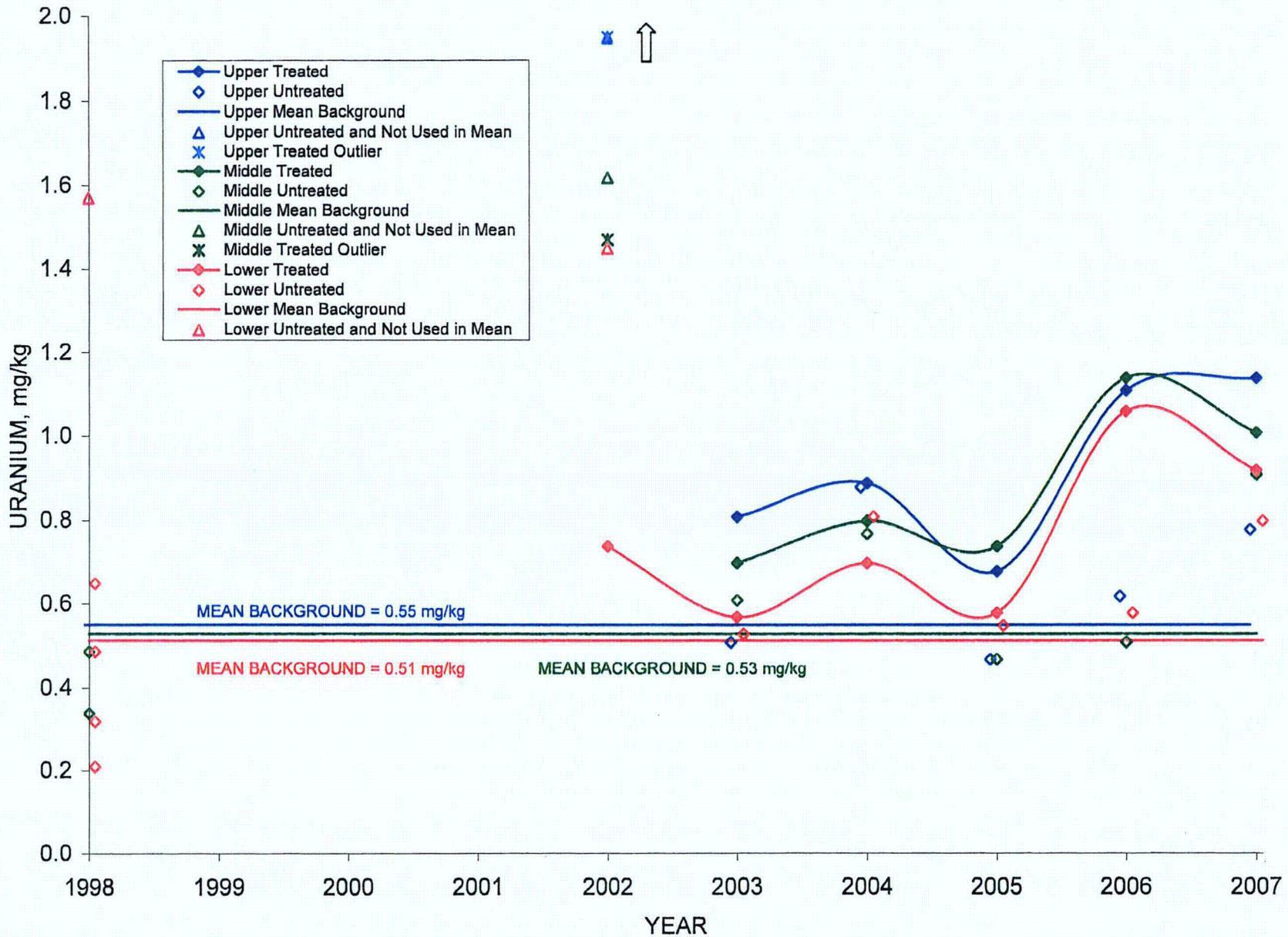


FIGURE 18. URANIUM CONCENTRATIONS VERSUS TIME FOR SECTION 28 CENTER PIVOT SOIL SAMPLES

