CIMARRON CORPORATION
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June 2, 2008

Mr. Kenneth Kalman
Office of Nuclear Materials Safety & Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Docket No. 70-925; License No. SNM-928
License Amendment Request for Groundwater Decommissioning

Dear Mr. Kalman:
Cimarron Corporation (Cimarron) has completed the decommissioning of buildings and soils at the Cimarron site, and is prepared to complete decommissioning by reducing the concentration of uranium in groundwater to comply with the license criterion of 180 pCi/l total uranium. Cimarron proposes to remediate groundwater by converting dissolved uranium to the solid phase, and establishing geochemical conditions that prevent its remobilization at concentrations exceeding the license criterion.

In 1999, NRC approved a site decommissioning plan (combining the April 1995 Site Decommissioning Plan and the July 1998 Decommissioning Plan Groundwater Evaluation Report) requiring additional groundwater assessment, and committing to additional action should it be determined that natural attenuation would not reduce groundwater concentrations to acceptable levels. Subsequent evaluation indicated that it would take decades for groundwater to attain the stipulated release criteria by natural attenuation. Consequently, Cimarron now submits the enclosed Groundwater Decommissioning Plan as an amendment to the NRC approved Site Decommissioning Plan. Cimarron provides Attachment 1 describing the content and status of the documents referenced in License Condition 10, which relate to the decommissioning of the site. Cimarron requests that License Condition 10 be revised to read:

> *For use in accordance with statements, representations, and conditions contained in letters dated September 14, 1990; July 25, 1995; January 28, 1997; February 10, 1998, and June 2, 2008.*

Attachment 2 provides a table showing how this submittal, in conjunction with previously submitted documents, satisfy the requirements for the content of a decommissioning plan as presented in NUREG-1757, "Consolidated Decommissioning Guidance".

Attachment 3 provides a table showing how Cimarron's Quality System satisfies the quality assurance requirements of Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations to License Termination) – Effluent Streams and the Environment".

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Attachment 4 provides a table showing how this submittal addresses technical issues raised in the PNNL report, "Evaluating the Efficacy of Uranium Bioremediation in the Subsurface: Technical Bases and Performance Indicators"

Finally, Attachment 5 provides a table listing the deficiencies identified by NRC in Cimarron's December 2003 license amendment request, identifying how and where those deficiencies are addressed in the Groundwater Decommissioning Plan.

Cimarron and its contractors (ENSR, LNST and ARCADIS) have been pursuing the implementation of an effective, cost-efficient approach to remediate the groundwater at the Cimarron site for more than three years through an in situ bioremediation program. We believed that such an approach is consistent with NRC's "Principles of Good Regulation". However, it has become apparent that the NRC is reluctant to support this approach, as shown by the continuing requests for additional information. A chronology of the numerous requests for information and conference calls over the past 18 months are summarized in Attachment 6.

NRC has informed Cimarron that NRC will not approve full-scale implementation of an in situ bioremediation program, stating that NRC will approve the development of in situ reactive zones in small areas. NRC asserts that information obtained from pilot-scale tests is needed to justify full-scale implementation of this technology, as well as to determine how long post-decommissioning monitoring should be performed.

Cimarron concludes that the conduct of pilot scale tests is impractical for two reasons. First, if Cimarron conducts pilot tests and NRC then does not approve full-scale implementation, there will be areas within which groundwater has been converted to reducing conditions and uranium has been immobilized. This will make any subsequent remediation technology, other than excavation of the water-bearing unit, prohibitively more expensive. Second, if NRC does not accept the geochemical modeling which demonstrates that immobilized uranium will not re-mobilize whether or not reducing conditions are maintained as sufficient to demonstrate the longevity of remediation, even decades of post-decommissioning monitoring will be insufficient to predict uranium concentration in groundwater over a thousand year period.

Cimarron submits as Attachment 7 an ALARA Evaluation for groundwater remediation. This ALARA Evaluation shows that no form of groundwater remediation is justifiable on a cost-benefit basis even if groundwater in the most contaminated area were currently being used as drinking water. Since groundwater is not being used, there is actually no reduction in dose as a result of groundwater remediation.

There has been no measurable exposure to licensed material at the site for several years. This lack of exposure will continue as long as the site is controlled, preventing the use of shallow groundwater for drinking water. Consequently, if NRC is unable to approve the enclosed plan through full-scale implementation, Cimarron proposes to "default" to natural attenuation, which will over time reduce groundwater concentrations

to less than the license criterion for uranium. This is the method originally approved by NRC in the April 1995 Site Decommissioning Plan and the July 1998 Decommissioning Plan Groundwater Evaluation Report. Cimarron proposes to implement the following controls in lieu of more "active" groundwater remediation:

- Continue annual environmental monitoring of approximately 20 wells distributed throughout the three areas in which groundwater exceeds license criteria. Monitoring wells to be sampled and analytical parameters will be agreed upon by NRC, DEQ, and Cimarron.
- Control use of the site to prevent use of shallow groundwater as drinking water, documented by quarterly site inspections. Cimarron would be willing to incorporate a restriction against the use of shallow groundwater for drinking water in the deed. Cimarron would not consider the use of such a control to result in a "restricted release" because this institutional control would be in effect only until groundwater complies with unrestricted release criteria.
- Discontinue its radiation protection program except as necessary to monitor the annual sampling and analysis of groundwater.
- Pursue closure for those issues addressed in the August 31, 2007 submittal.
- Pursue NRC concurrence that surface and subsurface soil in Subarea F complies with license criteria for unrestricted release.

Cimarron acknowledges that the time period required for natural attenuation to reduce groundwater concentrations to less than the license criterion is longer than was anticipated when the July 1998 Decommissioning Plan Groundwater Evaluation Report was approved by NRC. However, the proposed groundwater remediation program would represent expenditures of millions of dollars per man-rem avoided *if someone were currently using groundwater from the most highly impacted area*. But, as noted above, no one is using the water. Consequently, the application of more expensive technologies cannot be justified.

NRC approval of this license amendment request is respectfully requested. If you have any questions regarding this license amendment request, please call me at 405-775-5194 (OKC) or 405-642-5152 (mobile).

