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UMTRA GROUND WATER PROJECT

FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR THE URANIUM MILL TAILINGS REMEDIAL ACTION GROUND WATER PROJECT

VOLUME I

October 1996

Prepared by the

U.S. Department of Energy
Grand Junction Projects Office

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ABSTRACT: The purpose of the Uranium Mill Tailings Remedial Action (UMTRA) Ground Water Project is to eliminate, reduce, or address to acceptable levels the potential health and environmental consequences of milling activities by meeting Environmental Protection Agency (EPA) ground water standards. One of the first steps in the UMTRA Ground Water Project is the preparation of this Programmatic Environmental Impact Statement (PEIS). The EPA standards allow the use of different strategies for achieving compliance with the standards. This document analyzes the potential impacts of four alternatives for conducting the Ground Water Project. Each of the four alternatives evaluated in the PEIS is based on a different mix of strategies to meet EPA ground water standards. The PEIS is intended to serve as a programmatic planning document that provides an objective basis for determining site-specific ground water compliance strategies and data and information that can be used to prepare site-specific environmental impact analyses more efficiently. DOE will prepare appropriate further National Environmental Policy Act documentation before making site-specific decisions to implement the Ground Water Project. Affected States, Tribes, local government agencies, and members of the public have been involved in the process of preparing this PEIS; DOE encourages their continued participation in the site-specific decision making process.

Overview of the Public Comments and DOE Response:

Public Comment Process

On May 17, 1995, DOE published in the *Federal Register* a Notice of Availability of the draft *Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (60 FR 26417). The Notice invited interested agencies, organizations, and the general public to provide oral and written comments on the draft PEIS and announced the dates, times, and location of public comment meetings. DOE conducted 9 public comment meetings in communities near UMTRA sites during the 120 day public comment period.

To encourage public participation at the meetings, DOE also announced the hearings in local newspapers and on radio stations, prepared fact sheets describing the PEIS and the UMTRA project, provided translation services at Navajo Nation sites, and participated in interviews and discussions before and after the meetings. An independent moderator conducted the meetings using a format that enabled interactive communications among DOE representatives and meeting participants. Oral comments were recorded on flip charts and clarified as necessary to ensure their accuracy.

Major Issues Raised by Commentors

DOE received over 600 comments at the public meetings, through the mail, and by telephone via a toll-free number. DOE reviewed and considered all comments in preparing the final PEIS. The comment response document (Volume 2 of this PEIS) contains all written and oral comments received and DOE's responses, including, as appropriate, a discussion of changes made to the document or an explanation as to why no changes were made.

Many commentors expressed their views regarding actions that should be taken at specific sites, and asked for clarification regarding how site-specific decisions would be made and how they could participate in such decisions. In response, DOE revised the final PEIS to more clearly explain how site specific decisions would be made, including the Department's intention to conduct public meetings and prepare further NEPA documents, such as environmental assessments, before making site-specific cleanup decisions. DOE's response clarifies that no site specific decisions will be made until all relevant site characterization data and analyses are completed, all potential human and environmental risks are identified, and input from the public, tribal and state agencies has been provided.

Several commentors asked for a clarification of the definition of the alternatives considered. In response, DOE revised the final PEIS to more clearly explain the alternatives and their relationships, such as differences between No Action and passive remediation.

Several commentors stated that the draft PEIS did not adequately address Environmental Justice issues. In response, DOE enhanced the final PEIS with additional information regarding minority and low income populations and the potential for disproportionate impacts that might result from the programmatic alternatives. DOE will address specific Environmental Justice concerns in future site-specific NEPA documentation.

Several commentors expressed the concern that the proposed action would result in a bias towards passive remediation strategies, such as dilution and natural flushing, rather than active ground water cleanup approaches that would decrease the quantity of contaminants. These commentors generally were concerned with excessive reliance on institutional controls, and that passive strategies may not be protective of human health and the environment. In response to such comments, DOE noted that no final decisions have been made regarding site-specific ground water compliance strategies, that any site-specific strategies eventually selected will be protective of human health and the environment, and that this PEIS is not intended to convey a perception that most ground water remediation will focus on passive strategies.

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SUMMARY

This programmatic environmental impact statement (PEIS) was prepared for the Uranium Mill Tailings Remedial Action (UMTRA) Ground Water Project to comply with the National Environmental Policy Act (NEPA). This PEIS provides an analysis of the potential impacts of the alternatives and ground water compliance strategies as well as potential cumulative impacts.

On November 8, 1978, Congress enacted the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978, Public Law, codified at 42 USC §7901 *et seq.* Congress found that uranium mill tailings ". . . may pose a potential and significant radiation health hazard to the public, and that every reasonable effort should be made to provide for stabilization, disposal, and control in a safe, and environmentally sound manner of such tailings in order to prevent or minimize other environmental hazards from such tailings." Congress authorized the Secretary of Energy to designate inactive uranium processing sites for remedial action by the U.S. Department of Energy (DOE). Congress also directed the U.S. Environmental Protection Agency (EPA) to set the standards to be followed by the DOE for this process of stabilization, disposal, and control.

On January 5, 1983, EPA published standards (40 CFR Part 192) for the disposal and cleanup of residual radioactive materials. On September 3, 1985, the U.S. Court of Appeals for the Tenth Circuit set aside and remanded to EPA the ground water provisions of the standards. The EPA proposed new standards to replace remanded sections and changed other sections of 40 CFR Part 192. These proposed standards were published in the *Federal Register* on September 24, 1987 (52 FR 36000). Section 108 of the UMTRCA requires that DOE comply with EPA's proposed standards in the absence of final standards. The Ground Water Project was planned under the proposed standards. On January 11, 1995, EPA published the final rule, with which the DOE must now comply. The PEIS and the Ground Water Project are in accordance with the final standards. The EPA reserves the right to modify the ground water standards, if necessary, based on changes in EPA drinking water standards. Appendix A contains a copy of the 1983 EPA ground water compliance standards, the 1987 proposed changes to the standards, and the 1995 final rule.

Under UMTRA, DOE is responsible for bringing the designated processing sites into compliance with the EPA ground water standards and complying with all other applicable standards and requirements. The U.S. Nuclear Regulatory Commission (NRC) must concur with DOE's actions. States are full participants in the process. The DOE also must consult with any affected Indian tribes and the Bureau of Indian Affairs.

Uranium processing activities at most of the inactive mill sites resulted in the contamination of ground water beneath and, in some cases, downgradient of the sites. This contaminated ground water often has elevated levels of constituents such as but not limited to uranium and nitrates. The purpose of the UMTRA Ground Water Project is to eliminate or reduce to acceptable levels the potential health and environmental consequences of milling activities by meeting the EPA ground water standards.

The first step in the UMTRA Ground Water Project is the preparation of this PEIS. This document analyzes the potential impacts of four alternatives for conducting the Ground Water Project. These alternatives do not address site-specific ground water compliance strategies because the PEIS is a planning document only. It assesses the potential programmatic impacts of conducting the Ground Water Project, provides a method for determining the site-specific ground water compliance strategies, and provides data and information that can be used to prepare site-specific environmental impacts analyses more efficiently. Participation by affected states, tribes, and local government agencies will be encouraged during preparation of this PEIS, and during implementation of the alternative selected in the Record of Decision.

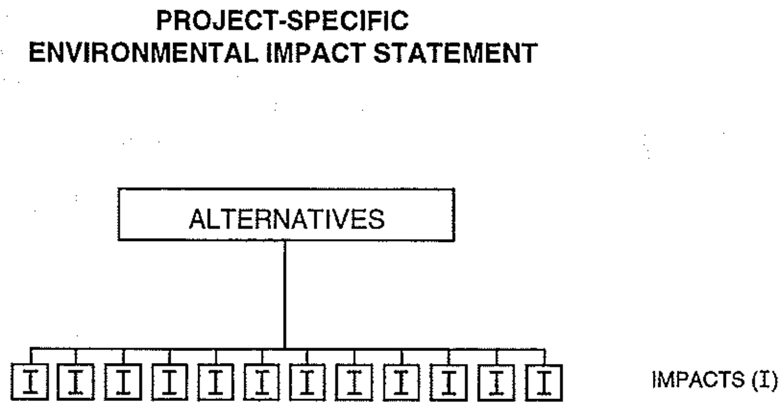
This PEIS differs substantially from a site-specific environmental impact statement because multiple ground water compliance strategies, each with its own set of potential impacts, could be used to implement all the alternatives except the no action alternative. In a traditional environmental impact statement, an impacts analysis leads directly to the defined alternatives. The impacts analysis for implementing alternatives in this PEIS first involves evaluating a ground water compliance strategy or strategies (Figure 1), the use of which will result in site-specific impacts. This PEIS impacts analysis assesses only the potential impacts of the various ground water compliance strategies, then relates them to the alternatives to provide a comparison of impacts.

DESCRIPTION OF THE PROPOSED ACTION (PREFERRED ALTERNATIVE) AND ALTERNATIVES

The PEIS considers four programmatic alternatives for implementing the UMTRA Ground Water Project: 1) the proposed action (DOE's preferred alternative), 2) no action, 3) active remediation to background levels, and 4) passive remediation. A Record of Decision will identify the alternative that will become the programmatic foundation for conducting the Ground Water Project at all sites. All the alternatives listed except the no action alternative would use one or more ground water compliance strategies to meet the EPA ground water standards. Table 1 shows the alternatives and the strategies that are described below.