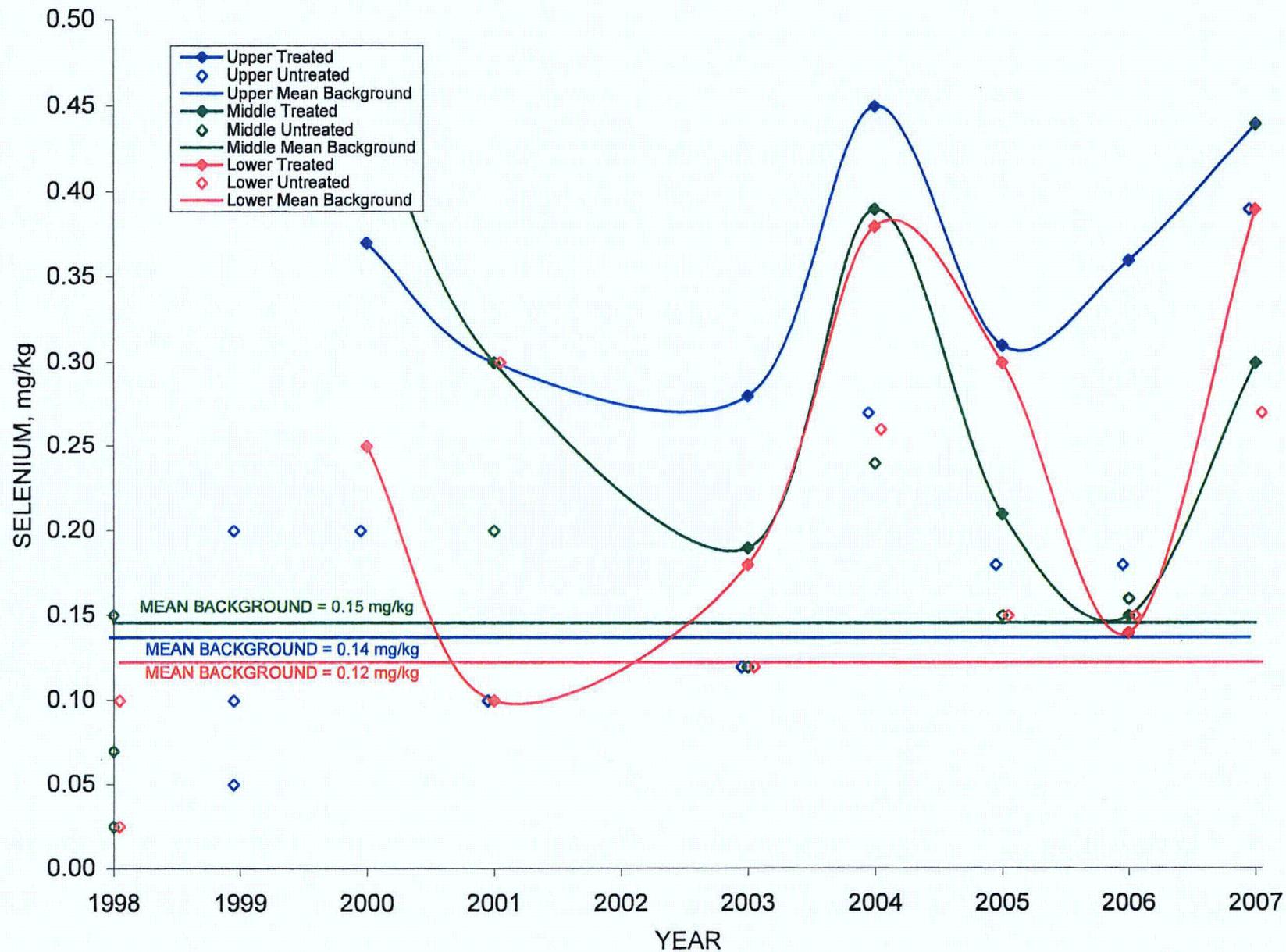


FIGURE 19. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTION 33 CENTER PIVOT SOIL SAMPLES