Sincerely,

Jeff Lux
Project Manager

Cc: Blair Spitzberg, NRC Region IV
David Cates, DEQ
Mike Broderick, DEQ

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Attachment 1

Cimarron License SNM-928 – Condition 10 References

Attachment 1
Cimarron License SNM-928 - Condition 10 References

Document Date	Description	Recommendation
11/19/1985	Request to possess 6,000 kg Thorium	License Item 6(D) authorizes possession of 6,000 kg Thorium - delete from license.
3/3/1986	Request to increase authorized quantity of <5% U-235 from 1,200 g to 6,000 g	License Item 6(A) authorizes possession of 1,200 g of U-235 - delete from license.
9/4/1987	Request to bury Option 2 material on site	Disposal of Option 2 material is complete - delete from license.
11/2/1989	Final release survey for Pu plant	Subarea I, in which the Pu plant resides, has been released for unrestricted use - delete from license.
8/22/1990	Request to discontinue filing 70.59 reports	9/14/90 letter from NRC (next citation) approves request - delete from license.
9/14/1990	NRC approval to discontinue 70.59 reports	See 8/22/90 above - Retain in condition 10
6/24/1992	Request for information from NRC - Organization chart, detail on invoice, status of Pu plant license termination, status of on site disposal cell approval, status of adequacy of disposal area and lagoon cleanup (Subarea L).	Organization has changed multiple times since this submittal, financial detail was provided, Subarea with Pu plant was released for unrestricted use, disposal is complete and Subarea L was released for unrestricted use - delete from license.
2/25/1993	Response to 1/8/93 RAI on disposal cell - Subsidence, Wind and water erosion, Deed notice and location markers, Commitment to complete decommissioning	Disposal and associated work is complete, condition 23 still requires continuing inspections - delete from license.
4/19/1994	Onsite Disposal Plan - Responsibilities, Defintions, Precautions, Characterization, Transportation, Disposal, Determination of activity in cell, Run-on and run-off control, Cap placement, Record of disposal	Decommissioning and disposal of soils is complete - delete from license.
5/31/1994	Response to 4/19/94 RAIs - Final survey of material in cell, Average concentration determination, Reg Guide 1.86 criteria, Option 2 limit, Hot spot averaging, Final survey of excavations, Final survey of cap, Use of NUREG/CR-5849	Decommissioning and disposal of soils is complete, issues addressed. Subarea N demonstrated releasable, but not released due to groundwater in Subarea K - delete from license.
7/20/1994	Response to 7/18/94 RAI - How to sample and analyze for Kd of soil in disposal cell	Decommissioning and disposal of soils is complete - delete from license.
9/21/1994	Response to 8/12/94 RAIs - Hot spot averaging of soil in disposal cell, QC samples, NUREG/CR-5849 calculations, Soil counter calibration	Disposal is complete, soil counter calibration has changed since this time and has been inspected repeatedly - delete from license
11/3/1994	Follow up on telephone conversation - Exposure to workers placing soil in disposal cell	Decommissioning and disposal of soils is complete - delete from license.
11/15/1994	License Amendment Request - Changes to Appendix A and Annex A	Appendix A and Annex A have changed substantially since this submittal. This submittal is no longer relevant - delete from license.

Attachment 1
Cimarron License SNM-928 - Condition 10 References

Document Date	Description	Recommendation
12/16/1994	License Amendment Request - Cimarron desires to designate Karen Morgan as RSO	License Condition 24 designates Karen Morgan as RSO - no longer needed - delete from license.
4/12/1995	Soil density test results for waste in and cap on disposal cell, Cell 2	Decommissioning and disposal of soils is complete - delete from license.
6/5/1995	Resume for Karen Morgan	License Condition 24 designates Karen Morgan as RSO - no longer needed - delete from license.
7/5/1995	Response to telephone inquiry on hot spot averaging in South Uranium Yard	The subject area (Subarea K) has been released for unrestricted use - delete from license.
7/25/1995	Submittal of Final Status Survey Plan for Phase II Areas	FSSR for Subarea F, a Phase II area, is in NRC review - retain in Condition 10.
8/9/1995	Submittal of Final Status Survey Report for Unaffected Areas (Phase I)	All Phase I areas have been released for unrestricted use -delete from license.
11/13/1995	Response to NRC comments on Final Status Survey Report for Phase I Areas	All Phase I areas have been released for unrestricted use -delete from license.
1/23/1996	License Amendment Request - Organization Change	Organization has changed since this submittal - it is no longer appropriate - delete from license
4/25/1996 (Listed twice)	Option 2 materal disposal procedure change from stockpiling to direct transportation to cell	Decommissioning and disposal of soils is complete - delete from license.
6/10/1996	RAIs regarding 4/25/96 proposal	Decommissioning and disposal of soils is complete - delete from license.
8/28/1996	Hot spot averaging in stockpiles and cell - not performed in five pond areas	Decommissioning and disposal of soils is complete - delete from license.
9/20/1996	Response to 8/16/96 RAIs - License Amendment Request - Changes to Appendix A and Annex A	Appendix A and Annex A have changed substantially since this submittal - delete from license.
11/20/1996	Proposed lung fluid solubility test	Decommissioning and disposal of soils is complete - delete from license.
1/2/1997	Response to 12/2/96 RAIs on Annex A	Appendix A and Annex A have changed substantially since this submittal - delete from license.
1/28/1997	Response to 10/31/96 NRC Comments on Final Status Survey Plan for Phase II Areas	FSSR for Subarea F, a Phase II area, is in NRC review - retain in Condition 10.
5/6/1997	Response to 2/25/97 NRC Comments - Volumetric averaging and groundwater contamination at Ponds 1 and 2, Averaging of paved areas, concrete in drainageways.	Issues all addressed except groundwater. Groundwater is addressed in Condition 27(b) - delete from license.
5/16/1997	Response to 3/5/97 NRC Comments on RPP -	Appendix A and Annex A have changed substantially since this submittal - delete from license.
12/5/1997	Response to 10/3/97 NRC Comments on Phase III Final Status Survey Plan	FSSRs for all Phase III areas have been approved by NRC. This is no longer needed - delete from license.

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Cimarron License SNM-928 - Condition 10 References

Document Date	Description	Recommendation
2/10/1998	Agenda for 2/17/98 Meeting w/ NRC - includes information on dose calculations	Provides basis for limits now stipulated in the license. Includes information on dose calculations - retain in Condition 10.
6/26/1998	Response to 2/9/98 NRC Comments on Phase III Final Status Survey Plan	FSSRs for all Phase III areas have been approved by NRC. This is no longer needed - delete from license.
7/2/1998	Responses to 7/1/98 Conference Call - Resolving questions about inspection report #70-925/97-02 - soil counter "traceability" and typographical error	Issues raised during conference call have been addressed - delete from license.
2/15/2000	Submittal of Final Status Survey Report for Phase III, Subarea K	Subarea K has been released from license - delete from license.
2/20/2001	Response to 1/29/01 NRC Comments on FSSR for Phase III, Subarea K - Hot spot averaging, revise Table 4.1	Subarea K has been released from license - delete from license.
4/17/2002	Decommissioning Schedule	Schedule no longer relevant - delete from license.
5/10/2002	Revised Decommissioning Schedule	Schedule no longer relevant - delete from license.

Attachment 2

NUREG-1757 Decommissioning Plan Requirements Addressed in Cimarron Documents

Attachment 2
NUREG-1757 Decommissioning Plan Requirements
Addressed In Cimarron Documents

Decommissioning Plan Contents As Per NUREG-1757	Location Topic Discussed In Cimarron Documents
Site Description	
Executive Summary	
Facility Operating History	
License Number/Status/Authorized Activities	Presented in Apr 1995 Site Decommissioning Plan - Section 1
License History	Presented in Oct 1994 Site Characterization Report - Section 2 Updated in Apr 1995 Site Decommissioning Plan - Section 1 Updated in Aug 2005 Sub-Area F Final Status Survey Report - Section 1
Previous Decommissioning Activities	Presented in Apr 1995 Site Decommissioning Plan - Section 1 Updated in Jul 1998 Decommissioning Plan Ground Water Evaluation Report - Section 4 Updated in Aug 2005 Site-Wide Groundwater Assessment Review
Spills	Described in Aug 2005 Site-Wide Groundwater Assessment Review
Burials	
Facility Description	
Site Location and Description	Presented in Apr 1995 Site Decommissioning Plan - Section 1
Population Distribution	Addressed in Apr 2008 Groundwater Decommissioning Plan - Section 2
Current/Future Land Use	Addressed in Apr 2008 Groundwater Decommissioning Plan - Section 2
Meteorology and Climatology	Presented in Oct 2006 Conceptual Site Model - Rev. 01 - Section 3
Geology and Seismology	Geology - Described in Jul 1998 Decommissioning Plan Ground Water Evaluation Report - Sections 2 and 3 Updated in Oct 2006 Conceptual Site Model - Rev. 01 - Sections 2 and 3 Seismology not relevant to proposed groundwater remediation
Surface Water Hydrology	Described in Jul 1998 Decommissioning Plan Ground Water Evaluation Report - Section 3 Updated in Oct 2006 Conceptual Site Model - Rev. 01 - Section 3
Groundwater Hydrology	Described in Jul 1998 Decommissioning Plan Ground Water Evaluation Report - Section 3 Updated in Oct 2006 Conceptual Site Model - Rev. 01 - Section 3
Natural Resources	Only natural resource which would impact dose estimates is shallow groundwater - addressed in Jun 2008 Groundwater Decommissioning Plan - Sections 3 - 5
Radiological Status of Facility	
Contaminated Structures	Decommissioned and released by NRC as described in Aug 2005 Sub-Area F Final Status Survey Report - Section 1
Contaminated Systems and Equipment	
Surface Soil Contamination	Soil decommissioning complete as described in Aug 2005 Sub-Area F Final Status Survey Report - Section 1
Subsurface Soil Contamination	
Surface Water	Described in Jul 1998 Decommissioning Plan Ground Water Evaluation Report - Section 3 Updated in Oct 2006 Conceptual Site Model - Rev. 01 - Section 3
Ground Water	Described in Jul 1998 Decommissioning Plan Ground Water Evaluation Report - Section 3 Updated in Oct 2006 Conceptual Site Model - Rev. 01 - Section 3

