U.S. Department of Energy
Grand Junction Office
2597 B¾ Road
Grand Junction, CO 81503

SEP 29 1999

John J. Surmeier, Chief
Uranium Recovery Branch
U.S. Nuclear Regulatory Commission
Division of Waste Management
Office of Nuclear Material Safety and Safeguards
Mail Stop T7J9
Washington, D.C. 20555

Subject: Transmittal of the Ground Water Compliance Action Plan for the New Rifle Site

Dear Mr. Surmeier:

Enclosed are three copies of the Ground Water Compliance Action Plan (GCAP) for the New Rifle, Colorado, UMTRA Project Site (September 1999). This GCAP serves as a stand-alone modification to *Section E.3.6 of the Final Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Sites at Rifle, Colorado* (DOE, 1992), and is a NRC concurrence document for compliance with Subpart B of 40 CFR 192 for the New Rifle Site.

The DOE has determined that natural flushing of the alluvial aquifer, in conjunction with the establishment of Alternate Concentration Limits and institutional controls, is the appropriate compliance strategy for remediation of all contaminants at the New Rifle Site, except vanadium. The DOE will conduct a laboratory and pilot study in FY 2000 that will collect data required to be able to determine the feasibility of implementing an active treatment process to enhance the effectiveness of natural flushing for vanadium remediation.

The GCAP is being transmitted to the State of Colorado, concurrent with this transmittal. The DOE will involve the State of Colorado in designing and implementing the vanadium pilot test, due to the requirements in the Ground Water Cooperative Agreement that identify cost-sharing provisions for implementing an active compliance strategy. The "pilot study" is not a cost-shared activity; however, the outcome of the study may lead to a cost-shared activity.

The DOE is currently in the process of completing the required National Environmental Policy Act requirements. An Environmental Assessment is under development at this time.

This concurrence document is listed as priority-10 on the NRC/DOE-GJO document review log. The log has a forecast NRC completion date of April 2000. Supporting technical data resides in the *Final Site Observational Work Plan (SOWP) for the Uranium Mill Tailings Remedial Action Project New Rifle Site* (September 1999) and the *Calculations Document* referenced in the final SOWP (September 1999). These documents have been previously transmitted to your office.

If you have any questions, please call me at 970/248-7612.

Sincerely,

Donald R. Metzler
Technical/Project Manager

Enclosures

cc w/enclosure:
S. Myers, Rifle City Manager

cc w/o enclosure:
C. Abrams, NRC
D. Gillen, NRC
M. Layton, NRC
W. Naugle, CDPHE/Denver
W. Von Till, NRC
S. Marutzky, MACTEC-ERS
Project File GWRFL1.9 (P. Taylor)

drm\nrflgc-1.doc

GJO–99–111–TAR

UMTRA GROUND WATER PROJECT

Ground Water Compliance Action Plan for the New Rifle, Colorado, UMTRA Project Site

September 1999

Prepared by the

U.S. Department of Energy
Grand Junction Office

Ground Water Compliance Action Plan for the New Rifle, Colorado, UMTRA Project Site

September 1999

Prepared by
U.S. Department of Energy
Grand Junction Office
Grand Junction, Colorado

Project Number UGW–511–0017–13–000
Document Number U0068900

Work Performed under DOE Contract No. DE–AC13–96GJ87335

Contents

Figures

Tables

1.0 Introduction

This Ground Water Compliance Action Plan (GCAP) will serve as a stand-alone modification to Section E.3.6 of the *Final Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Sites at Rifle, Colorado* (DOE 1992) and is the concurrence document for compliance with Subpart B of 40 CFR 192 for the New Rifle site.

The proposed compliance strategy for the New Rifle site is based on the "compliance strategy selection framework" following the steps prescribed in Section 2.1 of the *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS) (DOE 1996b) (Figure 1). The proposed action is based on information presented in the *Final Site Observational Work Plan for the UMTRA Project New Rifle Site* (SOWP) (DOE 1999).

2.0 Ground Water Compliance

The U. S. Department of Energy (DOE) is required by the PEIS to follow the ground water compliance strategy selection framework summarized in Figure 1 in selecting the appropriate compliance strategy to clean up ground water in the alluvial (uppermost) aquifer affected by former processing activities at the New Rifle site. The deeper Wasatch Formation is not contaminated at the New Rifle site and is therefore not considered in the development of a compliance strategy.

DOE has determined that natural flushing of the alluvial aquifer, in conjunction with the establishment of ACLs and institutional controls, is the appropriate compliance strategy for remediation of all contaminants at the New Rifle site, except vanadium. Additional data collection is required before an appropriate strategy can be implemented for vanadium. The compliance strategy focuses on contaminants of concern (COC) retained after completion of the updated human health and ecological risk assessment screening processes (DOE 1999). This proposed action has been determined by applying the compliance strategy selection framework from the PEIS, consisting of several evaluative steps discussed below. An explanation of how the targeted strategy was selected is summarized in Table 1.

2.1 Assessment of Environmental Data

The first step in the decision process was an assessment of both historical and new environmental data collected to characterize hydrogeological conditions and the extent of ground water contamination related to uranium processing activities at the site. The New Rifle site is located along a broad section of Colorado River floodplain alluvium consisting of a complex interfingering of fine and coarse-grain materials, which contain sand, silt, gravel, and cobbles. The thickness of the alluvial deposits at the New Rifle site ranges from 20 to 30 feet over most of the site. Up to 100 feet of alluvium is present down gradient from the site where it fills local valleys. Depths to ground water range from approximately 5 to 10 feet at the site. The greatest depth to water is 90 feet approximately 1½ miles down gradient from the site. Saturated thicknesses generally range from 10 to 20 ft in the vicinity of the site.