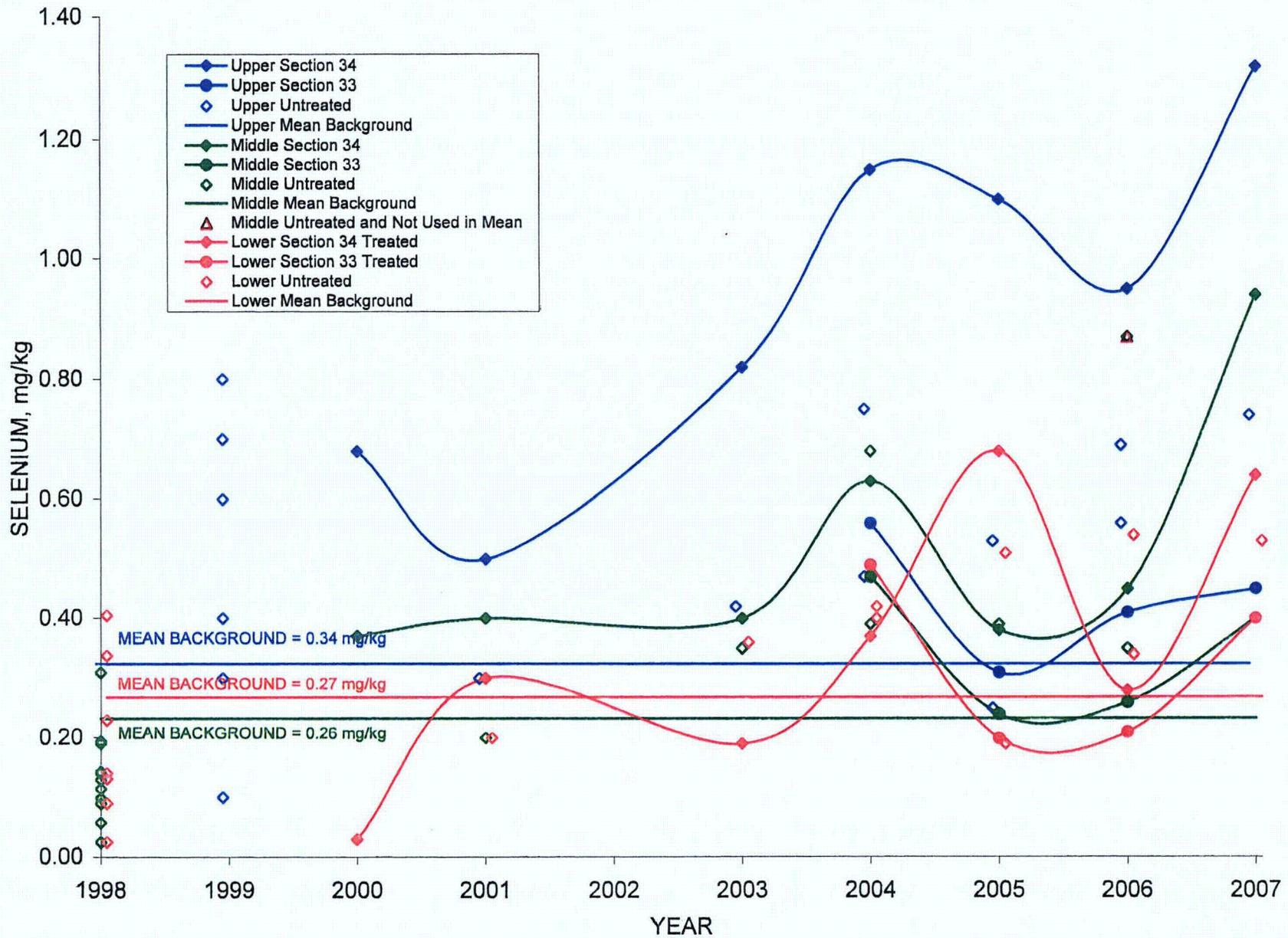


FIGURE 20. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTIONS 33 AND 34 FLOOD SOIL SAMPLES