Attachment 2
NUREG-1757 Decommissioning Plan Requirements
Addressed In Cimarron Documents

Decommissioning Plan Contents As Per NUREG-1757	Location Topic Discussed In Cimarron Documents
Program Organization	
Planned Decommissioning Activities	
Contaminated Structures	Decommissioning of structures and soil complete as described in Aug 2005 Sub-Area F Final Status Survey Report - Section 1
Contaminated Systems and Equipment	
Soil	
Surface and Ground Water	Addressed in Jun 2008 Groundwater Decommissioning Plan - Sections 3 - 5
Schedules	Addressed in Jun 2008 Groundwater Decommissioning Plan - Section 5
Project Management and Organization	
Decommissioning Management Organization	Addressed in Jun 2008 Groundwater Decommissioning Plan - Section 2
Decommissioning Task Management	
Decommissioning Management Positions and Qualifications	
Training	Addressed in Sep 2007 Quality System Manual - Section 2 Addressed in Feb 2008 Radiation Safety Plan - Section 2
Contractor Support	Addressed in Sep 2007 Quality System Manual - Sections 1 and 7 Addressed in Feb 2008 Radiation Safety Plan - Section 1
Radiation Safety Controls and Monitoring for Workers	Addressed in Feb 2008 Radiation Safety Plan - Sections 6 - 14
Nuclear Criticality Safety	N/A - as per License Condition 19
Health Physics Audits, Inspections, and Recordkeeping Program	Addressed in Sep 2007 Quality System Manual - Section 6 Addressed in Feb 2008 Radiation Safety Plan - Section 5
Environmental Monitoring and Control Program	
Environmental ALARA Evaluation Program	Addressed in Feb 2008 Radiation Safety Plan - Sections 4 and 15
Effluent Monitoring Program	N/A - no effluents will be created during groundwater remediation
Effluent Control Program	
Radioactive Waste Management Program	
Solid Radioactive Waste	N/A - no waste will be generated during groundwater remediation activities
Liquid Radioactive Waste	
Mixed Waste	
Quality Assurance Program	
Organization	All topics listed in this section are addressed in Sep 2007 Quality System Manual
Quality Assurance Program	
Document Control	
Control of Measuring and Test Equipment	
Corrective Action	
Quality Assurance Records	
Audits and Surveillances	
Modifications to Decommissioning Programs and Procedures	
	Provision for modifying Site Decommissioning Plan and procedures is specified in License Condition 27(e)

Attachment 3

Comparison of the Cimarron Quality System to Regulatory Guide 4.15 "Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations to License Termination) – Effluent Streams and The Environment"

Attachment 3
Comparison of the Cimarron Quality System to Regulatory Guide 4.15 "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) – Effluent Streams and the Environment"

Cimarron QA System Section and Item Description	Regulatory Guide 4.15 Rev. 2 Requirements Addressed
1.0 Organizational Structure and Responsibilities of Managerial and Operational Personnel	C.1
2.0 Quality Assurance Program	C, C.2
3.0 Design Control	C.8
4.0 Procurement Document Control	N/A
5.0 Instructions, Procedures, and Drawings	C.3
6.0 Document Control	C.3
7.0 Control of Purchased Items and Services	N/A
8.0 Identification and Control of Items	N/A
9.0 Control of Processes	C.3
10.0 Inspection	C.3
11.0 Test Control	C.8
12.0 Control of Measuring and Test Equipment (M&TE)	C.6.1
13.0 Handling, Storing and Shipping	C.3
14.0 Inspection, Test and Operating Status	C.3
15.0 Control on Nonconforming Items	C.10
16.0 Corrective Action	C.10
17.0 Quality Assurance Records	C.4
18.0 Audits	C.9
19.0 Quality Control in Environmental Sampling	C.5
20.0 Quality Control in the Radioanalytical Laboratory	C.6
21.0 Internal Quality Control Samples and Analysis	C.6.2
22.0 Performance Evaluation Program	C.6.3
23.0 QAPP (Quality Assurance Project Plan)	B, paragraph 3

Attachment 4

Comparison of the Groundwater Decommissioning Plan to "Prioritized Information and Monitoring Parameters for Assessment of Bioremediation Of U(VI) in Groundwater (Table 5.1 from PNNL Report 16385 [Long and Yabusaki, 2007])

Attachment 4
Comparison of the Groundwater Decommissioning Plan to "Prioritized Information and Monitoring Parameters for Assessment of Bioremediation of U(VI) in Groundwater" (Table 5.1 from PNNL Report 16385 [Long and Yabusaki, 2007])

Parameter Detailed in the PNNL Report	How Parameter is Addressed in the Groundwater Decommissioning Plan or Other Cimarron Documents
Mandatory Site Information: Uranium Distribution, Form, and Mobility	
Site conceptual model for uranium source term	Fully explained in ENSR's refined Oct. 06 Conceptual Site Model (CSM) Rev. 01 - Section 4
Spatial extent of contamination zone (plume geometry) (to ± 20%)	The areas of uranium impacts have been fully delineated through an extensive monitoring program as documented in July 1998 Decommissioning Plan Ground Water Evaluation Report - Section 3 and Oct 06 CSM Rev. 01 - Section 3.
Form and mobility/lability (to ± 30%)	Uranium has been analyzed in the soil and groundwater; geochemical modeling has been performed to predict speciation (uranyl carbonate); the distribution of uranium between soil and groundwater has been determined (ENSR, 2006, Section 5.1.2). Additional characterization will be performed as part of the groundwater remediation activities to determine the uranium concentration and form in the soil at the start of remediation (Section 5.2.1.1 of the Groundwater Decommissioning Plan, baseline soil mineralogy).
Mandatory Site Information: Hydrologic and Geologic Data	
Site conceptual model for subsurface (vadose zone and groundwater) flow and contaminant transport	Detailed in Oct 06 CSM Rev. 01; vadose zone is not a significant continuing source of uranium to the groundwater as discussed in December 2007 teleconference with the NRC and as documented in associated materials submitted to the NRC in November 2007 in preparation for the teleconference.
Temporal recharge (to ± 20%)	Extensively characterized and detailed in the Hydrology Addendum to the Groundwater Decommissioning Plan (Appendix B).
Vadose zone hydrogeology: porosity, water retention function parameters (to ± 20%)	The vadose zone is not a significant continuing source of uranium to the groundwater as discussed in December 2007 teleconference with the NRC and as documented in associated materials submitted to the NRC in November 2007 in preparation for the teleconference. The need to have this level of detail is based upon PNNL experience at Hanford where the vadose zone extends at some locations >250' below ground surface and has residual source contamination.
Groundwater flow velocity (Darcy flux) and direction (to ±30%)	Characterized for each area of the site where uranium is present at >180pCi/L as described in the Oct 06 CSM Rev. 01. Tracer testing will also be performed as