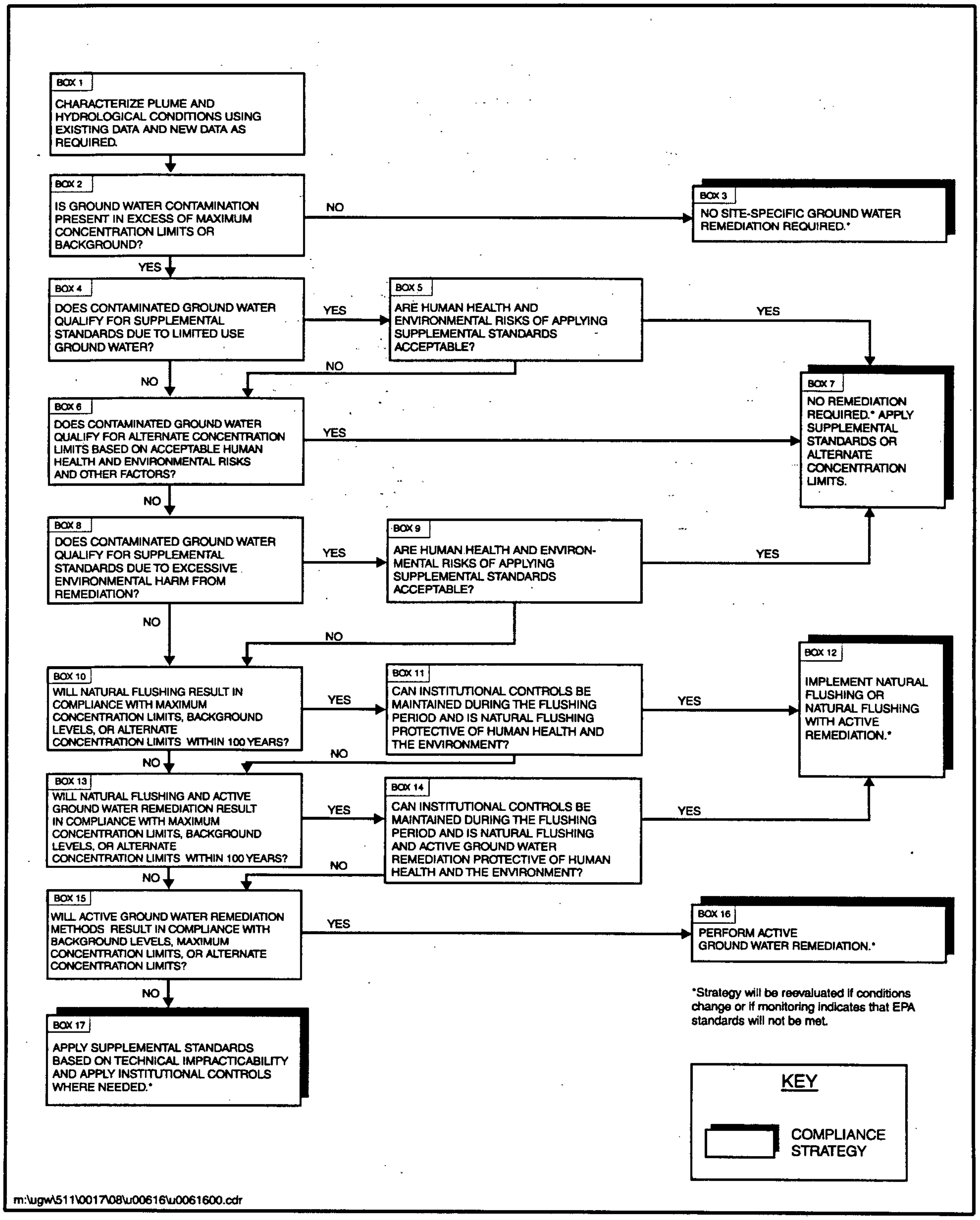


Figure 1. Compliance Selection Framework for the New Rifle Site

Recharge to the alluvial aquifer occurs mostly as infiltration of precipitation, leakage from the unnamed intermittent tributaries and Pioneer Ditch located north of U.S. Highway 6, and by the Colorado River, especially along the north-south reach of the river east of the site which appears to be a ground-water recharge source throughout the year. Discharge from the alluvial aquifer is to the mitigation wetland, to the Roaring Fork gravel pits, and to the Colorado River. Plant evapotranspiration in areas of shallow groundwater is the only other process by which ground water may be discharged from the alluvial aquifer. Ground water beneath the site generally flows in a west-southwest direction with a hydraulic gradient ranging from 0.0019 to 0.0040 ft/ft. The conceptual site model is presented in Section 5.0 of the SOWP (DOE 1999).

Table 1. Explanation of Compliance Strategy Selection Process

Box (Figure 1)	Action or Question	Result or Decision
1	Characterize plume and hydrological conditions.	See conceptual site model presented in Section 5.0 and contaminant screening presented in Section 6.0 of the New Rifle SOWP. Move to Box 2.
2	Is ground water contamination present in excess of UMTRA MCLs or background?	Selenium, arsenic, molybdenum, nitrate and uranium exceed the UMTRA MCLs at one or more monitoring points. Ammonium, fluoride, manganese, and vanadium are elevated compared to background and exceed RBCs. Move to Box 4.
4	Does contaminated ground water qualify for supplemental standards due to limited use ground water?	Alluvial ground water is a potential source of drinking water and therefore is not classified as limited use. Move to Box 6.
6	Does contaminated ground water qualify for ACLs based on acceptable human health and environmental risk and other factors?	Concentrations are above proposed ACLs at this time. Move to Box 8.
8	Does contaminated ground water qualify for supplemental standards due to excessive environmental harm from remediation?	Although the applicability has not been formally assessed, it is unlikely that remedial action would cause excessive harm to the environment. Move to Box 10.
10	Will natural flushing result in compliance with UMTRA MCLs, background, or ACLs within 100 years?	Ground water modeling shows that natural flushing will reduce all constituents except vanadium to background, ACLs or MCLs within the 100-year time frame. Data for vanadium are insufficient to evaluate vanadium behavior. Move to Box 11.
11	Can institutional controls be maintained during the flushing period and is the compliance strategy protective of human health and the environment?	The final compliance strategy is protective of human health and the environment. Institutional controls will be in place soon and will prevent use of water. Ground water can be used without restriction after 100 years and will be protective of human health and the environment at that time. Move to Box 12 – implement natural flushing.
12		Implement natural flushing.

2.2 Ground Water Contaminants

The second step compares the COCs in ground water with maximum concentration limits (MCLs), other existing water standards, or background levels. Ground water beneath the New Rifle site was contaminated by former vanadium and uranium ore-processing operations that were ongoing from 1958 through 1972, from lignite ash processing from 1964 to 1967, and from vanadium processing (which did not produce tailings) from 1973 to 1984. Site-specific field investigations revealed that the alluvial ground water is the only aquifer affected by the former milling operations.

COCs in the alluvial aquifer are identified as ammonia, arsenic, fluoride, manganese, molybdenum, nitrate, selenium, uranium, and vanadium.

Uranium contamination extends over the greatest area in the alluvial ground water. The extent of contamination is shown in Figure 2. Uranium concentration has migrated a significant distance off-site and the Roaring Fork gravel ponds separate two distinct plumes. The highest uranium concentration of 0.40 mg/L, which is over nine times the Uranium Mill Tailings Remedial Action (UMTRA) ground water standard of 0.044 mg/L, is located at location RFN–655, in the east plume near the northern boundary of the former tailing area. The increased ground water flow velocities created by the dewatering activities at the Roaring Fork gravel pond are enhancing natural flushing of uranium in this area. The highest concentration in the west plume is 0.227 mg/L at monitoring well RFN–596.

As with uranium, nitrate contamination has migrated offsite in a southwest-west direction, with two distinct plumes separated by the Roaring Fork gravel ponds, with evident enhancement of natural flushing by the activities at the gravel pond. The highest nitrate concentration in the east plume is 635 mg/L, over fourteen times the UMTRA ground water standard of 44 mg/L, which is located at RFN–589, between the Roaring Fork dewatering pond and the west end of the mitigation wetland. The highest concentration in the west plume is 377 mg/L at monitor well RFN–195.

The highest levels of molybdenum contamination, ranging between 3.6 and 6.4 mg/L, are located beneath the former tailings area (RFN–218, –219, –659) and the former gypsum-vanadium evaporation ponds (RFN–658). These values exceed the UMTRA ground water standard of 0.1 mg/L molybdenum. The plume extends offsite in a southwest-west direction as far downgradient as the Roaring Fork gravel operation. The most downgradient extent of the molybdenum plume is at monitor well RFN–195, located just west of the Roaring Fork holding pond.

The distribution of selenium contamination exceeding the 0.05 mg/L Safe Water Drinking Act (SWDA) standard, which is the proposed ACL for New Rifle, is generally confined to the site. An ACL is proposed because natural background concentrations exceed the UMTRA standard of 0.01 mg/L. The highest selenium concentration of 0.78 mg/L was detected at monitor well RFN–658, which is located, near the center of the former gypsum-vanadium evaporation pond.