1) ***Proposed action*** (Preferred Alternative)

The proposed action which is DOE's preferred alternative would use ground water compliance strategies tailored for each site to achieve conditions that are protective of human health and the environment. The proposed action would consider ground water compliance decisions in a step-by-step approach, beginning with consideration of "no remediation" strategy and proceeding, if necessary, to the passive strategy, such as natural flushing with compliance monitoring and institutional controls, and to a more complex, active ground water cleanup method, such as pump and treat or other engineered approaches to cleaning up contaminated ground water. For example, under the proposed action, if a site risk assessment and site observational work plan indicate that the strategy of "no remediation" would still be protective of human health and the environment, a more complex and potentially disruptive strategy involving active cleanup methods would not be necessary.



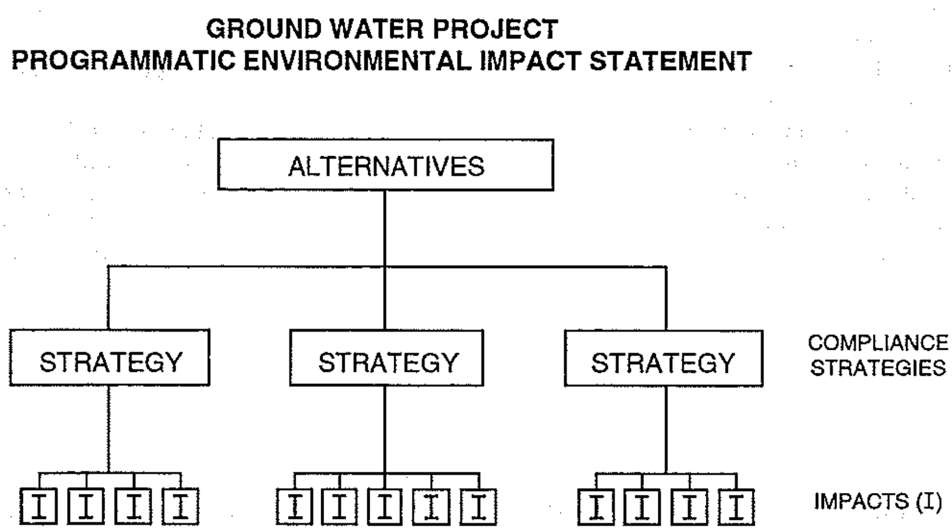


FIGURE 1
RELATIONSHIP BETWEEN ALTERNATIVES AND IMPACTS FOR PROJECT-SPECIFIC ENVIRONMENTAL IMPACT STATEMENTS AND THE GROUND WATER PROJECT PEIS

Table 1. Ground water compliance strategies that apply under each alternative

Strategy	Alternative: Proposed action	Alternative: No action[a]	Alternative: Active remediation to background levels	Alternative: Passive remediation
Active ground water remediation methods	√		√[b]	
Natural flushing [c]	√			√
No ground water remediation				
- Sites that qualify for supplemental standards [d] or alternate concentration limits[e].	√			√
- Sites that meet maximum concentration limits or background levels (no impacts).[f]	√			√

[a]The analysis of the no action alternative is required by the CEQ and DOE.
[b]Active remediation methods would not be used at sites where contamination does not exceed background and likely would not be used at sites that qualify for supplemental standards based on the existence of limited use ground water.
[c]Natural flushing means allowing the natural ground water movement and geochemical processes to decrease contaminant concentrations.
[d]Supplemental standards applicable for certain site conditions, as identified in the EPA standards, that are protective of human health and the environment, and may be applied in lieu of prescriptive levels.
[e]Concentrations of contaminants that may exceed the maximum concentration limits; or, limits for those constituents without maximum concentration limits. If DOE demonstrates, and NRC concurs, that human health and the environment would not be adversely affected, DOE may meet an alternate concentration limit.
[f]"No remediation" at sites that do not exceed maximum concentration limits or background levels is not the same as "no action" because these sites would require activities such as site characterization to show that no remediation is warranted.

The proposed action is intended to establish a consistent risk-based framework for implementing the UMTRA Ground Water Project and determining appropriate ground water compliance strategies at the UMTRA Project former processing sites. The determination of site-specific ground water compliance strategies would take into account site-specific ground water conditions; human and environmental risks; participation of the tribes, States and local communities; and cost. This approach is sufficiently flexible to allow for interim actions, such as alternate water supply systems, should these activities be necessary in order to reduce risk and/or support institutional controls. The proposed action would also allow the consideration of new ground water cleanup methods that become available.

2) *No action alternative*

The Council on Environmental Quality (CEQ) regulations for implementing the NEPA require assessment of the no action alternative (40 CFR §1502.14(d)), even if the agency is under a legislative mandate to act (51 FR 15618). The analysis of the no action alternative "provides a benchmark, enabling decision makers to compare the magnitude of environmental effects of the action alternatives" (51 FR 15618). Under the no action alternative, no further activities would be carried out to comply with EPA standards at the inactive UMTRA Project's former processing sites.

3) *Active remediation to background levels alternative*

Under this alternative, ground water at the former processing sites would be restored to background levels or to levels as close to background as possible using active ground water remediation methods. The rationale behind this alternative is that ground water at most of the former uranium processing sites was of better quality before uranium processing activities occurred and that the ground water should be restored to its preprocessing quality. If this alternative were implemented, most of the UMTRA Project sites would require the use of active ground water remediation methods such as gradient manipulation, ground water extraction and treatment, or *in situ* ground water treatment, regardless of the quality of the unaffected background ground water. The active ground water restoration method for each site would be determined by the observational approach and site-specific analyses would appear in the site-specific observational work plans.

4) *Passive remediation alternative*

Under this alternative, only passive remediation strategies would be used to meet the EPA ground water standards. The passive remediation strategies are 1) performing no remediation at sites that qualify for supplemental standards or alternate concentration limits or sites where contaminant concentrations are below maximum concentration limits or background levels, and 2) relying on natural flushing. Natural flushing means allowing the natural ground water movement and geochemical processes to decrease contaminant concentrations. This alternative differs from the no action alternative in that it includes site characterization, monitoring, and risk assessment activities.

Under the first strategy of this alternative, the DOE would apply supplemental standards or alternate concentration limits if maximum concentration limits and/or background concentrations were exceeded. If supplemental standards or alternate concentration limits are proposed at any site, concurrence by the NRC would be required.

Under the second strategy of this alternative, natural flushing would be used to achieve background levels or maximum concentration limits if supplemental standards and alternate concentration limits are not applied. Concurrence by the NRC would be required. According to the EPA standards, natural flushing can be used if it is shown to be protective of human health and the environment, meets the EPA standards within 100 years, and complies with the other criteria established for its use as discussed in Section 1.4.1. However, natural flushing may not meet the standards in 100 years and may not be protective of human health and the environment at all sites. For these cases, the passive remediation alternative may not result in compliance with the EPA standards.

The passive ground water compliance strategy selected for each site would be dependent on the observational approach and evaluating data gathered and included in Site

Observational Work Plans. Active ground water remediation methods would not be used, even if EPA standards cannot be met by implementing the above mentioned strategies.

EXISTING CONDITIONS

The designated UMTRA Project processing sites were active for varying lengths of time from the 1940s into the 1970s. These sites, the surrounding areas, and the underlying ground water constitute the affected environment for this PEIS. Minority or low income groups near UMTRA sites that have the potential for disproportionately high and adverse effects include those near the Tuba City and Monument Valley, Arizona; Shiprock, New Mexico; Mexican Hat, Utah; and Riverton, Wyoming, sites. Land contaminated by uranium mill tailings and other contaminants ranged from a low of 21 acres (ac) (8 hectares [ha]) at the Spook, Wyoming, site to a maximum of 612 ac (248 ha) at the Ambrosia Lake, New Mexico, site. The amount of contaminated materials ranged from 85,000 cubic yards (yd^3) (65,000 cubic meters [m^3]) at the North Continent Slick Rock, Colorado, site to 5,764,000 yd^3 (4,407,000 m^3) at the Falls City, Texas, site. The total amount of contaminated material at the sites is 39,000,000 yd^3 (30,000,000 m^3). As a result of uranium processing, contaminants have entered the ground water at most of the UMTRA Project sites. Some of the more common hazardous constituents that exceed maximum concentration limits at UMTRA sites include but are not limited to net gross alpha, molybdenum, nitrate, selenium, and uranium.

DOE currently estimates that approximately 10 billion gallons (gal) (39 million m^3) of ground water are contaminated. One site (Lowman, Idaho) shows no sign of contamination related to processing activities. The site with the largest amount of contamination, Gunnison, Colorado, has an estimated 1.9 billion gal (7.0 million m^3) of contaminated ground water.

Surface remediation of the designated sites has been in progress since the mid-1980s; surface remediation is complete at 18 sites and under way at four sites. The Belfield and Bowman, North Dakota, sites are not scheduled for surface remediation at the request of the state. Affected states are required by UMTRCA to cost share 10 percent of remedial action costs. Table 2 summarizes the environmental resources that are present at the former processing sites.

IMPACTS ANALYSIS

To evaluate the impacts of alternatives, a qualitative analysis of potential impacts of the ground water compliance strategies is used in this PEIS. This qualitative analysis compares the potential impacts of one alternative to another alternative rather than to site-specific impacts. For example, if the no action alternative is said to have a high potential for ecological risk, this potential impact is high only in relation to the other alternatives' potential for such an impact. These comparisons are not site specific; that type of assessment would be provided in the site-specific NEPA documents that tier off the PEIS. (Tiering is the process in which broad environmental issues are analyzed to facilitate subsequent site-specific decision making.) Further, this comparison treats all impacts equally so that, for example, the significance of potential impacts to human health are equated with potential impacts on cultural resources (Table 3).