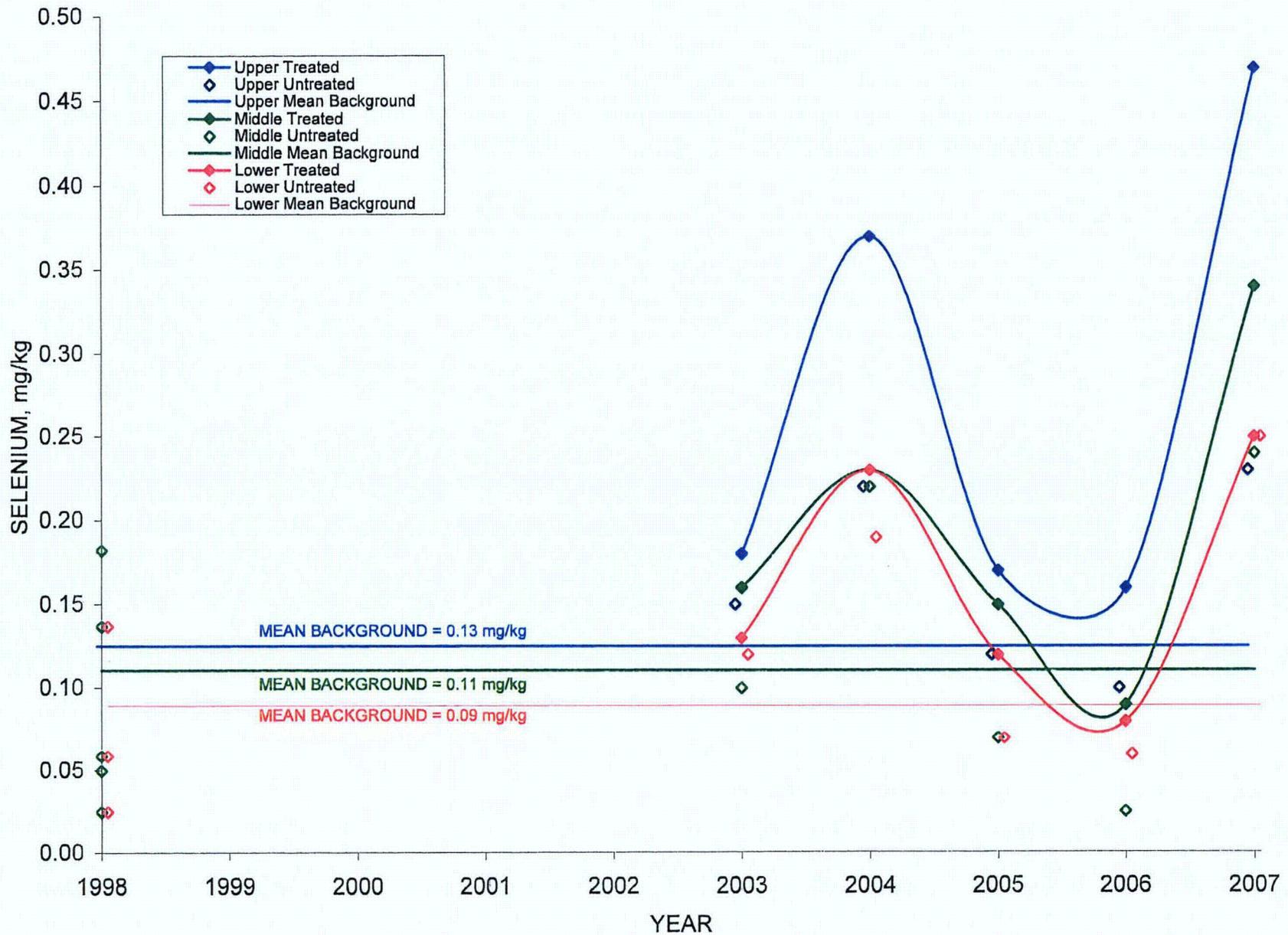


FIGURE 21. SELENIUM CONCENTRATIONS VERSUS TIME FOR SECTION 28 CENTER PIVOT SOIL SAMPLES

APPENDIX A

1999 and 2000 Soil Analysis

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)
<u>SECTION 33</u>												
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

Tables

B-1	2000 Hay Analyses	B-1
B-2	2001, 2002, 2003 and 2004 Hay Analyses	B-2
B-3	2005 through 2007 Hay Analyses.....	B-5

Table B-1. 2000 Hay Analyses

Sample	Uranium (mg/Kg)	Selenium (mg/Kg)	Moisture Content (%)	Percent Solids (%)
Homestake 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		2002		2003		2004	
		Uranium (mg/kg)	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
	<i>Average</i>		<i>0.580</i>	<i>1.413</i>	<i>1.32</i>	<i>1.80</i>	<i>0.73</i>	<i>1.70</i>	<i>1.63</i>
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
	<i>Average</i>		<i>0.566</i>	<i>1.050</i>	<i>0.37</i>	<i>1.17</i>	<i>0.70</i>	<i>1.47</i>	<i>0.51</i>
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	—	—	—	—	—	—
	<i>Average</i>		<i>0.296</i>	<i>0.868</i>	<i>0.78</i>	<i>1.81</i>	<i>0.73</i>	<i>1.55</i>	<i>0.90</i>