No ground water standards have been established for vanadium. The human health risk-based concentration for vanadium of 0.33 mg/L was adopted as an ACL for the New Rifle site. Elevated vanadium concentrations are generally confined to the site, with a "hot spot" localized in and adjacent to the former tailings pile footprint, although an area in the mitigation wetland southwest of the site also exceeds the ACL. The highest vanadium concentration of 25.3 mg/L (August 1998 sampling) was detected at monitor well RFN–658, near the former vanadium-gypsum evaporation pond. (This is the same well where the highest concentrations of arsenic and selenium were detected). This monitor well was installed in 1996 near the locations of the historical on-site wells RFN–593 and –594, which were removed during surface remediation. The historical wells showed a continuous decrease in vanadium concentrations, from 20 mg/L in

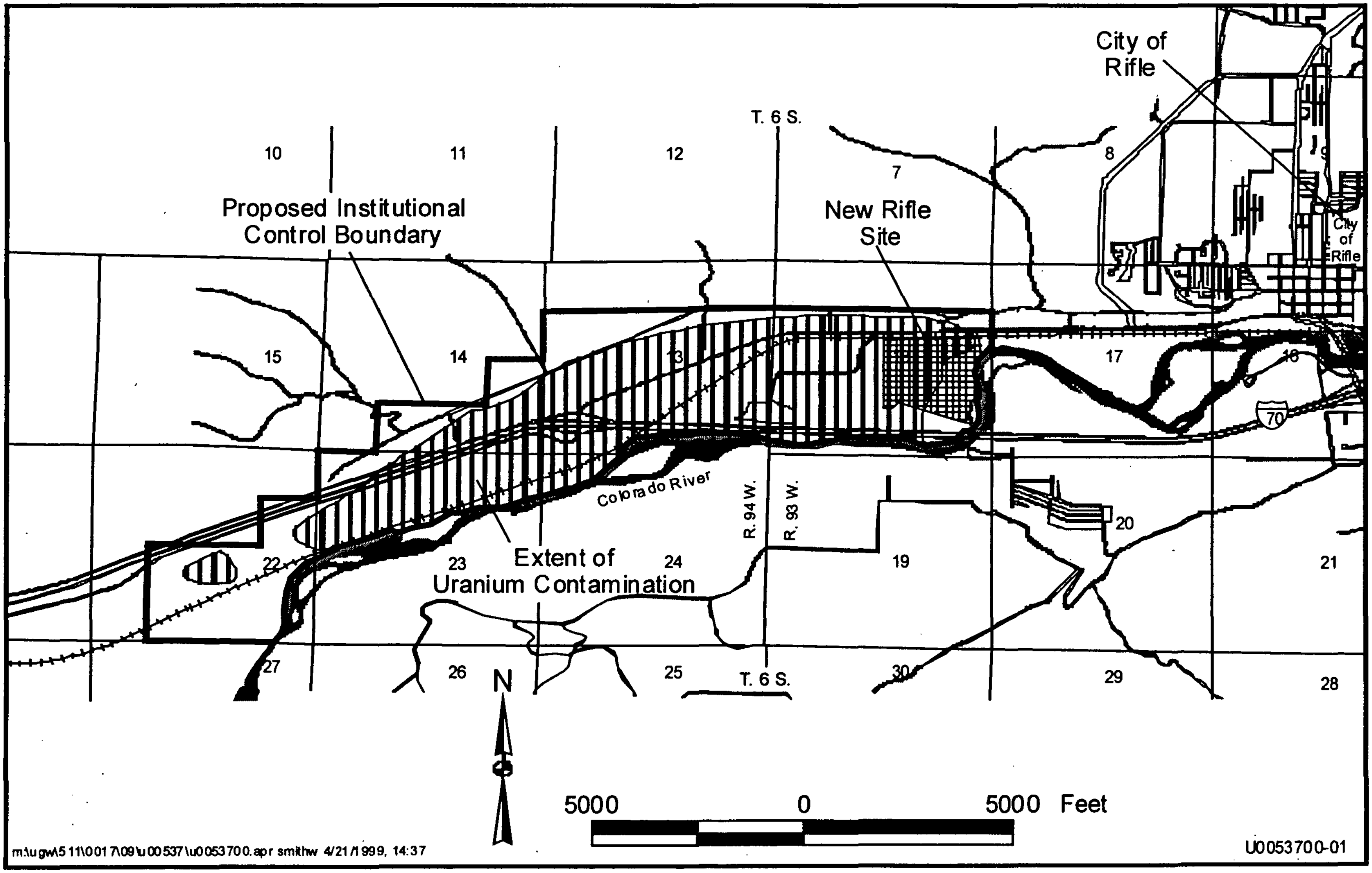


Figure 2. Extent of Contamination and Proposed Institutional Control Boundary at the New Rifle Site

1985 to 0.73 mg/L in 1992, when they were removed. The vanadium concentration at RFN–658, a stainless steel well point that was installed using a backhoe, was 44 mg/L in November 1996, and has since declined steadily to 12.9 mg/L in January 1999. The high initial concentration at this monitor well suggests that a more recent plume may have been mobilized during surface remediation.

The highest ammonia concentrations appear to originate near the center of the former gypsum-vanadium evaporation pond, and extend in a southwesterly direction through the western portion of the mitigation wetland. As of the August 1998 sampling, concentrations exceeding the 200 mg/L risk-based concentration for human health were observed at 10 sampling locations. The highest ammonia concentration of 669 mg/L is located at monitor well RFN–590, which is centered near the west end of the mitigation wetland, approximately 2,100 feet downgradient from the former source area. Elevated concentrations extend west of the mitigation wetland boundary to the Roaring Fork gravel operation.

Arsenic concentrations at most wells are below the detection limit of 0.001 mg/L, and exceed the UMTRA ground water standard of 0.05 mg/L at only two locations, RFN–658 and –659, along the eastern edge and at the southwest corner of the former tailings pile footprint. The highest concentration of 0.304 mg/L was observed at RFN–658.

Fluoride concentrations in the plume exceed the SDWA level of 4 mg/L at six sampling points, with a maximum concentration of 6.11 mg/L at RFN–636. Manganese concentrations exceed the proposed ACL of 4 mg/L (based on the average background concentration of 3.8 mg/L) at only three sampling locations, with concentrations of 7.77, 7.21, and 5.77 mg/L at RFN–590, –636, and –635, respectively.

2.3 Applicability of Natural Flushing

The third step determines whether natural flushing alone will result in compliance with MCLs, background levels, or ACLs within 100 years. Results of ground water contaminant transport modeling using the USGS MODFLOW software package (McDonald and Harbaugh 1988) and the MT3D transport code (Zheng 1990) are presented in Section 5.0 and Appendix D of the SOWP (DOE 1999). These codes are fully described in the references cited and have been verified, benchmarked, and approved for use by most government and regulatory agencies. Predicted concentrations for arsenic, molybdenum, nitrate, selenium, uranium, and vanadium after 100 years of natural flushing are summarized here.

2.3.1 Ground Water Modeling Predictions

Molybdenum is predicted to decrease to levels below the UMTRA standard of 0.1 mg/L after a period of about 25 years. The background concentration used for the modeling was 0.019 mg/L, and none of the background wells exceeded the MCL.

Uranium is predicted to decrease to levels below the UMTRA standard after a period of about 40 years. A background concentration of 0.038 mg/L uranium, the average calculated background uranium concentration, was used for purposes of ground water modeling. Levels of uranium in excess of 0.06 mg/L have been observed in some background monitor wells. Therefore, the compliance standard for uranium in site ground water may be either background or the UMTRA standard of 0.044 mg/L. The monitoring strategy is designed to account for variations in background uranium that may exceed the UMTRA standard.