Attachment 4
Comparison of the Groundwater Decommissioning Plan to "Prioritized Information and Monitoring Parameters for Assessment of Bioremediation of U(VI) in Groundwater" (Table 5.1 from PNNL Report 16385 [Long and Yabusaki, 2007])

Parameter Detailed in the PNNL Report	How Parameter is Addressed in the Groundwater Decommissioning Plan or Other Cimarron Documents
	described in Section 5.2.1.2 of the Groundwater Decommissioning Plan to obtain high resolution data on groundwater flow velocity and direction.
Water table dynamics	Current conditions detailed in the Hydrology Addendum included as Appendix B to the Groundwater Decommissioning Plan and Oct 06 CSM Rev. 01. Water levels in wells will be monitored prior to and during remediation as described in Section 5.2 of the plan.
Site hydrogeology: hydraulic conductivity, porosity, dispersivity, hydrofacies	Fully characterized and detailed in Oct 06 CSM Rev. 01. Additional focused information will be obtained through tracer testing during the groundwater remediation as described in Section 5.2.1.2 of the Groundwater Decommissioning Plan.
Remediation process conceptual model	Conceptual models have been developed for the remediation hydrology and geochemical aspects of the in-situ remediation plan as detailed in Section 3 of the Groundwater Decommissioning Plan.
Particle size characteristics	The baseline soil mineralogy analyses to be performed as described in Section 5.2.1.1 of the Groundwater Decommissioning Plan will provide this information prior to the start of remediation.
Mandatory Geochemical and Microbiological Performance Monitoring Parameters	
Background U(VI) concentration, monthly or bi-monthly and event-based (e.g., high water table).	Groundwater U(VI) concentrations have been extensively monitored; concentrations were monitored during August 2007 (high water table). Baseline sampling will take place prior to the start of remediation as described in Section 5.2.1.1 of the Groundwater Decommissioning Plan.
Treatment zone and down-gradient U(VI) concentration (required to be below MCL after treatment)	Sections 5.2.2.4 and 5.2.3.1 detail the performance monitoring and remedy completion demonstration testing of groundwater, respectively, to be conducted, with specific criteria for determining that the MCL has been met and maintained for 8 consecutive quarters with no significant increasing trends in the data as determined using EPA Sen's Slope Estimator method.
DO, ORP, specific conductivity, and pH measured hourly to 4 times daily in background and treatment zone (autonomous multiparameter probes)	Field parameters will be sampled as part of the remediation program as described in Section 5.2 of the Groundwater Decommissioning Plan.

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Parameter Detailed in the PNNL Report	How Parameter is Addressed in the Groundwater Decommissioning Plan or Other Cimarron Documents
Aqueous electron acceptors and reduction byproducts in background and treatment zone: nitrate, nitrite, ammonium, Mn(IV/II), sulfate, sulfide	Electron acceptors and reduction byproducts will be monitored as detailed in Sections 5.2.1.1 and 5.2.2.4 of the Groundwater Decommissioning Plan; these analyses will include: total organic carbon, sulfate, sulfide, dissolved iron, ferrous iron (Fe^{2+}), nitrate, and alkalinity. Manganese will not be analyzed since dissolved iron and ferrous iron will be indicators of iron reduction.
Fe(III) mineral abundance	Baseline mineralogy analyses will focus on iron, including quantification and speciation of the iron prior to the start of remediation, and the changes that occur to iron mineralogy as the remediation progresses. The baseline soil sampling and analyses are detailed in Section 5.2.1.1 of the Groundwater Decommissioning Plan.
Fe(II), sulfide measured in field at time of sampling for U(VI) (upgradient, treatment zone, and downgradient)	Ferrous iron and sulfide are performance monitoring parameters and will be monitored as described in Sections 5.2.1.1 and 5.2.2.4 of the Groundwater Decommissioning Plan.
Electron donor concentration in the treatment zone	Measurement of total organic carbon (TOC) is detailed throughout Section 5.2 of the Groundwater Decommissioning Plan and is a key aspect of the remediation hydraulics approach (e.g., facilitating distribution of TOC will be the goal of the injection and extraction systems).
Tracer for electron donor (to provide accurate indication of donor distribution)	Section 5.2.1.2 of the Groundwater Decommissioning Plan details tracer testing to be conducted as part of the first stage of the remediation system for the impacted groundwater areas. The goal of the tracer testing will be to refine the injection and extraction system to achieve optimum TOC distribution).
Alkalinity (measured in the field)	Alkalinity will be routinely measured as part of the performance monitoring program as described in Sections 5.2.1.1 and 5.2.2.4 of the Groundwater Decommissioning Plan.

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PNNL "Desirable" or "Optional" Performance Monitoring Parameters that are included in the Groundwater Decommissioning Plan
Desirable - *Depth discrete U(VI) data (upper/mid/lower part of contaminated zone):* Soil samples will be obtained from two depths at each sample location as described Sections 5.2.1.1 and 5.2.3.2 of the Groundwater Decommissioning Plan and summarized on page 3 of Figure 5-1.
Desirable - *Depth-discrete sediment sampling/extraction for U, Fe, AVS:* These parameters will be analyzed for at baseline, during the course of remediation (as part of the soil performance monitoring program), and as part of the remedy completion demonstration testing as described in Sections 5.2.1.1, 5.2.2.4 and 5.2.3.2, respectively, of the Groundwater Decommissioning Plan and summarized on page 3 of Figure 5-1.
Optional – *In situ redox status of U by direct sampling of in situ materials:* This will be determined through the use of electron and x-ray microprobe methods during the soil performance monitoring and remedy completion demonstration testing phases as described in Sections 5.2.2.4 and 5.2.3.2 of the Groundwater Decommissioning Plan and summarized on page 3 of Figure 5-1.

Reference

Long, P.E., and Yabusaki, S.B. 2007. Evaluating the Efficacy of Uranium Bioremediation in the Subsurface: Technical Bases and Performance Indicators. Pacific Northwest National Laboratory Report PNNL-16385.