Table 2. Resources at UMTRA Project processing sites

	Site characteristics								
UMTRA Project Site	Tribal lands	Urban setting	Suburban setting	Rural setting	Annual precipitation (inches/centimeters)	Wetlands	Surface water	Cultural/traditional resources	Threatened and endangered species
Monument Valley, AZ	√			√	6/15	√	√	√	
Tuba City, AZ	√			√	6/15				
Durango, CO			√		19/48		√		√
Grand Junction, CO		√			8/20	√	√		√
Gunnison, CO			√		11/28	√	√		√
Maybell, CO				√	13/33	√	√	√	√
Naturita, CO				√	9/23	√	√	√	√
Old Rifle, CO			√		11/28	√	√		√
New Rifle, CO			√		11/28	√	√		√
Slick Rock, CO (Union Carbide)				√	7/18	√	√	√	√
Slick Rock, CO (North Continent)				√	7/18	√	√	√	√
Lowman, ID				√	27/69	√	√		
Ambrosia Lake, NM				√	9/23			√	
Shiprock, NM	√		√		6/15	√	√		√
Belfield, ND			√		16/41	√	√	√	√
Bowman, ND				√	16/41	√	√	√	√
Lakeview, OR			√		17/43	√	√		
Canonsburg, PA		√			37/94		√	√	
Falls City, TX				√	30/76	√	√		√
Green River, UT				√	6/15		√	√	
Mexican Hat, UT	√			√	6/15	√	√		
Salt Lake City, UT		√			15/38	√	√		
Riverton, WY	√[a]			√	8/20	√	√	√	
Spook, WY				√	11/28		√		√
Total	5	3	7	14		18	22	11	14

[a] Tribal lands adjacent to the site.

Table 3. Comparison of the potential adverse environmental impacts of alternatives

Environmental factor	Alternative			
	Proposed action	No action	Active remediation to background levels	Passive remediation
Human health	Low	High	Low	Medium
Surface water	Low	High	Low	Medium
Ground water	Low	High	Low	Medium
Ecology				
Habitat destruction	Medium	Low	High	Low
Contaminated ground water	Low	High	Low	Medium
Land use				
Land acquisition	Medium	Low	High	Low
Institutional controls	Medium	Low	Medium	High
Contaminated ground water	Low	High	Low	Medium
Cultural/traditional resources				
Surface	Medium	Low	High	Low
Ground water	Medium	High	Low	High
Social and economic				
Institutional controls	Medium	Low	Medium	High
Contaminated ground water	Low	High	Low	Medium
Environmental justice	Low	High	Low	Low
Waste management	Medium	Low	High	Low

Notes:
1. High indicates high potential for negative impact relative to the other alternatives.
2. Medium indicates medium potential for negative impact relative to the other alternatives.
3. Low indicates little to no potential for negative impact relative to the other alternatives.
4. The degree of actual negative impact, if any, would be addressed once the site-specific ground water compliance strategies are determined; the analyses would appear in the site-specific NEPA document.

To give more weight to impacts that may have more significant consequences (for example, human health), long-term and short-term impacts are compared separately. Long-term impacts are those that would occur from leaving contaminated ground water in place or from implementing institutional controls for an extended period of time. Short-term impacts would usually occur only during construction activities. In general, these impacts would be potentially less significant than long-term impacts, because most (for example, habitat destruction, noise, and dust emissions) would be relatively minor and temporary, and could be mitigated. While these impacts are of concern, there is a greater concern regarding potential long-term health and environmental effects.

Potential short-term impacts of the alternatives

Potential short-term impacts to air quality, background noise levels, visual resources, transportation systems, utilities, and energy supplies would occur principally during site characterization, monitor well construction, and construction of ground water remediation facilities. There would be little or no impact on these resources due to the short duration and small scale of the ground-disturbing activities. Site characterization, monitoring, and construction activities have the potential to disturb sensitive habitats, species, and cultural/traditional resources. The probability of these disturbances would be remote because site characterization and construction activities can take place in areas away from these resources. In addition, if impacts to these resources occurred, their effects could be mitigated. Therefore, the potential for site characterization and construction activities to adversely affect these resources would be considered minor.

Potential long-term impacts of the alternatives

Potential long-term impacts could arise under the following circumstances:

- If the contaminated ground water did not comply with EPA standards and its use was not controlled. This could occur under the no action alternative.
- If the ground water compliance strategy was not protective of human health and the environment at all sites. This could occur under the passive remediation alternative.
- If institutional controls were in place for many years. This could occur under all the alternatives except the no action alternative.

Significant adverse impacts to human health and the environment could result under the no action alternative. Under this alternative, the public could be exposed to hazardous contaminants by drinking contaminated ground water or surface water that is a surface expression of contaminated ground water. Further, minority and/or low-income communities would be disproportionally impacted under no action. Adverse impacts to the environment could potentially occur if contamination enters the food chain (such as through livestock or produce) or affects sensitive habitats (such as wetlands) or threatened and endangered species. These potentially significant adverse impacts probably would not occur under the proposed action or the active remediation to background levels alternative, because these alternatives would comply with EPA standards at all UMTRA Project sites. In addition, surface and ground water monitoring would take place before and during implementation of the proposed action and the active remediation to background levels alternative to ensure the public is not exposed to existing or potential surface and ground water contamination.

Implementation of the passive remediation alternative also could result in potential exposure of humans and the environment to hazardous contaminants. During the time required to implement the passive remediation alternative, contaminated ground water could reach potential receptors such as domestic wells or surface water features. Both the proposed action and active remediation to background levels alternatives would use hydrogeologic data and risk assessments to identify the need for implementing active remediation strategies to remediate ground water quickly or divert the flow of contamination.

Implementation of institutional controls could result in potentially significant long-term land use and social and economic impacts. The passive remediation alternative could result in the need for institutional controls for more than 100 years if protection of the public and the environment were necessary. The proposed action and the active remediation to background levels alternatives would implement strategies to achieve ground water compliance within 100 years.

In summary, the proposed action and active remediation to background levels alternatives are most effective in protecting human health and the environment from the contaminated ground water at the UMTRA Project sites. When cost is factored in, the proposed action likely would be more cost-effective than the active remediation alternative, because it can rely on less costly passive ground water compliance strategies at sites where these strategies are shown to be protective of human health and the environment. Implementing the active remediation to background levels alternative would be the most costly because active ground water remediation methods would be used at most sites. In addition, both alternatives would result in compliance with the EPA ground water standards so the active remediation to background levels, with its reliance on active ground water remediation, would provide no additional benefits to human health and the environment.

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1.0 INTRODUCTION

From 1943 to 1970, much of the uranium ore mined in the United States was processed by private companies under procurement contracts with the U.S. Atomic Energy Commission. This ore was used in national defense research, weapons development, and the developing nuclear industry. After fulfilling their contracts, many of the uranium mills closed and left large quantities of waste, such as uranium mill tailings and abandoned mill buildings, at the mill sites.

Beginning in the late 1960s and 1970s, direct gamma radiation, radon gas, and uranium decay products at the abandoned mill sites were determined to be potential health hazards. In 1972 concern for the potential long-term adverse health affects from uranium mill tailings used as fill material in construction projects in Grand Junction, Colorado, led Congress to pass Title II of Public Law 92-314, which authorized the Atomic Energy Commission to pay for 75 percent of the cost of remediating such contaminated buildings. Public concern about other abandoned uranium mill sites led to engineering and radiological studies to identify other mill sites in need of cleanup. As a result of these studies Congress passed the *Uranium Mill Tailings Radiation Control Act* (UMTRCA) on November 8, 1978 (42 USC §7901 *et seq.*).

The UMTRCA directed the U.S. Department of Energy (DOE) to stabilize, dispose of, and control, in a safe and environmentally sound manner, uranium mill tailings at the designated inactive uranium mill sites. To comply with the law, DOE established the Uranium Mill Tailings Remedial Action (UMTRA) Project. Under the UMTRA Project, DOE has been performing remedial action of the surface contamination (including uranium mill tailings and abandoned mill buildings) since 1983; this effort is called the UMTRA Surface Project. The first site to be cleaned up is in Canonsburg, Pennsylvania; surface remediation has now been completed at 18 sites and is under way at four sites. The designated uranium mill sites at Belfield and Bowman, North Dakota, will not be remediated by DOE because the state of North Dakota has declined to provide their statutorily required cost-sharing to remediate the sites. Although it is unlikely that these two sites will be part of the UMTRA Ground Water Project, discussion of the sites is still included in the programmatic environmental impact statement (PEIS). The Surface Project is responsible for controlling the exposure and dispersion of uranium mill tailings and other contaminated materials by stabilizing this material in disposal cells. However, the Surface Project does not address the remediation of contaminated ground water at the UMTRA Project sites. Information about the Surface Project is summarized in Sections 3.1 and 3.2 of this PEIS.

The UMTRA Ground Water Project addresses residual ground water contamination, if any, from the UMTRA Project processing sites. The Ground Water Project would take measures to protect human health and the environment by complying with EPA standards in a cost-effective and publicly acceptable manner. The UMTRA Ground Water Project also would address potential ground water contamination associated with vicinity properties (properties outside the processing site boundary contaminated with tailings) on a case-by-case basis.

The volume of tailings at vicinity properties is, in almost all cases, much less than the volume of the tailings at the abandoned processing sites. The volume of tailings is just one of the criteria for determining if the vicinity property would be a source for ground water contamination and would fall within the Ground Water Project. Another difference between contamination from a processing site and a vicinity property site is that processing sites had the potential to impact ground water due to the use of chemicals, water discharge, and exposed saturated tailings. In most cases, the tailings were exposed to the environment for many years before remediation. Tailings at vicinity properties were not processed and typically were not exposed to the environment for many years, which would minimize or eliminate the potential for vicinity properties to be a source of ground water contamination. Other factors include depth to ground water, magnitude of source, soil and bedrock geochemistry, ground water recharge and discharge, background water geochemistry, climate, and condition of the vicinity property.