Based on modeling results, maximum selenium concentrations are predicted to decrease to 0.05 mg/L, approximately the SWDA standard and proposed site ACL, in about 100 years. Background wells had concentrations of selenium nearly twice the UMTRA standard of 0.01 mg/L, based on results from the most recent sampling round. However, these concentrations are all below the risk-based level of 0.18 mg/L, so they have been determined to be protective of human health and the environment.

Modeling results for arsenic, using the most recent sampling data, suggest that reducing arsenic concentrations to the UMTRA standard of 0.05 mg/L by natural flushing can occur as early as 20 years. These modeling results are consistent with decreases in arsenic concentrations observed to date.

Nitrate is predicted to decrease to levels below the UMTRA standard of 44 mg/L after 10 years of natural flushing. Modeling did not take into account geochemical and biological reactions that could affect nitrate behavior. However, a conservative modeling approach was used and it is anticipated that nitrate will be below the UMTRA standard easily within the 100-year natural flushing period.

A concentration of 0.33 mg/L is proposed as an ACL for vanadium. This is the human health risk-based concentration for use of water in a residential setting. Modeling predictions indicate that lowering concentrations of vanadium to the proposed ACL of 0.33 mg/L will require about 300 years of natural flushing. At the end of the statutory limit of 100 years of natural flushing, modeling predictions indicate that the vanadium concentration will have decreased only to 4.37 mg/L, over ten times higher than the ACL.

Modeling was not performed for ammonia, fluoride, and manganese, as no UMTRA standards exist for these contaminants. However, based on historical trends and geochemical similarity to other constituents, it is likely that these constituents will reach background levels or other applicable standards within the 100-year natural flushing time frame. Monitoring will be conducted for these constituents to ensure that contaminant trends are consistent with this assumption and that acceptable levels can be reached.

2.3.2 Vanadium

As noted above, modeling predictions indicate that lowering concentrations of vanadium to the 0.33 mg/L RBC (the proposed ACL) will require about 300 years of natural flushing. However, these results are not consistent with recently observed decreases in vanadium from approximately 25 mg/L in August 1998 to 12 mg/L in January 1999 at well RFN–658. Historically, plume values for vanadium were less than 2 mg/L; the observed high values were not observed until surface remediation activities were conducted.

Because of the uncertainty surrounding the behavior of vanadium, it is proposed that a pilot study be conducted to further investigate the nature of vanadium contamination and to monitor its behavior over time. Preliminary data indicate that active remediation would be required to reduce concentrations to the ACL, but data are insufficient at this time to select that option as the appropriate compliance strategy (particularly because no UMTRA standard exists for vanadium).

Upon completion of the pilot study, the selected option for vanadium will be one of the following: 1) natural flushing, 2) in-situ stabilization, 3) pump and treat, 4) soil removal, or 5) reactive barrier. The last two are considered unpromising at this time. The large quantity of soil that is expected to require removal would make soil removal economically unfeasible. However, additional site characterization will improve the estimate of the quantity of contaminated soil, and it is possible that the volume of contaminated soil will prove to be much lower than is currently believed. In this case, the economics of soil removal will be reevaluated.

Reactive barriers, or PeRT (Permeable Reactive Treatment) walls, use a bed of zero-valent iron (ZVI) to remove radionuclides and heavy metals from contaminated water. (The chemistry of ZVI is discussed in Section 3.1.1.) The problems with implementing a PeRT wall at New Rifle are twofold. First, the low mobility of vanadium, as indicated by the MT3D modeling, will also keep it from coming into contact with the PeRT wall in a reasonable time. Second, if the vanadium can be mobilized into the aqueous phase, the chemical addition necessary to induce this mobilization will also greatly reduce the effectiveness of the PeRT wall. Use of an ex situ ZVI reactor will make it possible for the mobilization-enhancement chemicals to be neutralized before the water comes into contact with the ZVI, but this is not possible with an in situ barrier. The data collected in the ZVI laboratory study described in Section 3.1.1 will apply to PeRT walls as well as to ex situ reactors, but at this time implementation of a PeRT wall at New Rifle appears unlikely.

Details of the pilot study are provided in Section 3.0.

2.4 Human Health and Environmental Risks

The fourth step considers whether institutional controls can be maintained during the flushing period and if natural flushing is protective of human health and the environment.

An Institutional Control Program is being developed to prevent the future use of the potentially harmful contaminated ground water associated with the New Rifle site during the 100-year natural flushing period. The institutional control mechanisms will include the use of both zone district changes and deed restrictions. In 1996 DOE extended the city water line west to just beyond the eastern site boundary. This line may be further extended as part of this remedial action. The proposed institutional control boundary is shown in Figure 2.

- The zone district changes will prohibit the use of the untreated contaminated shallow ground water for drinking purposes for humans. The zone changes will apply to the entire contaminated area plus a buffer area. Efforts are ongoing with the City of Rifle and Garfield County to initiate the zone district changes. It is anticipated that the zone changes will be effective by spring 2000.

- Ground water contaminant concentrations are increased and additional contaminants occur in the ground water beneath the New Rifle site and the UMETCO, Inc. property, located immediately to the west of the New Rifle site. Therefore, more stringent groundwater use restrictions will be placed on these properties to prohibit the use of the untreated contaminated ground water for drinking water, live stock watering, irrigation of edible vegetation, and for ornamental or landscaping purposes. However, the current sand and gravel mining activities at the UMETCO property will not be affected by the deed restriction. In order that a deed restriction is legal and enforceable, it must be initiated at the time of a land ownership transfer. Efforts are underway to establish deed restrictions at these two properties. It is anticipated that both deed restrictions will be in place by spring 2000.

The New Rifle site Institutional Controls Program, once finalized, will be effective and legally enforceable over the 100-year natural flushing period. If contaminants flush more quickly than predicted, restrictions on ground water use may be lifted sooner on a location by location basis.

An evaluation of present-day conditions associated with the area of groundwater contamination at the New Rifle site indicates that no risks currently exist for human receptors. No pathways are present at this time for use of untreated site-related ground water. Wells for the human consumption of ground water have been installed into the alluvial aquifer; however, the wells are required to have treatment systems to ensure that the ground water is safe for drinking. Potential future risks are based on current levels of contamination. These associated risks will decline with time along with the contaminant concentrations on which they are based.

Ecological risks reported for the New Rifle wetland and the Roaring Fork pond represent a combination of possible present risks and potential future risks. Present ecological risks include those where pathways and receptors currently exist (e.g., ingestion of surface water from the Roaring Fork pond by mule deer and muskrats). Future risks are those that could be present if and when the New Rifle wetland and Roaring Fork pond develop into more viable habitats.

It must be kept in mind that few of the risks discussed here represent threats to existing healthy populations. No evidence has been observed to date that indicates site-related contamination has resulted in environmental degradation. In the case of the Roaring Fork pond, the risk is associated with an ongoing gravel mining operation that is likely to continue for an estimated 10 to 20 years. The disturbed conditions created by the operation are likely to prevent any near-term development of the Roaring Fork pond into an important habitat for wildlife and to discourage its use as a significant food or water source for ecological receptors. After gravel mining operations cease and habitat development is more likely, ecological risks will probably have decreased to fairly insignificant levels as natural flushing continues to cause declining contaminant levels.