Attachment 5

Comparison of the Groundwater Decommissioning Plan to the Deficiencies Noted In NRC's March 27, 2007 Correspondence

Attachment 5
Comparison of the Groundwater Decommissioning Plan to the Deficiencies Noted in NRC's March 27, 2007 Correspondence

Deficiency Number and Concern	How Deficiency is Addressed in Groundwater Decommissioning Plan or Other Cimarron Documents
1, 2, 3 - The potential impact of seasonal events on the re-mobilization of uranium after in-situ bioremediation. • The number and duration of events presented was underestimated in extent, and the possible introduction of oxygen and other redox sensitive compounds introduced during the flooding events could induce changes to the groundwater geochemistry. • Accordingly consideration was provided for: o River flood stage events; o Periods of heavy rainfall; and o Ponded water vertically infiltrating to the water table.	A Hydrology Addendum was prepared to evaluate regional and site-specific transient hydrologic processes. Section 3.3 of the Groundwater Decommissioning Plan provides a summary of the hydrologic modeling and assessment completed, and the complete Hydrology Addendum is included as Appendix B to the plan. Section 3.4.4 of the plan discusses incorporation of the Hydrology Addendum evaluations and results into the geochemical modeling evaluations.
4 - Final calibration input and output files (electronic files) for the MODFLOW and MODPATH model runs are needed (with the appropriate documentation via CD or DVD) so that the NRC staff can independently verify these calibration runs.	The electronic input and output MODFLOW files for the BA#1 and WAA models are included as Appendix F on a compact disk. The Groundwater Flow Modeling Report (ENSR, 2006) included as Appendix A serves as complete documentation for these models.
5 - The SDP did not provide any information on the calibration of these transport models. • In order to conduct independent reviews of the transport models, the NRC staff should be provided with the final calibration input and output files (electronic files) to review the MT3DMS model runs.	Section 3.4 of the Groundwater Decommissioning Plan describes the geochemical modeling completed. In addition, the Groundwater Flow Modeling Report is included as Appendix A to the plan and the output from the modeling is included on a compact disk in Appendix F as noted above.
6 - Unsaturated zone characterization and modeling are needed if a considerable source of residual uranium is in the unsaturated zone. • Characterization and modeling of the unsaturated flow and transport conditions may be warranted to assess the earlier discussion on ground-water recharge and water-table fluctuations.	Figures 3-1 and 3-2 summarize current uranium groundwater activity information for the areas of concern. The information indicates that no significant changes in the uranium area of impact locations or extent have occurred, despite the significant precipitation and ponding events that occurred during the summer of 2007.
7 - The SDP should contain a detailed QA/QC program plan specific to characterization, monitoring, and modeling to confirm the efficacy of the uranium bioremediation program. • Further discussion of quality assurance (QA) and quality control (QC) protocols needs to be provided	Section 6 of the Groundwater Decommissioning Plan presents a summary of the Cimarron Quality Assurance Program. In addition, preliminary Data Quality Objectives for the groundwater decommissioning activities are included in Appendix C to the plan. Appendix E includes the Quality System Manual Table of Contents and a cross reference for the Quality System Manual sections to the applicable sections of the Regulatory Guide 4.15 to demonstrate how Cimarron's Quality System satisfies the requirements of this guidance.

Attachment 5
Comparison of the Groundwater Decommissioning Plan to the Deficiencies Noted in NRC's March 27, 2007 Correspondence

Deficiency Number and Concern	How Deficiency is Addressed in Groundwater Decommissioning Plan or Other Cimarron Documents
8 - Better address the difficulty in determining injection and subsurface distribution of "amendment" in a non-homogenous setting. • More description is needed to describe the "staged approach" to injections and monitoring.	Section 5.2 of the Groundwater Decommissioning Plan describes the proposed recirculation remedial approach in which injection and extraction wells will be used to accelerate the movement of amendment to locations where the groundwater has naturally taken uranium since its release and to ensure that the amendment is distributed throughout the impacted areas of the formation. In addition, performance monitoring will be conducted as described in Section 5.2.2.4 to ensure that appropriate distribution of the amendment is achieved. Section 5.2.1.2 describes the establishment and monitoring of initial treatment areas at downgradient, middle, and upgradient locations within the areas of impact with results of monitoring of the initial treatment areas used to refine the CSM and to provide information for design of the full-scale treatment system. This staged approach to the remediation is depicted graphically in Figure 5-1.
9 - The monitoring program and well network is inadequate given the uncertainty associated with re-mobilization of uranium.	Figure 5-2 of the Groundwater Decommissioning Plan shows the proposed monitoring well network and initially selected monitoring locations for the baseline sampling, performance and remedy demonstration completion monitoring of groundwater as described in Section 5.2. The groundwater sampling and monitoring program is summarized on page 3 of Figure 5-1. In addition, Figure 5-2 shows the location of several additional monitoring wells proposed for installation as part of the initial treatment area implementation.
10 - Additional characterization of uranium in the WA Area and Western Upland (WU) areas in groundwater is requested	Figure 3-2 summarizes current uranium groundwater activity information for the WAA and WUA and includes data from an August 2007 sampling event to provide additional characterization of groundwater impacts. Additional information will be collected during the staged implementation and the information collected will be used to refine the CSM. This information will be shared with the NRC at the intervals as depicted on Figure 5-1 which presents the Bioremediation Implementation Process.

Attachment 5
Comparison of the Groundwater Decommissioning Plan to the Deficiencies Noted in NRC's March 27, 2007 Correspondence

Deficiency Number and Concern	How Deficiency is Addressed in Groundwater Decommissioning Plan or Other Cimarron Documents
11 - Additional information is requested for the remediation procedure of the ground-water system in the WU area where the licensee proposes to use infiltration and recovery trenches with treated ground-water to remove uranium from the ground-water.	The proposed approach for the WUA will utilize a series of injection and extraction wells similar to the approach proposed for the other impacted areas at the site as described in Section 5.2 of the Groundwater Decommissioning Plan.
12 - Additional information is requested for the numerical ground-water flow model that ENSR developed to evaluate flow to a receptor trench in the WU area. • The input and output files (electronic files) of the numerical model should be provided with the appropriate documentation via CD or DVD so that the NRC staff can independently verify this model.	As discussed with the NRC on April 20 and April 30, 2007, no numerical (coded) groundwater model was developed for the WUA that is suitable for evaluating the remediation design. Groundwater flow directions, gradients and fluxes were evaluated using water level measurements obtained from wells installed throughout this area. An injection/extraction well approach is now proposed for remediation of this area as described in Section 5.2 of the Groundwater Decommissioning Plan.
13 - Information is requested on how the uranium currently associated with the solids will react when molasses is injected. • If the uranium is presently sorbed to iron oxyhydroxides, conversion of these solid phases to sulfides could release more uranium into the ground-water. Since the geochemical model assumes equilibria, it cannot predict whether the uranium will desorb or precipitate. Therefore, the conceptual models need to consider non-equilibrium conditions and its affect on uranium behavior.	Section 4 of the Groundwater Decommissioning Plan describes in detail the process by which uranium bound to the iron oxides will be released upon reductive dissolution of the iron minerals but then will be immediately reduced and incorporated into the iron sulfide matrix. Section 3.4 discusses the geochemical modeling approach and how the model addresses non-equilibrium conditions.
14 - Provide evidence to support that phases in the future would be more sorptive than those now present is unfounded. • Demonstrate that the aquifer solids will be more sorptive toward uranium after in-situ remediation.	Section 4 of the Groundwater Decommissioning Plan describes in detail the iron and sulfide phases that will form under reducing conditions. Numerous literature sources are referenced in this section and clearly demonstrate that amorphous ferric iron mineral phases are highly sorptive for uranium.
15 - Provide supporting evidence for the "coating" process by which uraninite will be precipitated first, followed by Iron Sulfide (FeS) which would be laid down over the Uranium Oxide as a FeS coating. • Will this process reduce the porosity of the formation?	Section 4 of the Groundwater Decommissioning Plan describes in detail the uranium immobilization process. Numerous literature sources are referenced in this section to support the understanding and documentation of this process. In addition, Section 4.3 includes a discussion of the effects of the immobilization process on the porosity of the formation and includes an estimate of porosity change using the Kozeny-Carmen equation (which relates permeability to porosity, tortuosity and an effective hydraulic pore radius).