1.1 PURPOSE OF AND NEED FOR DOE ACTION

In the UMTRCA, Congress acknowledged the potentially harmful health effects associated with uranium mill tailings. As required by the UMTRCA, the U.S. Environmental Protection Agency (EPA) developed standards to protect the public and the environment from potential radiological and nonradiological hazards from the abandoned mill processing sites; these standards include exposure limits for surface contamination and concentration limits for ground water protection. DOE is responsible for performing remedial action to bring the surface and ground water contaminant levels at the abandoned mill processing sites into compliance with EPA standards. DOE accomplishes this function through the UMTRA Project. Remedial action is conducted with the concurrence of the U.S. Nuclear Regulatory Commission (NRC) and the full participation of affected states and in consultation with Indian tribes. In addition, the NRC, Hopi Tribe, and Navajo Nation are cooperating agencies in the preparation of this PEIS.

Uranium processing activities at most of the processing mill sites designated for remediation under the UMTRCA resulted in the formation of contaminated ground water beneath and, in some cases, downgradient of the sites. This contaminated ground water often has elevated levels of hazardous constituents such as uranium and nitrates. The purpose of the DOE UMTRA Ground Water Project is to protect human health and the environment by meeting EPA standards in areas where ground water has been contaminated with hazardous constituents from former processing sites.

A major first step in the UMTRA Ground Water Project is the preparation of this PEIS. This document analyzes potential impacts of the alternatives, including the proposed action, which is DOE's preferred alternative. These alternatives are programmatic in that they are plans for conducting the UMTRA Ground Water Project. The alternatives, which are described in Section 2.0, do not address site-specific ground water compliance. This PEIS is a planning document for the Ground Water Project and assesses the potential programmatic impacts of conducting the Project. It provides a method for determining the site-specific ground water compliance strategies and identifies data and information that are needed to prepare site-specific environmental impacts analyses more efficiently.

This PEIS satisfies a *National Environmental Policy Act* (NEPA) (42 USC §4321 *et seq.*) requirement by describing the proposed action and the alternatives and the existing conditions at the UMTRA sites, assessing potential impacts of the Ground Water Project as defined by the proposed action and the alternatives, and comparing the potential impacts of the proposed action and the alternatives.

1.2 URANIUM MILL TAILINGS RADIATION CONTROL ACT

Congress passed the UMTRCA in 1978 in response to concerns raised about potential radiation health hazards to the public from long-term exposure to uranium mill tailings (Figure 1.1). The purposes of the UMTRCA are to stabilize and control uranium mill tailings at designated inactive mill sites and to regulate uranium mill tailings at active processing sites.

The UMTRCA has three parts, or "titles." Title I directs DOE to complete remedial action at 22 inactive uranium mill sites at which all or a substantial portion of uranium was processed for sale to a federal agency, and which no longer had a license to process uranium ore as of January 1, 1978. The Secretary of Energy was given the authority to add sites to the list. Designated uranium processing sites will be or have been remediated under Title I (Figure 1.2). Title II directs NRC to regulate uranium mill tailings at those processing sites having an active license on January 1, 1978. Title II sites are in various stages of surface and ground water remediation by private mill site operators (under Title II ground water remediation is conducted in conjunction with surface remediation). Title II sites are being remediated independently of one another and of the Title I sites. Title III directs NRC to study whether two New Mexico uranium mill sites should be designated by the Secretary of Energy as processing sites under Title I; the mill sites were not so designated.

In an amendment to the UMTRCA, DOE was authorized to perform ground water remediation at the designated processing sites without a time limitation (42 USC §7922(a)). Congress also directed DOE to comply with EPA's proposed ground water regulations until such time as EPA promulgates final regulations (42 USC §7918(a)(3)). EPA issued its proposed ground water protection standards on September 24, 1987 (52 FR 36000). Planning for the Ground Water Project occurred while the proposed rules were in effect. On January 11, 1995, the EPA published the final rule (60 FR 2854).

The responsibility for fulfilling the legislative mandate under the UMTRCA is divided between DOE, NRC, EPA, Indian tribes, and states. Their roles are described in the following subsections.