A large portion of the New Rifle wetland is in the process of being reconstructed. Site-related contamination will probably limit the types of vegetation that can initially thrive in that location. Undoubtedly the same limitations will affect aquatic organisms as well. However, as contamination decreases through time, the New Rifle wetland can be expected to become more diverse and support a greater variety of plant and animal species. Thus, site-related contamination more probably represents a short-term hindrance to wetland reconstruction than a threat to existing viable populations. Risks associated with the already established portion of the New Rifle wetland are generally low, especially in terms of probable population effects.

Development of a compliance strategy for the site must account for current risks and for potential risks that could exist for up to 100 years in the future. Table 2 summarizes the contaminants that could not be eliminated through application of human health or ecological screening criteria during the risk assessment updates described in the SOWP (DOE 1999). However, hypothetical risks through use of ground water for drinking or agricultural purposes are mitigated through the institutional controls established for the site for the duration of the natural flushing period.

Table 2. Summary of Current and Potential Future Risks

Contaminant	Potential Future Human Health Risks		Current/Future Ecological Risks	
	On-site	Off-site	NRW	RFP
Ammonia	Y	Y*	ND	Y
Arsenic	Y	N	N	N
Cadmium	N	N	Y	Y
Fluoride	Y	Y*	Y	N
Manganese	Y	Y	N	N
Molybdenum	Y	Y	ND	ND
Nitrate	Y	Y	ND	Y
Selenium	Y	Y*	N	N
Sulfate	N	N	N	Y
Uranium	Y	Y	Y	Y
Vanadium	Y	Y*	N	N

Y = contaminant is a COC
N = contaminant is not a COC
* = Contaminant extends only immediately downgradient of site
ND = not sufficient data to evaluate
NRW = New Rifle wetland
RFP = Roaring Fork pond

Additional information on potential risk to human health and the environment is provided in Section 4.0.

2.5 Compliance Strategy Selection

The fifth and final step in the framework is the selection of an appropriate compliance strategy to meet the U.S. Environmental Protection Agency (EPA) ground water protection standards. DOE has determined that natural flushing of the alluvial aquifer, in conjunction with the establishment of ACLs and institutional controls, is the appropriate compliance strategy for remediation of all contaminants at the New Rifle site, except vanadium. Additional data collection is required before an appropriate strategy can be implemented for vanadium. This approach will be protective of human health and the environment.

2.6 Ground Water Monitoring

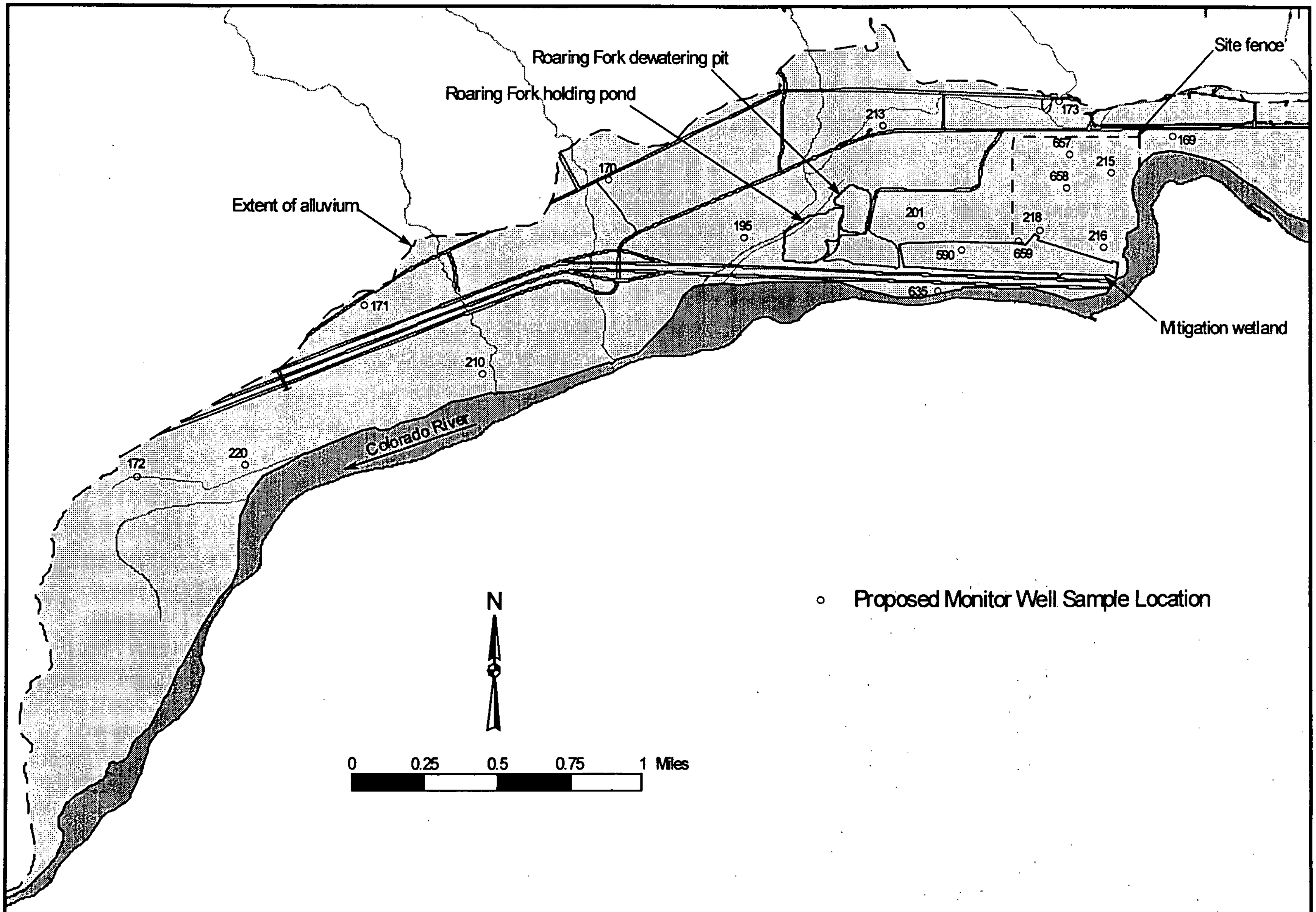
The monitoring strategy for the alluvial aquifer is designed to determine the progress of the natural flushing process in meeting compliance standards for site COCs. The progress will be tracked by comparing the actual concentrations against the model predictions and associated uncertainties (e.g. error bars). Standards for selenium, vanadium, and ammonia are their proposed ACLs of 0.05 mg/L, 0.33 mg/L, and 200 mg/L (as NH_4), respectively. For uranium, the cleanup goal is the UMTRA standard of 0.044 mg/L or background, whichever is higher. For arsenic, the cleanup goal is the UMTRA standard of 0.05 mg/L, for molybdenum the cleanup goal is the UMTRA standard of 0.1 mg/L, and for nitrate the cleanup goal is the UMTRA standard of 44 mg/L. The goal for fluoride is the SDWA MCL of 4 mg/L. The cleanup goal for manganese is approximately background, or 4 mg/L. Monitoring will focus on these contaminants.