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Comparison of the Groundwater Decommissioning Plan to the Deficiencies Noted in NRC's March 27, 2007 Correspondence

Deficiency Number and Concern	How Deficiency is Addressed in Groundwater Decommissioning Plan or Other Cimarron Documents
16 - Residual concentrations of uranium could exceed 180 pCi/L in 155 years after treatment. • Groundwater containing uranium at concentrations above the License Condition 27.b. limit would not be safe for a resident farmer.	The geochemical model has been revised to use site-specific information when available and to avoid use of unrealistic extremes to demonstrate the efficacy of the proposed approach as described in Section 3.4 of the Groundwater Decommissioning Plan.
17 - Characterization of solid phases present needed to justify equilibrium. • Proposed analytical techniques may not provide sufficient definition for minor amounts of certain solid phase minerals.	The proposed soil sampling and analyses to be conducted are described in Sections 5.2.1.1 (baseline sampling), 5.2.2.4 (performance monitoring), and 5.2.3 (remedy completion demonstration testing) of the Groundwater Decommissioning Plan and summarized on page 3 of Figure 5-1. Additional detail on the soil analytical methods is provided in Appendix D to the plan.

Attachment 6

Summary of Efforts to Address Continuing NRC Questions Over the Last 18 Months

Attachment 6
Summary of Efforts to Address Continuing NRC Questions Over the Last 18 Months

Date	Activity
December 11, 2006	Submission of License Amendment Request, including: o Groundwater Remediation Work Plan o Geochemical Modeling Report o Groundwater Flow Model Report
January 2007	Receipt and review of "guidance" from DOE in the form of a PNNL report entitled "Evaluating the Efficacy of Uranium Bioremediation in the Subsurface: Technical Bases and Performance Indicators": o Careful consideration of the report showed that it had limited applicability to Cimarron given the very different nature of the conditions between the Cimarron and Hanford sites, for example: ▪ Depth to groundwater and residual source material in vadose zone: • 20 feet at Cimarron, source areas removed • 100 to ~250 feet at Hanford; entire thickness of vadose zone potentially contaminated with residual uranium source
March 27, 2007	Receipt of Deficiencies Notice and Rejection of LAR from NRC: o 17 "deficiencies" noted; however, ▪ 2 of the deficiencies were merely requests for input/output files from modeling activities conducted to support the LAR. ▪ 1 deficiency is not applicable to the Cimarron site because the deficiency requests discussion of treatment of a residual source in the vadose zone; however, such a residual source of uranium is not present at the site. ▪ 9 of the deficiencies were requests for additional information on the geochemistry process, approach to treatment of the WUA, soil analytical method details, monitoring program details, site geology and uranium impact details, Cimarron QA/QC program, and planned staged approach to remediation. ▪ The remaining 5 deficiencies were requests for additional analyses, including a hydrologic analysis to address potential infiltration and river impacts on groundwater flow and remedial activities, updating of the groundwater flow model to account for transient processes, evaluation of non-equilibrium conditions in the geochemical modeling, and use of site-specific rather than worst-case values in modeling activities.

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Summary of Efforts to Address Continuing NRC Questions Over the Last 18 Months

Date	Activity
April 20, 2007	Full day meeting with NRC, Cimarron, ARCADIS, and ENSR staff at NRC Headquarters: o Meeting objective(s): to discuss License Amendment Request deficiencies and applicability of work performed and described in a PNNL report o Meeting outcome: ▪ The NRC provided more detail on the requested additional information and analyses as summarized above in the listing of deficiencies. ▪ The NRC was concerned with how to demonstrate the longevity of the remedy and suggested that leaching tests (column studies) be conducted on soil samples from the treated areas. ▪ The NRC indicated that they believed that pilot testing was required prior to full-scale implementation so that initial field information could be used to confirm the success of the approach and to provide additional information for refinement of the implementation. ▪ The NRC and the Cimarron team agreed to additional technical discussions on: • Hydrologic assessments and modeling • QA/QC program for the Cimarron site • WUA geology and remediation approach • Geochemical modeling inputs and approach to addressing transient events
April 30, 2007	Seventy-five minute conference call with NRC and ENSR regarding groundwater flow modeling and hydrologic assessment of site: o Call objective(s): Discuss deficiencies 1, 2, 3, and 6 especially as they pertained to the hydrology/hydraulics of the site and to identify action items/path forward to address the deficiencies. o Call outcome: Per discussion with the NRC, the Cimarron team agreed to conduct the following additional analyses to address the deficiencies: ▪ Collect site-specific data on transient processes including installation of a meteorological station and collection of water levels and river stage information. ▪ Evaluate hydrologic processes using analytic or numerical modeling as appropriate.

Attachment 6
Summary of Efforts to Address Continuing NRC Questions Over the Last 18 Months

Date	Activity
	▪ Evaluate the effects of the transient hydrologic conditions on the geochemistry and include pertinent results of the hydrologic study in the geochemical modeling. ▪ Re-evaluate the WUA CSM and approach.
May 23, 2007	Submission of PowerPoint presentation on geochemistry and geochemical modeling to NRC: o Submission objective(s): Provide information on geochemical basis for treatment technology as background for conference call.
May 24, 2007	Two hour conference call with NRC, ARCADIS, ODEQ, and Cimarron staff: o Call objective(s): to provide the NRC with a better understanding of the geochemical process and the geochemical modeling approach. o Call outcome: ▪ NRC requested additional information on uranium concentrations in the vadose zone and potential for leaching to the water table, as well as treatment of the vadose zone. ▪ NRC requested additional information on the linkage of the groundwater model and the geochemical model. ▪ Tronox agreed to preparation of a flow chart for submission to the NRC to illustrate the staged field implementation approach and the modeling adjustments/re-evaluations that will be conducted as additional information is collected during the staged implementation of the remediation process.
April through August 2007	Due to record precipitation in the May to July timeframe, Cimarron identified the opportunity to obtain site-specific data (rather than modeled or predicted information) for use in preparation of the requested hydrologic analysis for the site. Cimarron obtained measurements of depth to water at a number of wells in the BA#1 area during this period in which almost twice the normal precipitation fell. Observations were also made with respect to the river's elevation relative to the site and to note if there were any areas of ponded water (due to overtopping or poor drainage).
August 13, 2007	Submission of draft flow chart with staged remediation approach and deficiencies matrix: o Submission objective(s): Address each of the deficiencies noted in the March 27, 2007 letter from NRC in detail and to provide the agreed-upon flow chart illustrating the staged field implementation approach.

Attachment 6
Summary of Efforts to Address Continuing NRC Questions Over the Last 18 Months

Date	Activity
August 14-23, 2007	Conducted additional groundwater sampling at the Cimarron site: o Sampling objective(s): Obtain additional geochemical and uranium area of impact delineation information for site per NRC request included in deficiency 10 and as discussed at the April 20, 2007 meeting.
September 5, 2007	Conference call with NRC, Cimarron, ARCADIS, LNST, ENSR, ODEQ staff: o Call objective(s): Review Cimarron's responses to the deficiencies identified by the NRC with respect to the December 2006 LAR in order to obtain a clear understanding of any remaining regulatory issues and clear the path forward for work plan completion and the submission of a revised LAR to the NRC. o Call outcome: ▪ Revisions were requested by the NRC to the hydrologic modeling and assessments conducted to further address flooding and recharge events on the vertical flux of water through the vadose zone ▪ Calibration of site models was requested by the NRC using recently obtained site-specific data and discussion of this calibration in the revised LAR. ▪ Cimarron team to prepare 3-D illustrations of site geology, area of impact location and proposed remedial design for submission to NRC. ▪ Cimarron team to provide additional information on design of remedial process including timeframe for reactions, injection frequencies and rates, approach to ensuring that "pushing" of uranium impacts does not occur. ▪ Cimarron team agreed to further discussions with NRC about defining "completion" of remediation from a licensing perspective. ▪ Cimarron team agreed to an additional conference call between NRC and LNST regarding details of QA program for Cimarron. ▪ Cimarron team agreed to an additional conference call to further address potential vadose zone issues.
September 19, 2007	Conference call with NRC (Jacob Philip) and LNST (Barb Lucas): o Call objective(s): Discuss Cimarron's QA System o Call outcome: ▪ It was agreed that the revised LAR will contain a brief