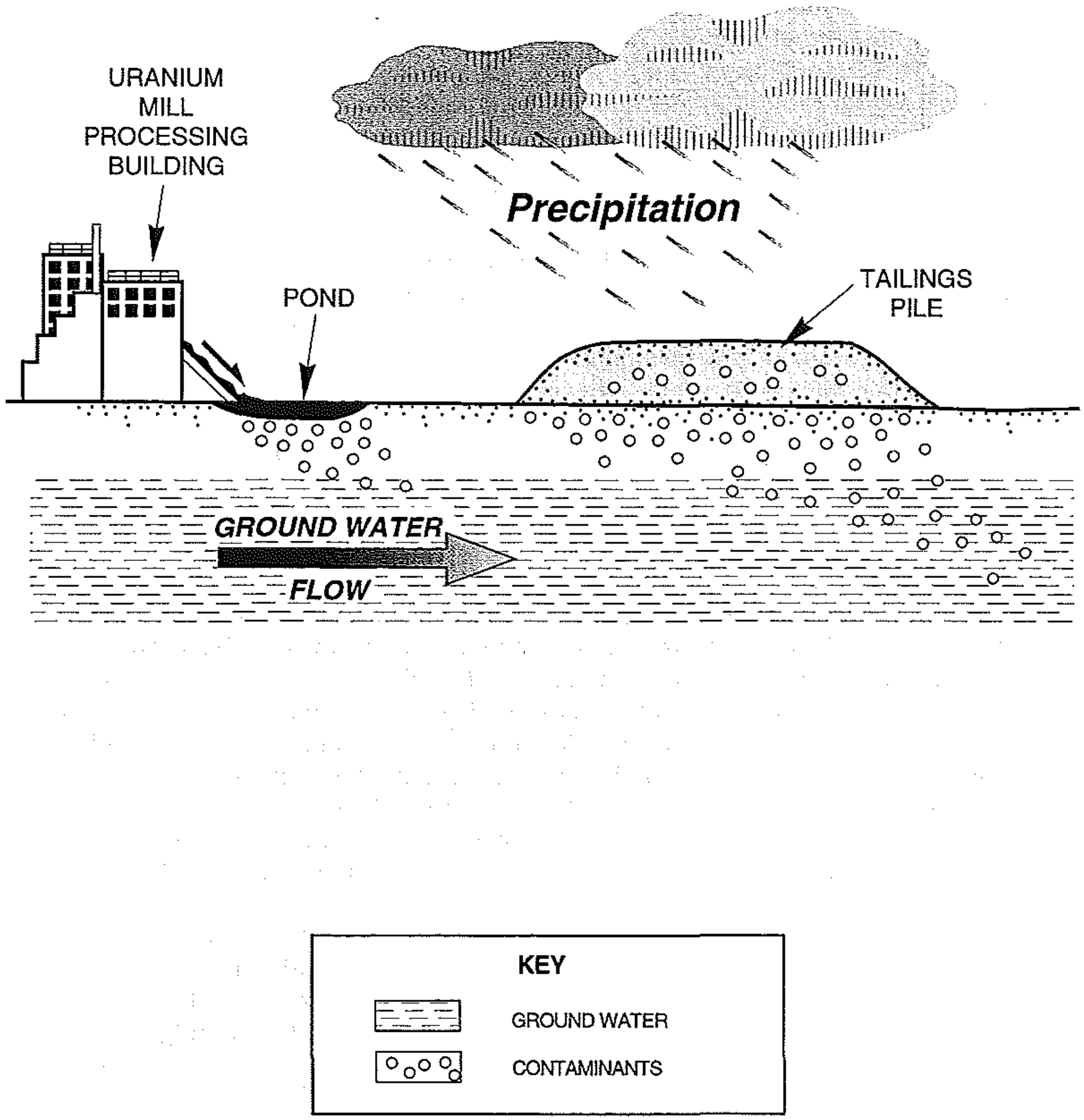


FIGURE 1.1
URANIUM MILL PROCESSING SITE

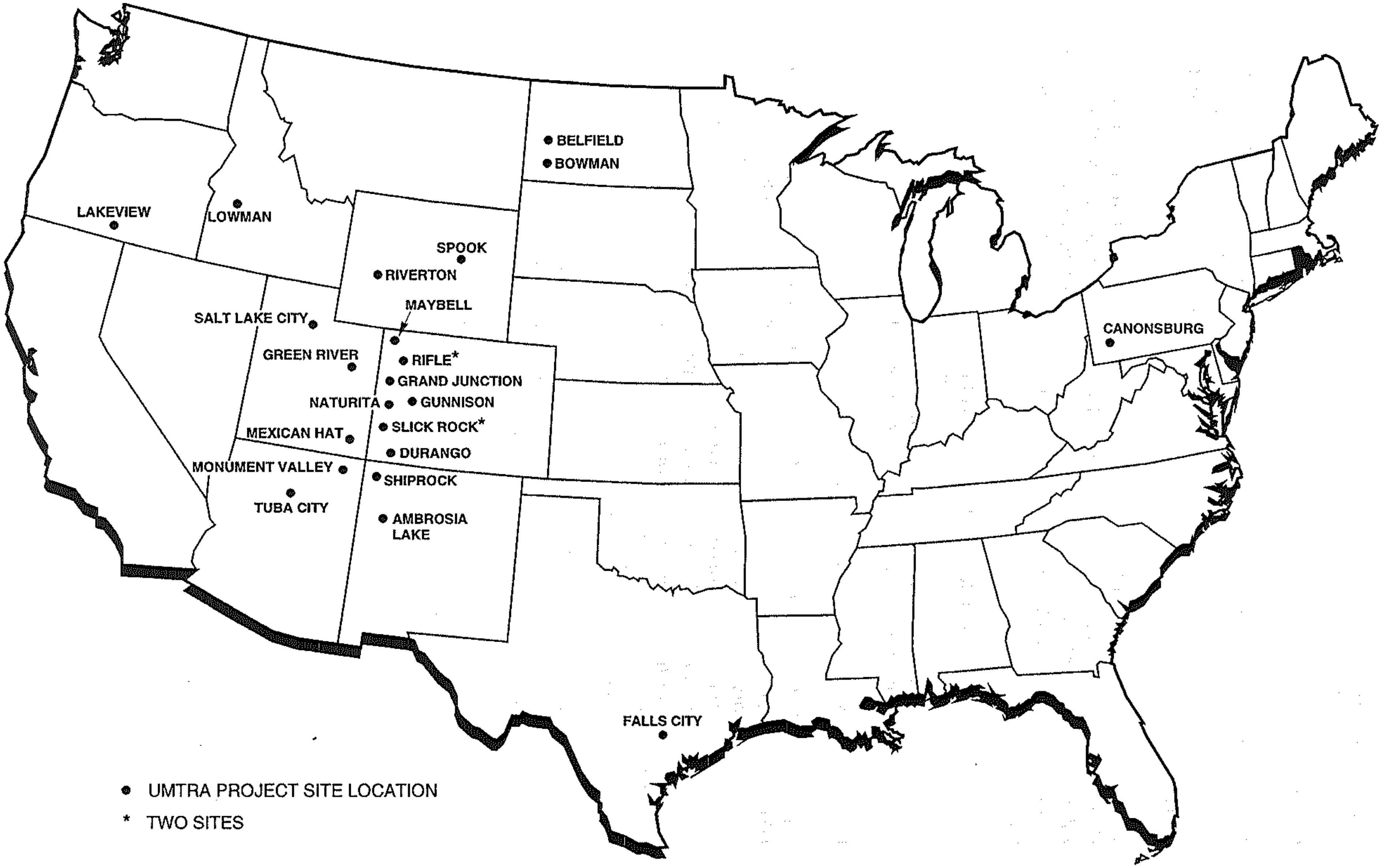


FIGURE 1.2
UMTRA PROJECT SITE LOCATION MAP

MAC: NONSITE/PEIS95/UMTRALOCMAP

1.2.1 U.S. Department of Energy

As the lead agency in the execution of the UMTRCA, DOE is responsible for the overall management of the UMTRA Project. This includes responsibility for all programmatic decisions and the review and supervision of all work completed by DOE contractors.

Within DOE, the Assistant Secretary for Environmental Management at DOE Headquarters oversees the administration of the UMTRA Project. The DOE Albuquerque Operations Office is the responsible field office, and daily operation of the UMTRA Ground Water Project is conducted by DOE's UMTRA Project Office in Grand Junction, Colorado.

DOE is committed to conducting the UMTRA Project in an environmentally sound manner that is protective of human health and the environment consistent with DOE Order 5400.1, *General Environmental Protection Program*, and in accordance with all applicable environmental laws.

1.2.2 U.S. Nuclear Regulatory Commission

The UMTRCA designated NRC as the federal regulatory oversight agency for the UMTRA Project. As part of this oversight responsibility, NRC published the *Final Generic Environmental Impact Statement on Uranium Milling* in 1980 (NRC, 1980). This document assessed the nature and extent of the impacts of uranium milling and provided information on what the regulatory requirements for management and disposal of mill tailings and mill decommissioning should be. This generic environmental impact statement is the programmatic environmental impact statement for the UMTRA Surface Project.

Remedial actions are selected and performed with the concurrence of the NRC. The NRC also licenses the completed disposal sites for long-term care. (Refer to Section 1.4, Regulatory Compliance, for a discussion of licensing.)

NRC provides technical and regulatory review of certain UMTRA Project documents, including remedial action plans, completion reports, long-term surveillance plans, and certification reports. An NRC concurrence with these documents is required to obtain a license for the disposal sites.

1.2.3 U.S. Environmental Protection Agency

As specified in the UMTRCA, EPA was required to establish standards for remediating and disposing of contaminated material from inactive uranium processing sites. Section 1.4, Regulatory Compliance, describes the EPA standards.

1.2.4 Indian tribes and states

Under the plan established by the UMTRCA, states participate fully in the selection and performance of remedial action for which states pay part of the cost (10 percent). Remedial action on Indian lands is to be selected and performed in consultation with the affected Indian tribes and the Bureau of Indian Affairs. Indian tribes are not required to pay any of the costs of remedial action.

The DOE has entered into cooperative agreements with the states and Indian tribes for the performance of the surface remedial action. New cooperative agreements for the UMTRA Ground Water Project, which would outline the new roles and responsibilities of the parties, would be negotiated between the DOE and the states and Indian tribes.

The participation of the states and Indian tribes in the UMTRA Ground Water Project would include review of major technical documents and activities related to site-specific ground water compliance. The states (including local governments) and Indian tribes also would play a key role in the implementation of institutional controls during ground water remediation, as appropriate.

The states and Indian tribes participated in the initial ground water PEIS activities, including the scoping meetings and hearings, and provided comments on the draft PEIS. In addition, the Hopi Tribe and Navajo Nation are cooperating agencies in the preparation of the PEIS.

The DOE recognizes that as a federal agency, it has a fiduciary duty to act in the best interests of the affected Indian tribes under the United States' trust responsibility with Indian nations. The DOE's policy with respect to its relationships with Indian tribes is more fully described in DOE Order 1230.2, *American Indian Tribal Government Policy.*

1.3 NATIONAL ENVIRONMENTAL POLICY ACT

The NEPA of 1969 (42 USC §4321 *et seq.*) declared a national policy for promoting efforts to prevent or eliminate damage to the environment. This act requires federal agencies to prepare a detailed statement that identifies and analyzes the environmental impacts of a proposed action that may significantly affect the quality of the human environment (42 USC §4321(c)). The Council on Environmental Quality (CEQ) regulations that implement NEPA (40 CFR Parts 1500-1508) provide requirements for carrying out the substantive and procedural elements of NEPA. The regulations also require that each federal agency develop its own implementing procedures (40 CFR §1507.3). The DOE implementing requirements for compliance with NEPA are contained in 10 CFR Part 1021.

As discussed in Section 1.2, UMTRCA directed DOE to perform remedial action that would stabilize and control the uranium mill tailings and associated contamination at inactive uranium processing sites in 10 states and on tribal lands. Implementation of UMTRCA represents a major federal action subject to NEPA requirements. In 1982, EPA prepared an environmental impact statement that analyzed the impacts of implementing the compliance standards (40 CFR Part 192) for the UMTRA Project (EPA, 1982). The DOE NEPA documents (environmental impact statements and environmental assessments) analyzing site-specific impacts of surface remediation have been completed for the sites. These documents are referenced in Section 3.2, Site Descriptions. Site-specific NEPA documents would be prepared for ground water activities.

One approach considered to address the programmatic impacts was to assess the impacts of the UMTRA Ground Water Project in DOE's waste management PEIS. Site-specific UMTRA Ground Water Project NEPA documents would have tiered off the waste management PEIS (the concept of tiering is described in Section 1.3.1). Although the UMTRA Project is part of DOE's Environmental Restoration Program, DOE is evaluating UMTRA Ground Water Project activities in a separate PEIS for four reasons. First, the UMTRA Project is an autonomous project with a clearly defined legislative, regulatory, and technical scope that is distinct from other DOE programs. Second, the NEPA process is complete for surface disposal of tailings at most UMTRA Project sites, and the Surface Project is expected to be near completion before a Record of Decision is issued for the Environmental Management Program PEIS. Third, the Environmental Management Program PEIS will not provide the level of detail necessary so that the site-specific NEPA documents can tier off the PEIS. Fourth, the UMTRA Project is regulated by NRC, while the Environmental Management Program sites are regulated primarily by EPA and the states. This PEIS is a comprehensive planning and decision-making document that would 1) provide the basis for determining the appropriate ground water compliance strategy at each UMTRA Project processing site; 2) assess the potential programmatic impacts of the UMTRA Ground Water Project; and 3) provide a tiering document for the site-specific NEPA documents.

The regulations for implementing NEPA provide for the preparation of program-wide environmental impact statements (40 CFR §1502.4(b)) for broad federal actions such as implementation of a new program or regulation. Programmatic NEPA documents are subject to the same preparation, issuance, and circulation requirements as other NEPA documents (10 CFR §1021.330).

1.3.1 Tiering

Preparation of the UMTRA Ground Water Project PEIS is consistent with the concept of tiering (40 CFR §1508.28), in which broad-scope environmental impact statements analyze general policy or program issues to facilitate subsequent site-specific decision-making. The NEPA implementing regulations encourage this tiering approach. These regulations indicate that the issues discussed in the broad, policy-level environmental impact statement need only be summarized or incorporated by reference into the site-specific NEPA documents that are published after the policy-level environmental impact statement. These site-specific documents focus on issues specific to actions that followed publication of the PEIS (40 CFR §1502.20). Programmatic issues that are analyzed in this ground water PEIS and would be summarized or incorporated by reference in the site-specific NEPA documents include the following:

- The framework for determining the ground water compliance strategy for meeting the EPA ground water standards at each UMTRA Project site (refer to Section 2.1)
- The categories of impacts to be assessed for each ground water compliance strategy (refer to Section 4.0)
- The assessment of impacts of programmatic alternatives (refer to Section 4.0)
- The methods for assessing risk (refer to Appendix B)
- The detailed discussions of ground water characterization and remediation methods (refer to Section 2.8 and Appendix C).