Wells RFN–218, –657, –658, and –659 have been established as appropriate for monitoring the "hot spots" with highest concentrations of vanadium, arsenic, and selenium, as well as elevated concentrations of most other constituents. Based on the ground water modeling, these contaminants are likely to take the longest time to flush from the system. In addition to the "hot spot" wells denoted above, wells RFN–169, –170, –171, –172, –173, –195, –201, –210, –213, –215, –216, –220, –590, and –635 have been established as appropriate for monitoring progress of the natural flushing in the alluvial aquifer. The perimeter of the plume is approximately defined by well RFN–172 to the southwest; wells RFN–171, –170, –173, and –213 along the northern boundary; well RFN–169 to the northeast; and wells RFN–215 and –216 to the southeast. In no case is the concentration of any COC at any of these perimeter wells more than twice the standard, whereas some of the other wells exceed treatment standards by a factor of five or higher for many COCs. Background wells RFN–169 and –173 will be used to monitor background concentrations of uranium to assist in establishing the appropriate cleanup standard (UMTRA standard or background, whichever is higher).

The other wells in the natural flushing monitoring program are intended to monitor the progress of the flushing in key points within the boundaries of the plume. Well RFN–220 is north of the railroad track between wells RFN–172 and –620, and currently does not show contamination for any of the New Rifle COCs. Well RFN–210, which exceeds the UMTRA standard for uranium only (but is within the range of background), is along the railroad tracks near the Colorado River south of Interstate 70. Wells RFN–195 and –201, which exceed the cleanup goals for ammonia, nitrate, molybdenum and uranium, are located to the west and east, respectively, of the Roaring Fork gravel pit, approximately on the north-south centerline of the current plume. Well RFN–590 is immediately south of the borrow pit pond and exceeds UMTRA standards for molybdenum, nitrate, selenium, and uranium, and cleanup goals for ammonia, manganese, and vanadium. Well RFN–635 is well to the south of the borrow pit pond, south of Interstate 70 along the Colorado River; it exceeds UMTRA standards for molybdenum, nitrate, selenium, uranium and cleanup goals for ammonia, fluoride, and manganese. The proposed monitoring locations are shown on Figure 3.

Results of ground water modeling for six of the COCs at the New Rifle site (arsenic, molybdenum, selenium, uranium, nitrate, and vanadium) are presented in Section 2.3.1. This modeling indicates that concentrations of all of these COCs are expected to decrease and that the contaminant plumes for all these COCs are not expected to spread beyond their current boundaries. The monitoring plan is intended to confirm that the natural flushing is progressing approximately in conformance with the predictions of the model and that constituents that were not modeled decrease as well.

Sampling of each well will take place annually for 10 years. If a COC sampled in a well is below standards for a consecutive 3-year period, cleanup will be considered complete at that location and monitoring will be discontinued for that COC. After the first 10 years of monitoring have been completed, monitoring will be reduced to every 5 years until the year 2030, assuming COCs continue to show a decline through the first 10-year period. At that time the monitoring strategy will be reevaluated and adjusted as appropriate based on previous results. Any COC that is below standards will be analyzed for 3 consecutive years to eliminate it from further analysis. If the monitoring of wells at the perimeter of the contaminant plumes shows that contaminants have begun to spread beyond the current plume boundaries, or if some other changes in contaminant trends are noted, the sampling plan may also be reevaluated and adjusted at that time. If monitoring indicates that all contaminants in some areas have decreased below cleanup



m:\ugw\511\0017\08\u00602\u0060200.apr reynoldm 9/2/1999, 14:46

U0060200-18

Figure 3. Proposed Monitoring Locations for the New Rifle Site

goals, institutional controls can be lifted in those areas. As part of the monitoring program, DOE will also evaluate the effectiveness of the institutional controls on a regular basis (e.g., yearly surveys of changes in water use in the area).

Monitor wells not required as part of the monitor network will be abandoned according to applicable State of Colorado regulations and UMTRA project procedures. Abandonment will be accomplished in the near future under the LTSM program.

Table 3. Summary of Monitoring Requirements

Location	Monitoring Purpose	Analytes	Frequency[a]
RFN–218, –657, –658, –659	Monitor hot-spots	As, V, Se, Mo, U, NH_4, NO_3, Mn, F	Annually for 10 years; every 5 years thereafter until 2030
RFN–170, –210, –172	Monitor middle and leading edge of Mo and U plumes.	Mo, U	Annually for 10 years; every 5 years thereafter until 2030
RFN–169, –173	Monitor background to establish appropriate standard for uranium; ensure no upgradient spread of plumes	As, V, Se, Mo, U, NH_4, NO_3, Mn, F	Annually for 10 years; every 5 years thereafter until 2030
RFN–171, –220, –213	Monitor spread of plume to uncontaminated areas downgradient	Mo, U	Annually for 10 years; every 5 years thereafter until 2030
RFN–215, –216, –201, –195, –590, –635	Monitor flushing in main body of plumes	As, V, Se, Mo, U, NH_4, NO_3, Mn, F	Annually for 10 years; every 5 years thereafter until 2030

[a]Monitoring for a COC will be discontinued if below standards for three consecutive sampling rounds.

3.0 Vanadium Pilot Study

The proposed remedial action relies primarily on natural flushing to reduce levels of COCs to below the applicable MCLs and ACLs within the statutory time limit of 100 years. Current data is insufficient to determine whether concentrations of vanadium can be reduced to the ACL by natural flushing alone within the time available. An economic evaluation has determined that, if active treatment is required to enhance the natural flushing process for vanadium, the most cost-effective active treatment process for removal of vanadium from ground water at the New Rifle site would utilize zero-valent iron (ZVI) as the reactive media. However, the process cannot be implemented until a number of technical questions are satisfactorily answered.

This section describes a laboratory and pilot study that will be undertaken to obtain the data required to be able to determine the feasibility of implementing an active treatment process to enhance the effectiveness of natural flushing for vanadium remediation.

3.1 Scope of Pilot Study

The pilot study will investigate: (1) the efficiency of water treatment of vanadium and other contaminants by zero-valent iron (ZVI), (2) the efficiency of treating ammonia by pH-conditioned volatilization, (3) enhancing vanadium desorption, and (4) stabilizing vanadium using sorptive materials. The initial phase of the pilot study will collect basic data on these processes in the laboratory. This will be followed by a field demonstration phase in which the most promising process(es) will be tested at the site.

3.1.1 Zero-Valent Iron (ZVI)

ZVI is a low-cost treatment media that has been shown to be effective in treating many redox-sensitive contaminants including vanadium. When a stream of water containing dissolved metals, including radionuclides, is passed through a layer of ZVI, the metals are reduced from an ionic form to their metallic state, where they plate out on the iron surface. Previous studies performed at GJO demonstrated that ZVI reduces concentrations of arsenic, vanadium, and uranium by orders of magnitude. Contact with ZVI can also reduce concentrations of selenium and molybdenum, albeit not as dramatically. ZVI has typically been implemented in the form of a passive barrier or PeRT (Permeable Reactive Treatment) wall. The barrier is installed at the leading edge of a source of contaminated water, which percolates through the barrier under hydraulic pressure. It can also be implemented in an ex-situ reactor. A laboratory study will be performed to determine the residence time that will result in the optimum ex-situ reactor performance. Although the primary purpose of the study is to determine the feasibility of ex-situ treatment, the results can also be used to evaluate an in-situ permeable reactive barrier.