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

Irrigation Area	Sample	2001		2002		2003		2004	
		Uranium (mg/kg)	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
	<i>Average</i>		<i>0.550</i>	<i>1.050</i>	<i>0.91</i>	<i>0.83</i>	<i>0.89</i>	<i>1.62</i>	<i>1.03</i>
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	---	---	---	---	---	---
	<i>Average</i>		<i>0.380</i>	<i>0.822</i>	<i>1.52</i>	<i>1.14</i>	<i>0.56</i>	<i>0.80</i>	<i>0.88</i>
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	---	---
<i>Average</i>		<i>0.714</i>	<i>0.784</i>	<i>0.54</i>	<i>1.06</i>	<i>1.15</i>	<i>1.11</i>	---	---
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	---	---	---	---
<i>Average</i>		---	---	<i>0.89</i>	<i>1.17</i>	---	---	---	---

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

Irrigation Area	Sample	2001		2002		2003		2004	
		Uranium (mg/kg)	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
	<i>Average</i>		---	---	<i>0.29</i>	<i>0.79</i>	<i>0.99</i>	<i>1.62</i>	<i>1.09</i>
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
	<i>Average</i>		---	---	---	<i>0.98</i>	<i>1.28</i>	<i>1.17</i>	<i>1.08</i>
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
	<i>Average</i>		---	---	---	<i>1.14</i>	<i>1.00</i>	<i>0.85</i>	<i>1.03</i>

Table B-3. 2005 through 2007 Hay Analyses

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

Table B-3. 2005 through 2007 Hay Analyses (cont.)

Irrigation Area	Sample	2005		2006		2007	
		Uranium (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Selenium (mg/kg)
Section 33 - Flood - 1st Cut	#1	0.5	0.3	—	—	—	—
	#2	0.3	<0.20	—	—	—	—
	<i>Average</i>	<i>0.40</i>	<i><0.25</i>	—	—	—	—
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	—	—
	#8	3.0	2.7	0.6	0.7	—	—
	#9	2.2	1.7	0.6	0.9	—	—
	#10	2.4	1.5	0.6	0.4	—	—
	#11	1.0	1.9	—	—	—	—
	#12	1.3	1.6	—	—	—	—
<i>Average</i>	<i>1.8</i>	<i>1.9</i>	<i>0.79</i>	<i>0.75</i>	<i>1.02</i>	<i>1.43</i>	
Section 34 - Flood - 2nd Cut	#1	0.7	0.7	1.3	1.1	—	—
	#2	0.7	1.0	0.9	1.3	—	—
	#3	1.0	1.1	0.8	0.9	—	—
	#4	0.9	0.8	0.5	2.5	—	—
	#5	0.8	0.6	0.6	1.9	—	—
	#6	1.2	0.6	0.6	0.7	—	—
<i>Average</i>	<i>0.88</i>	<i>0.80</i>	<i>0.78</i>	<i>1.4</i>	—	—	

Table B-3. 2005 through 2007 Hay Analyses (cont.)

Irrigation Area	Sample	2005		2006		2007	
		Uranium (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Selenium (mg/kg)
Section 28 - Pivot - 1st Cut	#1	1.6	1.4	1.0	0.6	0.7	1.0
	#2	1.6	1.7	1.2	1.1	1.1	1.2
	#3	2.1	1.7	1.0	0.8	0.9	1.2
	#4	1.8	1.8	1.5	1.3	0.9	0.9
	#5	1.8	1.1	1.5	1.3	0.6	0.6
	#6	1.5	1.5	1.3	1.7	0.6	0.7
	#7	1.5	1.6	0.7	1.1	0.6	0.7
	#8	1.9	0.9	1.3	1.5	1.0	0.7
	#9	3.3	1.5	1.3	1.1	1.3	1.0
	#10	1.9	1.5	1.4	1.4	0.7	1.1
	#11	1.7	2.4	1.3	1.2	0.9	1.0
	#12	1.3	0.9	1.0	0.9	0.9	0.9
	<i>Average</i>		<i>1.8</i>	<i>1.5</i>	<i>1.2</i>	<i>1.2</i>	<i>0.9</i>
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	0.9
	#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
	<i>Average</i>		<i>0.94</i>	<i>1.2</i>	<i>0.77</i>	<i>1.3</i>	<i>1.59</i>
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
	<i>Average</i>		<i>1.4</i>	<i>1.5</i>	<i>0.62</i>	<i>0.95</i>	<i>1.17</i>