Attachment 6
Summary of Efforts to Address Continuing NRC Questions
Over the Last 18 Months

Date	Activity
	narrative describing the Cimarron site Quality Assurance System (QAS) with supporting "documents", including the table of contents of the QA Manual, a copy of the cross walk table between Cimarron QAS and the various QA System requirements, and DQOs for the activities included in the groundwater decommissioning. ▪ The NRC agreed that each contractor could / should provide its own QAPP with no requirement for a Cimarron QAPP which addresses the entire project in a single document.
November 11, 2007	Additional information submission to the NRC: o Submission objective(s): Information addressing NRC requests submitted in advance for discussion on December 19, 2007, including: ▪ An "excerpt" from the Hydrology Addendum in preparation by ENSR for incorporation into the Revised License Amendment Request that focused on the vadose zone issues NRC raised in the September 5, 2007 call. ▪ A set of figures that illustrate 1) the locations and concentrations of uranium in soils at the Burial Area #1 plume and 2) the lithology of the alluvium and spatial relationship of the underlying sandstone and mudstone, and 3) a comparison between the vadose zone and seasonally-saturated zone uranium concentrations at Hanford and Cimarron. ▪ A proposed agenda for a 'comprehensive" December 19, 2007 conference call. ▪ An updated flow chart that provides better clarity on the overall process of implementing the remediation program and defining when remediation will be complete and how Cimarron would propose to achieve license termination. ▪ A listing of additional data to be included in Cimarron's revised License Amendment Request.
December 19, 2007	Ninety minute conference call with NRC, Cimarron, ARCADIS, LNST, ENSR, ODEQ staff: o Call objective(s): ▪ Cimarron objective: To confirm that all questions have been answered, all issues resolved, all deficiencies addressed. ▪ NRC objective: To discuss the potential vadose zone issues, endpoint/license termination requirements, and methods of demonstrating longevity of the remedy.

Attachment 6
Summary of Efforts to Address Continuing NRC Questions Over the Last 18 Months

Date	Activity
	○ Call outcome: ▪ Discussed that the Hanford and Cimarron vadose zones are not comparable and that there is not a residual source of uranium in the Cimarron vadose zone. The amount of uranium leaching from the capillary/vadose zone at Cimarron will be minimal, but has been accounted for in the geochemical model. ▪ Discussed the results of the Hydrology Addendum prepared by ENSR and how the results have been incorporated into the remedial plan. ▪ Discussed the 3-D depictions of the geology at the site and how the proposed remedial design will address the different hydrogeologic zones. ▪ Presented a summary of the proposed oxidative aging testing procedure to be used to demonstrate that adequate mineralogy is in place and will have the required permanence. ▪ Presented a summary of the proposed statistical evaluation of groundwater monitoring results to demonstrate achievement of the remedial objectives. ▪ Discussed the requirements for license termination and data to be provided to the NRC to demonstrate success and longevity of the remedy.
January 7, 2008	NRC Call to ARCADIS (Cimarron team member): ○ Call objective(s): ▪ Seeking information on potential conflict of interest with the role of PNNL going forward. ▪ Advising of the NRC's interest to have a follow-up call to the call of December 19, 2007 – for more information transfer. ○ Call outcome: ▪ PNNL will not serve as a subcontractor to ARCADIS on the ART project at the Hanford site to avoid any potential conflicts of interest. ▪ Based on the additional analyses conducted, information provided to NRC, and conference calls to date, Cimarron believes that all of the NRC's deficiencies have been addressed and that the Groundwater Decommissioning Plan submission provides all of the information needed by the NRC to evaluate the bioremediation plan for the

Attachment 6
Summary of Efforts to Address Continuing NRC Questions Over the Last 18 Months

Date	Activity
	Cimarron site and therefore further conference calls are not needed.
January 9, 2008	Submit minutes of December 19, 2007 conference call to the NRC: o Submission objective(s): To identify areas of concurrence from the December 19, 2007 conference call and to establish NRC support for the proposed bioremediation Groundwater Decommissioning Plan in order to optimize the chances that the revised LAR would be accepted after more than a year of addressing NRC questions and concerns. o NRC response: The NRC did not provide a response to the conference call summary submittal.

Attachment 7

Technical Memorandum
"ALARA Calculation for Cimarron Groundwater"

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Technical Memorandum

May 27, 2008

To: Jeff Lux

From: Harry J. Newman, CHP H J Newman 5/27/2008

Subject: ALARA Calculations for Cimarron Groundwater

Introduction

Cimarron Corporation (Cimarron) is evaluating methods for groundwater remediation at its Crescent, Oklahoma site and has requested an evaluation of the hypothetical dose which would be avoided if groundwater containing total uranium above 180 pCi/L total uranium were remediated to an activity concentration below 180 pCi/L. The 180 pCi/L concentration level for total uranium in groundwater is the remediation criterion approved by NRC in license condition 27(c). Groundwater at the Cimarron site exceeds this criterion in three areas; the most elevated concentrations are found downgradient from Burial Area #1 (BA #1) in the northeastern portion of the site. All other source terms have been remediated, thus, there are no soil sources to impact groundwater except those associated with soil/water partitioning.

This memorandum discusses the ALARA[1] considerations and presents analysis of the hypothetical dose to individuals from the installation of a well in the most highly impacted groundwater at the Cimarron facility. The calculated dose is hypothetical because:

1. There are no potential receptors living onsite using groundwater.
2. The most severely impacted groundwater is within the Cimarron River floodplain, and is periodically inundated, making use of a well in this area unfeasible over time.
3. Current land management prohibits the use of groundwater at the site.
4. A potable public water supply is available on the site.

[1] ALARA means "As Low As is Reasonably Achievable" which is an approach used for radiation protection to manage and control exposures (both individual and collective to the work force and to the general public) and releases of radioactive material to the environment so that the levels are as low as is reasonable taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit, but rather a process which has the objective of attaining doses as far below the applicable limit of this part as is reasonably achievable.

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Methods/Discussion

The ALARA calculations utilize a proprietary groundwater pathways dose model developed by Lucas Newman Science and Technologies, Inc. (LNST). The dose model has been utilized at several NRC-licensed sites, and its results have been accepted by NRC. The LNST dose model includes capabilities for input of probabilistic parameter distributions, and determines dose from all credible pathways. The model assumes no soil source term except as associated with soil/water partitioning, and calculates dose not only from drinking water ingestion, but also from consumption of crops, milk, soil (incidental), and cattle, as well as inhalation of re-suspended soil impacted via by irrigation.

The ALARA calculation required the projection of total uranium concentration over time, since continuous extraction of water from the most highly impacted areas will result in declining concentrations over time. A well pumping model[2] was developed by ENSR International, Inc. (ENSR) based upon the numerical hydrogeological model created for BA #1 at the Cimarron site. Appendix 1 provides the analysis which yielded concentration of total uranium versus time when pumping from the most highly impacted area within the plume.