3.1.2 Ammonia Removal

Results of ZVI treatment for ammonia from previous studies have been mixed; removal of ammonia was observed in some experiments but not in others. In fact, nitrate may be reduced to ammonia causing ammonia concentrations to increase. Ammonia in aqueous solution can be removed by pH adjustment. Above a pH of about 9.2, most of the ammonia exists in the form of dissolved ammonia gas (NH_3), and below this pH the positively charged ammonium ion (NH_4^+) predominates. While NH_4^+ is nonvolatile, NH_3 is volatile and can be removed from ground water by air stripping. Air stripping is more efficient at elevated pH because of the partitioning to NH_3. Adding residence time to the reactor can further enhance stripping because, as NH_3 is vaporized, some of the NH_4^+ in solution will convert to NH_3 to maintain the equilibrium. This NH_3 will be stripped off in turn, and the process continues until the water is withdrawn or until the ammonia is depleted. The laboratory study will determine the combination of residence time and pH that will optimize reactor size and chemical consumption.

3.1.3 Enhanced Vanadium Desorption

In order for implementation of an active treatment process for vanadium remediation at the New Rifle site to be effective, the ground water extraction must remove enough vanadium to reduce concentrations in the soil to the point where natural flushing will remove the remaining vanadium within the statutory time frame. But if the distribution coefficient of vanadium is high enough that natural flushing will not mobilize vanadium at the required rates, the extraction of ground water will not mobilize it either. The desorption of vanadium must be enhanced for the extraction system to be successful.

Most of the vanadium in the New Rifle ground water is in the +5 oxidation state called vanadate. Vanadate occurs in solution as an anion and readily complexes with hydroxyl ions causing it to be more sorptive at low pH values and more mobile at elevated pH values. Thus, desorption could be enhanced by increasing pH using bases such as sodium hydroxide. Increasing the pH from 6.8 (approximately the pH of the Rifle ground water) to 10 will increase partitioning into the soluble phase by several orders of magnitude.

Alternatively, the distribution ratio could be decreased by adding a chelating or complexing agent to the ground water. An example is the use of citrate, which is known to chelate with iron. Because iron tends to stabilize vanadate, the addition of citrate should mobilize vanadate. Other agents are probably known from wastewater treatment, ore milling, and ground-water remediation industries that could be used to enhance the flushing of vanadium.

The laboratory study will determine the most effective method for enhancing the mobility of vanadium. A literature search will be conducted to gather information regarding the mobility of vanadium. This search will focus on complexing agents that are known or are likely to solubilize vanadium, and will also consider the environmental acceptability of the agents. Laboratory tests will then be conducted using vanadium-contaminated soil samples from the vicinity of RFN–658, which is expected to have the highest contaminant levels.

3.1.4 Stabilization of Vanadium

The occurrence of a contaminant such as vanadium in an aquifer does not necessarily indicate that ground water will be contaminated. Vanadium is a relatively common element in the earth's crust (average crustal concentration is about 135 mg/kg or about the same as chloride). Contamination to ground water only occurs if a contaminant is released from the solid fraction. If the contaminant can be incorporated into stable minerals then the potential for release to ground water (and the risk of exposure) is minimized. Contaminants can be stabilized in-situ by increasing the amount partitioned into the immobile solid fraction. Vanadium has a tendency to partition strongly to mineral phases and thus might be a good candidate for the application of in-situ stabilization technologies. If vanadium could be effectively stabilized in-situ, no extraction or treatment system would be required, so the cost of treatment could be minimized.

One means of increasing the sorptive portion of the aquifer is to introduce ferric oxyhydroxide (Morrison et al., 1996). This can be accomplished by injecting dissolved ferric chloride into the aquifer. The acidic ferric chloride solution reacts with alkaline aquifer materials and precipitates ferric oxyhydroxide which immobilizes vanadium by incorporating it in a semicrystalline structure. Laboratory tests and a pilot demonstration are needed to determine the acid-neutralizing capacity of the aquifer and the ability of the ferric oxyhydroxide to incorporate vanadium. Another method to stabilize vanadium is to pump sodium dithionite into the sediments (Fruchter et al., 1997). The laboratory study will determine the most effective method for stabilizing vanadium, using vanadium-contaminated soil samples from the vicinity of RFN–658, which is expected to have the highest contaminant levels.

3.2 Field Demonstration Test

Based on the results of the laboratory studies the technology having the most promise for vanadium remediation will be selected and implemented on a pilot scale at the New Rifle site. If in-situ vanadium stabilization can be successfully demonstrated on a laboratory scale, it will almost certainly be the most cost-effective process. If in-situ stabilization cannot be demonstrated or is found to be otherwise unfeasible (e.g. if it does not find acceptance with regulators or stakeholders), an active treatment process will be implemented. The active process will utilize enhanced vanadium mobilization and ZVI treatment. Depending on the results of the ZVI laboratory studies, an ammonia stripping process may or may not be required.

Additional site characterization will have been performed by the time the field demonstration has been completed. This characterization will determine the source and extent of the vanadium contamination. In addition, it will determine whether the decrease in vanadium concentrations in the ground water, as observed by comparing the data from August 1998 with that from January 1999, is due to increased effectiveness of natural flushing, beyond what the site modeling predicts, or is a result of other causes. Once the field demonstration test has been concluded, the results of the test and the additional site characterization will be reviewed to determine whether it is necessary to implement a full-scale treatment system at the site.

3.3 Limitations of Active Remediation

The successful implementation of active remediation depends on several technologies which have not been demonstrated or that have not been adequately characterized. In particular, the extraction process depends upon development and field implementation of an effective technology for mobilizing vanadium. If vanadium mobilization cannot be demonstrated, the proposed process will not be feasible.

The ZVI process requires the additional characterization described above in order to determine how the treated water will be disposed. Disposal options for the treated water include:

- Discharge to the wetlands situated immediately south of the site between the site and the Colorado River, most likely by construction of an infiltration trench immediately upgradient of the wetlands.
- Direct discharge to the Colorado River.
- Discharge to injection wells, which would be used to conduct the treated effluent directly back into the alluvial aquifer
- Discharge to a municipal water treatment facility, in this case, the Rifle municipal water treatment plant, which is adjacent to the site.

The nature of the disposal system will be determined after completion of the additional laboratory work on the ZVI process, as discussed above. This laboratory work will allow the effluent to be characterized, so that determination of the most appropriate disposal option can be made.

The effectiveness of the ground water extraction system, and in particular the vanadium mobilization process, is the primary factor that will determine whether aquifer cleanup goals can be met. 40 CFR 192.21(f) allows the application of supplemental standards in the event that restoration of ground water is technically impracticable from an engineering perspective. This would only be considered for the New Rifle site if the laboratory and pilot studies were unable to demonstrate increases in vanadium mobilization that would be sufficient to substantially reduce vanadium levels in the aquifer to the point where the remediation can be completed by natural flushing.

4.0 Environmental Considerations

To comply with National Environmental Policy Act (NEPA) requirements, DOE prepared the PEIS, which was issued in October (DOE 1996b). The PEIS assesses the potential programmatic effects of conducting the ground water project, provides a method for determining site-specific ground water compliance strategies, and provides data and information that can be used to prepare site-specific environmental impact analyses more efficiently. In the proposed action (preferred alternative), ground water compliance strategies are tailored to each site to achieve conditions that are protective of human health and the environment. The selection framework for determining an appropriate compliance strategy at each site is presented in Section 2.1 of the PEIS and is discussed in Section 2.0 of this GCAP. Relevant areas of environmental concern are discussed below.

Environmental issues and resources potentially affected by the proposed action may include the following:

- Risk to human health and the environment.
- Ground water use.
- Surface water use.
- Land use.
- Exposure to potentially contaminated ground water.
- Environmental site restoration.