The site-specific NEPA documents would focus on issues relevant to ground water compliance decisions for a particular site. This approach would minimize the length of each site-specific NEPA document but would allow the assessment to address all pertinent environmental issues. This would include enough ground water data and analyses so the public and agencies can determine if the proposed ground water compliance strategy is appropriate.

<u>Pollution prevention</u>

Pollution prevention was addressed in the CEQ memorandum of January 12, 1993, "Pollution Prevention and the National Environmental Policy Act." Pollution prevention includes ". . . reducing or eliminating hazardous or other pollution inputs which can contribute to both point and non-point source pollution, . . ." and ". . . preventing the disposal and transfer of pollution from one media to another . . . ." Overall, the UMTRA Project can be considered a pollution prevention project because the Surface Project stabilizes the uranium mill tailings and other contaminated material into disposal cells, which prevents or inhibits the spread of contamination onto the land surface or into the ground water, and the Ground Water Project remediates contaminated ground water.

The Ground Water Project would address the prevention and potential spread of pollution, including contaminated ground water that has the potential to create human and ecological health risks; the discharge of contaminated sludge and water generated from ground water cleanup; the prevention of fugitive dust emissions from remedial action; and the prevention of the use of contaminated ground water through institutional controls. The site-specific environmental documents would assess specific avenues for pollution and measures to prevent this pollution at each of the UMTRA Project sites.

1.3.2 Cooperating agencies

NEPA mandates that all federal agencies seek comments from governmental agencies that have jurisdiction or special expertise with respect to any environmental impact involved in a proposed action or alternative (42 USC §4321(c)). The extent of participation by a cooperating agency varies from active participation in developing information and analyses for the environmental impact statement to the roles of consultation and review. The Navajo Nation, Hopi Tribe, and NRC are cooperating agencies for the PEIS.

Participation by affected tribes, states, other agencies, and local governments also is encouraged in the preparation of the PEIS. Representatives of the tribes, states, local governments, other agencies, and the public participated in scoping meetings and hearings, and provided comments on the draft PEIS (refer to Section 1.6). Information obtained from these sources was used to identify issues addressed in the draft PEIS and to revise it, where necessary. The PEIS implementation plan (DOE, 1994a) discusses the comments received during scoping and how those comments were addressed in the draft PEIS. Volume II of this final PEIS contains all comments received during the hearings and comment period, and DOE's responses. The affected tribes, states, and public, along with local and federal government agencies, would continue to be actively involved in the PEIS process and the site-specific environmental documents that would tier off the PEIS.

1.4 REGULATORY COMPLIANCE

The UMTRA Project is regulated by both EPA and NRC regulations (40 CFR Part 192 and 10 CFR Part 40, respectively). DOE must comply with EPA and NRC regulations for remediation of uranium mill tailings and associated ground water contamination and for long-term care. This section provides an overview of the regulations pertaining to ground water protection standards and describes the general requirements for long-term surveillance and monitoring at processing sites.

Decisions regarding consistency with tribal and state laws and regulations would be made by DOE, in consultation with the tribes and states. These decisions would consider cases where an approved wellhead protection area, under the Safe Drinking Water Act, is associated with the site. DOE would comply with the provisions of that legislation unless the President of the United States, through the EPA, grants an exemption.

1.4.1 EPA standards

The UMTRCA requires that EPA promulgate standards for protecting public health, safety, and the environment from radiological hazardous constituents associated with the processing, possession, transfer, and disposal of residual radioactive materials. The UMTRCA and EPA define residual radioactive materials as tailings and other wastes that DOE determines to be radioactive that have resulted from uranium ores processing. These wastes may be in the form of tailings or other materials such as demolition debris and nonradiological hazards associated with residual radioactive materials. EPA has interpreted this definition to include sludges and captured contaminated water from the processing sites (60 FR 2854).

On January 5, 1983, EPA published standards (40 CFR Part 192) for the disposal and cleanup of residual radioactive materials. On September 3, 1985, the U.S. Court of Appeals for the Tenth Circuit set aside and remanded to EPA the ground water provisions of the standards. EPA proposed new standards to replace remanded sections and changed other sections of 40 CFR Part 192. These proposed standards were published in the *Federal Register* on September 24, 1987 (52 FR 36000). Section 108 of the UMTRCA requires that DOE comply with EPA's proposed standards in the absence of final standards. The Ground Water Project was planned under the proposed standards. On January 11, 1995, EPA published the final rule, with which the DOE must now comply. The PEIS and the Ground Water Project are in accordance with the final standards. The EPA reserves the right to modify the ground water standards, if necessary, based on changes in EPA drinking water standards. Appendix A contains a copy of the 1983 EPA ground water compliance standards, the 1987 proposed changes to the standards, and the 1995 final rule.

The EPA standards have three subparts that apply to the UMTRA Project: Subpart A, Subpart B, and Subpart C.

Subpart A—Standards for residual radioactive materials

Subpart A, "Standards for the Control of Residual Radioactive Materials From Inactive Uranium Processing Sites," addresses control or disposal of the residual radioactive materials at processing or disposal sites. Compliance with Subpart A is being met under the UMTRA Surface Project. This subpart is not discussed further in the PEIS.

Subpart B—Background levels, maximum concentration limits, alternate concentration limits, monitoring, natural flushing

Subpart B, "Standards for Cleanup of Land and Buildings Contaminated With Residual Radioactive Materials From Inactive Uranium Processing Sites," requires conducting remedial action at processing sites to ensure that the amounts of residual radioactive materials and associated hazardous constituents in ground water do not exceed any one of the following three standards in 60 FR 2854:

- Background levels for these constituents

- Maximum concentration limits—EPA's maximum concentration of certain hazardous constituents for ground water protection. Hazardous constituents with maximum concentration limits that may be present in contaminated ground water at UMTRA Project sites include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, nitrate, radium, selenium, silver, and uranium.

- Alternate concentration limits—concentrations of contaminants that may exceed the maximum concentration limits; or, limits for those constituents without maximum concentration limits. If DOE determines, and NRC concurs, that human health and the environment would not be adversely affected, DOE may meet an alternate concentration limit.

Subpart B also defines limited use ground water. Ground water may be classified as limited use if the total dissolved solids exceed 10,000 milligrams per liter (mg/L); there is widespread surrounding contamination that cannot be cleaned up using treatment methods reasonably employed in public water supply systems; or the quantity of ground water available is less than 150 gallons (gal) (570 liters [L]) per day.

Subpart B also has provisions that allow natural flushing as a way to meet the EPA ground water standards. Natural flushing means letting natural ground water processes reduce the contamination in ground water to background levels, below the maximum concentration limits, or to alternate concentration limits. The following conditions must be met before natural flushing can be implemented:

- Natural flushing must allow standards (background levels, maximum concentration limits, or alternate concentration limits) to be met within 100 years.

- Institutional controls with a high degree of permanence that will effectively protect public health and the environment, and satisfy beneficial uses of ground water must be viable and enforceable (a description of institutional controls is provided below).

- Ground water must not be a current or projected source for a public water system during the period of natural flushing. A public water system is defined in 40 CFR §125.58 as a "system for the provision to the public of piped water for human consumption, if such system has at least fifteen (15) service connections or regularly serves at least twenty-five (25) individuals. This term (public water system) includes 1) any collection, treatment, storage, and distribution facilities under the control of the operator of the system and used primarily in connection with the system; and 2) any collection of pretreatment storage facilities not under the control of the operator of the system which are used primarily in connection with the system."

Subpart B also requires that DOE monitor the ground water contamination for compliance with Subpart B standards and define the extent of ground water contamination so that measures can be taken, if necessary, to protect human health and the environment.

The EPA standards specify a point of compliance for disposal of the surface contamination but indicate that this does not suffice for the cleanup of contaminated ground water. For the Ground Water Project, "compliance must be achieved anywhere contamination above the levels established by these standards is found or projected to be found in ground water outside the disposal area and its cover" (60 FR 2854).

Subpart C—Implementation

Subpart C, Implementation, provides guidance for implementing methods and procedures that will reasonably assure the public that the provisions of Subparts A and B are satisfied. The conditions of Subpart B should be met on a site-specific basis, using information gathered from site characterization and monitoring. The plan to meet the conditions of Subpart B should be stated in the compliance strategy document or remedial action plan. This plan should also consider future ground water plume movement. If natural flushing is the selected compliance strategy, Subpart C requires compliance monitoring to verify anticipated plume movement and the associated reduction in plume contamination. Finally, the plan should specify details of the method to be used to meet the standards and, if necessary, the remedial action.