The graph in Appendix 2 presents total uranium concentration versus time while pumping, and displays the exponential equation describing the declining radioactivity concentration in the hypothetical well. Appendix 2 also provides calculations of the hypothetical dose rate at the beginning of each year based upon the total uranium concentration being withdrawn from well at the beginning of the year. An initial (time zero) total uranium concentration of 3,000 pCi/L was utilized. Calculations yielded a corresponding initial dose rate of 303 mrem/yr[3]. Because the uranium concentration begins to decline immediately upon pumping, the dose rate also begins to decline immediately. Solving the following integral yields the cumulative hypothetical dose over any time period immediately following initial pumping from the well.

$$\text{Cumulative hypothetical dose (mrem)} = 303 \int e^{-0.6037t}\, dt$$

Note that the concentration of uranium declines at such a rate that by year five groundwater concentrations are below the groundwater release criterion. Consequently, dose incurred following this point would is not assumed to contribute to the hypothetical dose avoided through remediation. The integral dose avoided is calculated as 477 mrem to the individual. For a family of four persons living onsite and using the groundwater from a well installed in the most

[2] Email from M. Meenan, ENSR to H. Newman, Lucas Newman Science and Technologies, Inc., dated 3/21/2008. The well pumping model assumptions are provided in Appendix 1.

[3] The calculations referred to are company privileged and proprietary information and can be submitted under separate cover in accordance with the provisions of 10 CFR 2.390 if requested.

highly impacted area, the total hypothetical dose avoided would be less than 2 rem.

The resident farmer scenario for exposure is a hypothetical scenario at the Cimarron site; there are no current public exposure routes. It should be evident that calculated dose to the residential farmer family from the installation of a well within the most highly impacted area at the facility is also hypothetical. Since no dose is being received, no dose would be avoided by reducing groundwater to less than the stipulated criteria. Therefore, using this measure, the current cost per person-rem avoided is infinite.

The accepted measure used for comparison of whether actions taken may be considered ALARA is $1,000 to $2,000 per person-rem avoided[4]. If a residential farmer family were to reside under the worst case conditions cited above, it appears that the cost could be on the order of millions of dollars per person-rem avoided. The cost to avoid dose will continue to increase as the commencement of remediation is delayed, since natural attenuation of the plume will continue to reduce the maximum concentration of uranium in groundwater over time.

Conclusion

An evaluation was performed to determine the order of magnitude costs associated with reduction of dose due to a hypothetical well installed and used under the residential farmer scenario at the Cimarron site. Because there is no actual exposure at this time, the actual dose avoided is zero and the cost per person-rem avoided is infinite. Under the hypothetical resident farmer scenario, the cost to reduce exposure would appear to approach the level of millions of dollars per person-rem avoided. These costs would exceed the established criteria ($1,000 to $2,000 per person-rem) by many orders of magnitude.

[4] The statement over-simplifies the ALARA concept. Further information may be located at: http://www.nrc.gov/reading-rm/doc-collections/insp-manual/inspection-procedure/ip69004.pdf

APPENDIX 1

The following equation has been derived to calculate the uranium concentration in groundwater pumped out from a well at any time:

$$C_w = C_w^o \left(\frac{Kd \cdot \rho_b}{Kd \cdot \rho_b + \theta} \right)^{\left| \frac{70268 \cdot Q \cdot t}{A \cdot D \cdot \theta} \right|}$$

Where:

C_w = uranium concentration from pumping well at time t (pCi/L)			
C_w^o = initial uranium concentration in groundwater (pCi/L)	3000		
Kd = uranium distribution coefficient (L/kg)	3	(use 0.6 for sand, 2 for silt, and 3 for silty clay)	
ρ_b = soil bulk density (kg/L)	1.68		
θ = aquifer porosity	0.3		
Q = pumping rate (gpm)	1.835095	see comm	9.65E+05 gal per yr discuss w/ ENSR- what rate is sustainable in BA #1 plume? Can the river be used for irrigation? Is this a more reasonable assumption?
t = pumping duration (year)	variable (w)		River water cannot be used for irrigation due to high salt content.
A = plume area within the radius of influence of the pumping well (ft^2))	2826	get appropriate value from ENSR	(Typical radius values are 30 ft for sandy alluvium and 15 ft for transition zone)
D = thickness of aquifer (feet)	15	discuss w/ ENSR	

Assumptions:

1. Uniform and homogeneous aquifer matrix;
2. Slug flow in uranium transport
3. Instantaneous equilibrium between solid and water;
4. Pumping well in the center of plume;
5. No infiltration from unsaturated zone.
6. No influx of uranium from area outside the radius of influence.

7. Pumping rate (Q) is assumed constant and is based on:

Irrigation Rate (L/m^2/d)	1	2642.01 gpd	1.83 gpm
DW intake rate (l/d)	2	0.53 gpd	0.00 gpm
			1.84 gpm

An equation that includes an infiltration term could be derived; however, the equation became very complicated and difficult to solve. Most importantly, the infiltration term does not change the result from the above equation by more than one percent. As a result, the infiltration term is not included in the above equation.

APPENDIX 2

w (year)		Initial Conc. (pCi/L)	dose rate (mrem/y) at beginning of	Integral dose (mrem), year w	fraction
0	Cw =	3000	3.03E+02	2.27E+02	4.53E-01
1	Cw =	1640.28774	1.66E+02	3.52E+02	7.01E-01
2	Cw =	896.847952	9.06E+01	4.20E+02	8.37E-01
3	Cw =	490.362899	4.95E+01	4.57E+02	9.11E-01
4	Cw =	268.112083	2.71E+01	4.77E+02	9.51E-01
5	Cw =	146.593654	1.48E+01	4.86E+02	9.73E-01
6	Cw =	80.1519243	8.10E+00	4.95E+02	9.85E-01
7	Cw =	43.8240728	4.43E+00	4.98E+02	9.92E-01
8	Cw =	23.9613631	2.42E+00	5.00E+02	9.96E-01
9	Cw =	13.1011767	1.32E+00	5.01E+02	9.96E-01
10	Cw =	7.16323314	7.23E-01	5.01E+02	9.99E-01
11	Cw =	3.91658782	3.96E-01	5.02E+02	9.99E-01
12	Cw =	2.14144366	2.16E-01	5.02E+02	1.00E+00
13	Cw =	1.17086126	1.18E-01	5.02E+02	1.00E+00
14	Cw =	0.64016312	6.47E-02	5.02E+02	1.00E+00
15	Cw =	0.35002817	3.54E-02	5.02E+02	1.00E+00
16	Cw =	0.19138231	1.93E-02	5.02E+02	1.00E+00
17	Cw =	0.10464068	1.06E-02	5.02E+02	1.00E+00
18	Cw =	0.05721361	5.78E-03	5.02E+02	1.00E+00
19	Cw =	0.03128226	3.16E-03	5.02E+02	1.00E+00
20	Cw =	0.01710397	1.73E-03	5.02E+02	1.00E+00
25	Cw =	0.00083578	8.44E-05	5.02E+02	1.00E+00
30	Cw =	4.084E-05	4.12E-06	5.02E+02	1.00E+00
35	Cw =	1.9956E-06	2.02E-07	5.02E+02	1.00E+00
40	Cw =	9.7515E-08	9.85E-09	5.02E+02	1.00E+00
45	Cw =	4.765E-09	4.81E-10	5.02E+02	1.00E+00
50	Cw =	2.3284E-10	2.35E-11	5.02E+02	1.00E+00
55	Cw =	1.1378E-11	1.15E-12	5.02E+02	1.00E+00
60	Cw =	5.5597E-13	5.62E-14	5.02E+02	1.00E+00
65	Cw =	2.7167E-14	2.74E-15	5.02E+02	1.00E+00
70	Cw =	1.3275E-15	1.34E-16	5.02E+02	1.00E+00