Environmental impacts from the proposed action on these issues and resources have been assessed in several referenced documents (DOE 1990, 1992, 1996a, 1996b, and 1999). Results of this assessment are summarized in the following sections for both of the most likely remediation scenarios. Section 4.1 discusses the environmental issues that are common to both remediation scenarios. Section 4.2 covers environmental impacts associated with natural flushing, assuming that natural flushing will be adequate to reduce concentrations of all COCs to their respective standards or ACLs within the statutory time limit of 100 years. Section 4.3 covers the environmental impacts of active remediation, assuming that some form of pump-and-treat system will be required for vanadium.

As described in Section 2.3.2, two other options for active remediation, soil removal and PeRT walls, are not considered promising at this time. Should circumstances change in the future such that either of these technologies becomes the preferred treatment option, the GCAP will be revised to address the associated environmental issues.

4.1 Common Environmental Issues

On the basis of data in the SOWP, nine constituents present in the alluvial aquifer—ammonia, arsenic, fluoride, manganese, molybdenum, nitrate, selenium, uranium, and vanadium—were determined to pose a potential risk to human health, or to exceed established standards. The data also indicated that contamination was restricted to the surficial aquifer; the deeper Wasatch

Formation has not been contaminated as a result of residual radioactive material. Therefore, the risk assessment in the final SOWP (Section 6.0) focuses on the surficial aquifer.

The SOWP determined that ingestion of untreated alluvial ground water as a regular source of drinking water would result in the only unacceptable risks to human health. Currently this pathway is incomplete; hence, no current human health risk exists. Under the proposed action, institutional controls would prohibit ground water use for any purpose for 100 years; after that time the alluvial aquifer would be available for unrestricted use. Because of the institutional control restrictions, no human health risks will exist for the duration of those controls. Concentrations of all COCs, with the possible exception of vanadium, will decrease to their respective standards or ACLs after no more than 100 years of natural flushing. Concentrations of vanadium will be substantially reduced by natural flushing, although additional data must, and will, be collected to determine whether vanadium levels can decrease to below the proposed ACL through 100 years of natural flushing without the need for active treatment to enhance the flushing process. Active treatment will be implemented if it is demonstrated to be necessary. Therefore, unrestricted use of site ground water after the termination of institutional controls will pose no unacceptable human health risk.

As described in Section 2.4, site ground water currently presents few ecological risks, and those few risks that do exist tend to limit the diversity of species that can thrive in the area, rather than representing threats to existing healthy populations. If ground water from on site wells or wells on the UMETCO property were used for irrigation, the water could be harmful to terrestrial plants because of current concentrations of arsenic and vanadium. Also, ammonia levels would be expected to limit the potential species that could be used to revegetate the New Rifle wetland during near-term reconstruction activities. Proposed institutional controls would prohibit use of alluvial ground water from the site or UMETCO properties for irrigation or in ponds or fountains for 100 years; no ecological risks from alluvial ground water will exist during that time.

Existing documents, including the SOWP and the PEIS (Sections 4.4.2 and 4.4.3), describe the human health and ecological risks associated with implementing the proposed compliance strategy. Implementation of institutional controls will be protective of human health and the environment. Both the SOWP and the Environmental Impact Statement for surface remediation identify background ground water quality as generally poor and not projected for use as a public water supply system.

To accommodate the NEPA obligation to make relevant environmental information available to public officials and citizens before decisions are made and before actions are implemented, DOE has distributed relevant environmental documents (including this document) to the stakeholders.

4.2 Environmental Issues Associated with Natural Flushing

Natural flushing will not involve any surface-disturbing activities. The only field activities required following implementation of the GCAP will be continued monitoring of the wells shown in Figure 3, along with limited well-abandonment activities. Therefore, potential adverse effects typically associated with surface-disturbing activities will not occur.

Natural flushing will produce no adverse effects to air quality, surface water quality, cultural resources, sensitive plant or wildlife species (including threatened or endangered species), or designated or sensitive natural resource areas (e.g., wetlands, wilderness, parks, and scenic rivers). Although contaminants will flush to the Colorado River, ground water quality results presented in the SOWP indicate that the dilution factor of the Colorado River is so great that the COCs are essentially undetectable. General comments received in the PEIS suggest that the public may consider monitoring wells a scenic impact. The majority of the wells at the New Rifle site are hidden by distance and visual barriers, but any potential impacts could be resolved with flush mounts of the well at the surface.

4.3 Environmental Issues Associated with Active Remediation

Surface-disturbing activities associated with an active remediation system include the installation of the extraction well and piping system, the vanadium mobilization system, the treatment system, and the effluent disposal piping. These will be limited to the confined area of the vanadium "hot spot" and to the short duration of active treatment. After active treatment has been completed, all equipment associated with the active treatment system will be dismantled and removed from the site, and disturbed surface areas will be restored to their original condition. All these activities will be monitored to insure that permanent adverse effects typically associated with surface-disturbing activities do not occur.

The active remediation system will be designed to produce no adverse effects to air quality, surface water quality, cultural resources, sensitive plant or wildlife species (including threatened or endangered species), or designated or sensitive natural resource areas (e.g., wetlands, wilderness, parks, and scenic rivers). Potential visual impacts associated with the extraction and monitoring wells could be resolved with flush mounts of the well at the surface and by installing the distribution piping underground to the maximum extent possible. There will be a visual impact associated with the installation and operation of the active treatment system, but the duration of the active treatment is sufficiently short that this is not considered to be a major issue.

5.0 References

Fruchter, J. S., C. R. Cole, M. D. Williams, V. R. Vermeul, S. S. Teel, J. E. Ammonette, J. E. Szecsody, S. B. Yabusaki, 1997. *Creation of a Subsurface Permeable Treatment Barrier Using In Situ Redox Manipulation*, in Conference Proceedings of the International Containment Technology Conference, St. Petersburg, FL, pp. 704-710.

McDonald, M.G., and A.W. Harbaugh, 1988. *Techniques of Water-Resources Investigations of the United States Geological Survey,* Chapter A1: A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, Book 6, Modeling Techniques, U.S. Geological Survey Open-File Report.

Morrison, S. J., R. R. Spangler, and S. A. Morris, 1996. *Subsurface Injection of Dissolved Ferric Chloride to Form a Chemical Barrier: Laboratory Investigations*, Ground Water, v. 34, pp 75-83.

U.S. Department of Energy, 1990. *Final Environmental Impact Statement for Remedial Actions at the Former Union Carbide Corporation Uranium Mill Sites, Rifle, Garfield County, Colorado,* DOE/EIS–0132–F, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico, March.

U.S. Department of Energy, 1992. *Final Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Sits at Rifle, Colorado*, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico, February.

———, 1996a. *Baseline Risk Assessment of Ground Water Contamination at the Uranium Mill Tailings Sites Near Rifle, Colorado,* DOE/AL/62350–179, Rev. 2, February.

———, 1996b. *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project,* DOE/EIS–0198, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico, October.

———, 1999. *Final Site Observational Work Plan for the UMTRA Project New Rifle Site,* GJO-99-88-TAR, Rev. 1, prepared by the U.S. Department of Energy, UMTRA Project Office, Grand Junction Office, Grand Junction, Colorado, April.

Zheng, C., 1990. *MT3D, A Modular Three-Dimensional Transport Model*, Documentation and User's Guide, First Edition, S.S. Papadopulos and Associates, Inc., Bethesda, Maryland.