Supplemental standards

Subpart C specifies eight conditions for which DOE may apply supplemental standards to contaminated ground water. These standards are supplemental to background levels, maximum concentration limits, or alternate concentration limits. Supplemental standards as cited below in 40 CFR §192.21 may be applied if any one of the following conditions is met:

a) Remedial actions required to satisfy Subpart A or B of the standards would pose a clear and present risk of injury to workers or to members of the public, notwithstanding reasonable measures to avoid or reduce risk.

b) Remedial actions to satisfy the cleanup standards for land and ground water, notwithstanding reasonable measures to limit damage, would directly produce health and environmental harm that is clearly excessive compared to the health and environmental benefits, now or in the future. A clear excess of health and environmental harm is harm that is long-term, manifest, and grossly disproportionate to health and environmental benefits that may reasonably be anticipated.

c) The estimated cost of remedial action to meet the standards at a "vicinity" site is unreasonably high relative to the long-term benefits, and the residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a vicinity site should be considered in evaluating this hazard. Remedial action will generally not be necessary where residual radioactive materials have been placed semi-permanently in a location where minor quantities of residual radioactive materials are involved. Examples are residual radioactive materials under hard surface public roads and sidewalks, around public sewer lines, or in fence post foundations. Supplemental standards should not be applied at such sites, however, unless individuals are likely to be exposed for long periods of time to radiation from such materials at levels above those that would prevail under the standards.

d) The cost of a remedial action for cleanup of a building under the standards is clearly unreasonably high relative to the benefits. Factors that should be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be affected by the remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of less costly remedial methods than removal of residual radioactive materials.

e) There is no known remedial action.

f) The restoration of ground water quality at any designated processing site is technically impracticable from an engineering perspective.

g) The ground water is not a current or potential source of drinking water, in the absence of contamination from residual radioactive materials, due to the following:

- the concentration of total dissolved solids is in excess of 10,000 mg/L or,

- widespread, ambient contamination not due to activities involving residual radioactive materials from a designated processing site exists that cannot be cleaned up using treatment methods reasonably employed in public water systems. Ambient conditions caused by natural or human-induced conditions exclude contributions from residual radioactive materials or,

- the quantity of water reasonably available for sustained continuous use is less than 150 gal (570 L) per day. The parameters for determining the quantity of water reasonably available shall be determined by the DOE with the concurrence of the NRC.

h) Radionuclides other than radium-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials.

The standards that most likely would apply to the Ground Water Project are b, e, f, and g above.

The EPA final rule states that if supplemental standards are applied, DOE must select and perform remedial action that comes as close to meeting the otherwise applicable standard as reasonably achievable. Supplemental standards must also ensure that current and projected uses of the affected ground water are preserved.

Institutional controls

Institutional controls are controls that effectively protect public health and the environment. They typically depend on some social order to ensure that protection is effective. On the UMTRA Ground Water Project, institutional controls would reduce exposure to or mitigate health risks by 1) preventing intrusion into contaminated ground water, or 2) restricting access to or use of contaminated ground water for unacceptable purposes. As a last resort, institutional controls could limit human access to the land above the contaminated ground water. The EPA standards allow the use of institutional controls in place of remediation only if their effectiveness can be verified and maintained. The EPA standards permit the use of institutional controls at sites where remediation can occur through natural flushing of the aquifer within 100 years. However, the standards do not limit the use of institutional controls to the sites that can meet the standards through natural flushing. Institutional controls may also be used to protect public health or the environment when DOE finds them necessary and appropriate prior to commencing active remedial action, during active remedial action, or during implementation of other compliance strategies.

The EPA standards require that institutional controls

- have a high degree of permanence.
- protect public health and the environment.
- satisfy beneficial uses of ground water.
- are enforceable by administrative or judicial branches of government entities.
- can be effectively maintained and verified.

An example of acceptable institutional controls cited in the EPA standards is deed restriction that can be enforced by a unit of government (either administratively or through judicial processes). Another example is federal or state ownership of land containing contaminated ground water. EPA recognizes that a combination of controls may be needed to adequately protect public health and safety. Measures such as signs, health advisories, or other measures that require voluntary cooperation of private parties can be used to complement other enforceable institutional controls but cannot be considered as primary protective measures. In addition, the use of an alternate water supply in conjunction with institutional controls that would prevent human contact with contaminated ground water would be a viable institutional control.

Key to identifying, implementing, and enforcing institutional controls is participation by tribal, state, and local governments. While DOE is responsible for compliance with the EPA standards at UMTRA sites, its authority to implement and enforce institutional controls may be limited, particularly where tailings are disposed of off the processing site and land is privately owned or is owned or controlled by tribal, state, or other public agencies. Similarly, ground water contamination from uranium processing may have moved beyond the processing site to areas that are not within the DOE jurisdiction.

The need for and duration of institutional controls depends on the compliance strategy selected for a site, the type and level of risk, and existing site conditions. As risks decrease over time, so should the restrictiveness of institutional controls. Contaminated plume movement might require applying the restrictions to an extended area over time. Therefore, to ensure extended protection of public health, the environment, and beneficial uses the water could have satisfied, it is important that the effectiveness of institutional controls can be verified and modified as necessary.

Institutional controls, if any, will be selected in cooperation with the Indian tribes, states, and local governments. DOE will verify that the institutional controls are effective. Site-specific institutional controls will not be selected and implemented without DOE and NRC concurrence.

1.4.2 <u>NRC licensing regulations and program</u>

The UMTRCA authorized DOE to care for the uranium mill tailings disposal sites under a license issued by NRC. The UMTRCA stipulates the NRC will promulgate regulations to ensure the permanent disposal sites are monitored and maintained in accordance with the general license. Regulations in 10 CFR §40.27, *General License for Custody and Long-Term Care of Residual Radioactive Material Disposal Sites,* describe the licensing mechanism for the long-term care of each UMTRA Project disposal site, when NRC accepts the site-specific long-term surveillance plan. Long-term care includes surveillance and maintenance needed to protect public health and safety.

<u>On-site stabilization</u>

At former processing sites where tailings are stabilized in on-site disposal cells, contaminated ground water may require remediation. This could occur if ground water moves from below the disposal cell. The NRC may license these disposal sites in two steps. The first step is NRC's acceptance of the long-term care program for all surface remedial action that includes compliance with the EPA standards that protect the ground water from further contamination from the tailings. In the second step, the DOE must verify, and NRC must concur, that ground water compliance has been met in accordance with 40 CFR Part 192, Subpart B. The long-term surveillance plan will be appropriately amended, signifying that the second step of the licensing process is complete.

Off-site stabilization

For the disposal cells where the residual radioactive materials were relocated off the processing site, NRC will license the disposal site in one step. The processing sites themselves will not be licensed by NRC. Compliance with EPA ground water standards will require NRC concurrence.

1.4.3 DOE requirements

DOE Order 5400.1, *General Environmental Protection Program,* established environmental protection program requirements for DOE operations, including the UMTRA Project, for ensuring compliance with executive orders and applicable federal, tribal, state, and local environmental protection laws and regulations. DOE also established requirements for the protection of the public and workers from radiological hazards in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*; DOE Order 5480.11, *Radiation Protection for Occupational Workers*; and 10 CFR Part 835, *Occupational Radiation Protection.* These and all other applicable requirements are routinely incorporated into UMTRA Project activities.

1.4.4 DOE Office of Environmental Justice requirements

Executive Order 12898, *Federal Action to Address Environmental Justice in Minority Populations and Low Income Populations*, directs federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations. Executive Order 12898 also directs the EPA administrator to convene an interagency Federal Working Group on Environmental Justice. The Working Group is directed to provide guidance to federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority and low-income populations. The Working Group has not yet issued the guidance directed by Executive Order 12898. In coordination with the Working Group, the DOE is in the process of developing internal guidance on implementing the Executive Order. Because both the Working Group and the DOE are still in the process of developing guidance, the approach taken in this analysis may depart somewhat from the guidance that is eventually issued, but will comply with the intent of the Executive Order.

1.4.5 Other Presidential Executive Order requirements

Executive Order 11990, *Protection of Wetlands*, requires all federal agencies to issue or amend existing procedures to ensure wetlands protection is considered in decision-making. This requirement is routinely incorporated into UMTRA Project activities.

Executive Order 11988, *Floodplain Management*, requires each federal agency to issue or amend existing regulations and procedures to ensure that the potential effects of any action it may take in a floodplain are evaluated and that its planning programs and budget requirements reflect consideration of flood hazards and floodplain management. The UMTRA Project activity planning routinely identifies and considers the impacts of Project actions on floodplains.

1.4.6 Tribal law requirements

The DOE shall follow all applicable tribal laws and regulations in performing ground water compliance activities on Indian lands. In the event of conflicting applications of federal, state, and tribal law, the subject activity will be carried out pursuant to the following order of priority in application: 1) federal, 2) tribal, and 3) state.

1.5 PROPOSED ACTION SUMMARY

This PEIS considers four approaches (also called "alternatives") for implementing the UMTRA Ground Water Project. These alternatives are described in Section 2.0. The proposed action (preferred alternative) is summarized below.

The proposed action provides a consistent approach, based on a health- and environmental risk-based framework, for implementing the UMTRA Ground Water Project and determining appropriate ground water compliance strategies at the UMTRA Project processing sites. The success of the proposed action in determining these strategies would depend on the analysis of site-specific data to characterize the hydrogeological conditions and determine the potential human health and environmental risks.

The following site-specific ground water compliance strategies could be used under the proposed action:

- No remediation
- Natural flushing
- Active ground water remediation.

These strategies could be used individually or in combination to meet the standards. For example, active ground water remediation methods could be used in conjunction with natural flushing.

The proposed action is flexible because it provides a framework for the Ground Water Project decision-making process if new ground water cleanup methods become available. The proposed action considers ground water compliance in a step-by-step approach, beginning with the no remediation strategy and ending with more complex, active ground water cleanup strategies. When a site baseline risk assessment for ground water contamination and a site observational work plan indicate the no remediation strategy would be protective of human health and the environment, a more complex and potentially disruptive strategy involving active cleanup methods would not be necessary. The proposed action would tailor ground water compliance strategies for each site, based on the likelihood that they would result in conditions that are protective of human health and the environment. A more detailed description of the proposed action appears in Section 2.1.

1.6 PUBLIC PARTICIPATION

An important component of the PEIS is the participation by government agencies, organizations, the public, and other interested parties in determining the scope and content of this PEIS and reviewing and commenting on the draft and final PEIS. Throughout the UMTRA Ground Water Project, the DOE will provide opportunities for productive, ongoing discussions with the public and local, state, tribal, and federal officials as part of DOE's daily activities.

Regulations that implement NEPA (in 40 CFR §1501.7) stipulate there must be an early, open, and continuing public participation process for determining the scope of the issues that will be addressed and for identifying significant issues related to the proposed action. This process is called scoping. The UMTRA Ground Water Project PEIS scoping process began with the preparation of a Notice of Intent, published in the *Federal Register* on November 18, 1992 (57 FR 54374). This notice provided dates, locations, and times of the first scoping meetings. Dates, locations, and times of the remaining public scoping meetings were published in the *Federal Register* on February 8, 1993 (58 FR 7551). Nineteen public scoping meetings in 16 communities were held between November 18, 1992 and April 15, 1993 to solicit public input regarding the scope and content of the PEIS (Figure 1.3).

The UMTRA Ground Water Project PEIS implementation plan summarizes the comments received during scoping and provides DOE's response to how the comments were addressed in the PEIS (DOE, 1994a). A complete list of all comments received is archived in the UMTRA Project Document Control Center.

The NEPA and DOE implementing regulations also require that at least one public hearing be held for the public to comment on the draft PEIS (10 CFR §1021.313). A notice of availability (NOA) of the draft PEIS was published in the *Federal Register* on May 17, 1995 (60 FR 26417). The NOA summarized the proposed action, provided background information on the UMTRA Ground Water Project, described the public comment process, and announced the dates, times, and locations of the public hearings. Nine public hearings were

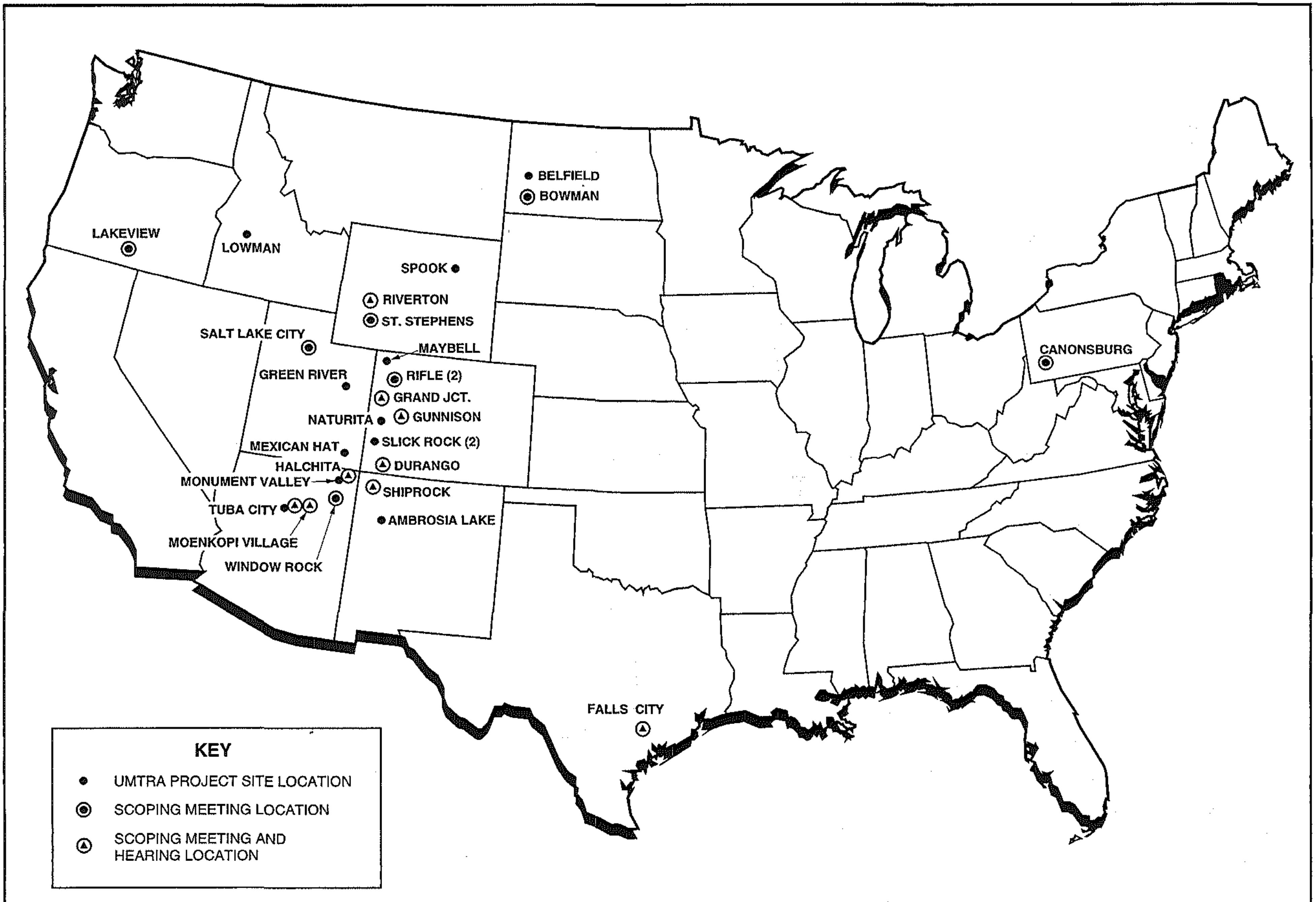


FIGURE 1.3
UMTRA PROJECT SITE AND SCOPING MEETING AND HEARING LOCATIONS

MAC: NONSITE/PEIS95/MTGLOCS

conducted in nearby site communities between June 7 and 28, 1995, to solicit public input on the draft PEIS (Figure 1.3).

The PEIS public affairs program provides continued opportunities for public involvement throughout the UMTRA Ground Water Project. This section provides an overview of the participation process for the PEIS and the planned course of action for future public participation in the Ground Water Project.

1.6.1 Scoping process and results

DOE encouraged members of the public, tribal and state representatives, and other agencies to participate in scoping. Notices announcing the start of scoping were placed in the *Federal Register* and advertisements were placed in local newspapers and on local radio stations. Orientation meetings were held at some sites to explain the scoping process to the public. Congressional representatives and state and local agencies were contacted during prescoping community assessments to determine the scoping activities that would work best in individual communities. Media briefings were held and media briefing kits were available prior to scoping meetings to announce the opportunities for public participation. UMTRA Project spokespersons were available before and after scoping meetings for interviews.

Several communication methods facilitated scoping: fact sheets were prepared and distributed that described the PEIS process, the proposed action and alternatives, ground water contamination, ground water remediation technologies, and site-specific conditions. In recognition of non-English speaking community members, DOE offered translation services upon request. At meetings held for the Navajo Nation, a Navajo language interpreter was used during the presentation and group discussions. A Navajo language audio tape of the scoping materials was produced and distributed to Navajo Nation radio stations, chapter houses, and libraries. The scoping meetings included viewgraph presentations and small group discussions with technical staff.

More than 500 scoping comments were received. Comments were accepted at the scoping meetings, through the mail, and by telephone via a toll-free number.

DOE reviewed all scoping comments. The comments generally indicated four categories of concern: human health and the environment, programmatic issues, ground water monitoring and site characterization, and site-specific Surface Project comments. The PEIS Implementation Plan (DOE, 1994a) summarizes these comments and describes how they were to be addressed in the draft PEIS.

1.6.2 Public hearings and comment period

A 120-day public comment period and nine public hearings were held after the draft PEIS was published. Information on the availability of the draft PEIS, methods for submitting comments, and the date, time, and place of the public hearings were announced in the *Federal Register*, in local newspapers, and on radio stations.

Many of the same communication methods that were used in the scoping meetings were used to encourage participation at the public hearings. Both before and after media briefings, UMTRA Project spokespersons were available for interviews and further discussion. Fact sheets were prepared that described the PEIS and the Ground Water Project, and translation services were provided at hearings held at Navajo Nation and Hopi Tribe sites. The public hearings followed an interactive format to facilitate communications between DOE representatives and people who attended the hearings. An independent facilitator conducted the meetings following overview presentations by DOE UMTRA Project site managers and Ground Water Project managers. Oral comments were recorded on flip charts and clarified as necessary to ensure accuracy in recording. Project personnel also responded to comments and discussed issues raised during the meetings.

A total of 576 comments were received at the public hearings, through the mail, and by telephone via a toll-free number. Comment topics included, but were not limited to, the alternatives, ground water compliance strategies, EPA ground water standards, institutional controls, costs, human health and environmental risks, prioritization, ground water characterization, and future public participation. Comments were evaluated and incorporated as applicable into this final PEIS. The comments and response document (Volume II) that accompanies the PEIS provides all written and oral comments received, DOE's responses, and changes made to the document, as appropriate.

1.6.3 Future public participation activities

The final PEIS will be distributed to the public for at least 30 days before the Record of Decision is issued. The Record of Decision will announce the DOE decision regarding how to conduct the Ground Water Project. It also will summarize the mitigation measures that will be taken to avoid or minimize potential human health and environmental impacts (40 CFR §1505.2).

DOE's commitment to encouraging public participation would continue during site-specific ground water compliance activities at many UMTRA Project processing sites. This would include providing information on ground water characterization activities and risk assessments, and seeking input regarding site-specific ground water compliance decisions. DOE will use various methods of communication including announcements through local media to notify the public of opportunities to meet with DOE representatives.

Site-specific NEPA documentation (for example, categorical exclusions and environmental assessments) would be prepared. They would assess preremediation activities, the proposed ground water compliance strategy and alternatives, analyze impacts of implementing compliance actions, and specify any mitigation measures that might be necessary to reduce adverse impacts.

DOE expects that environmental assessments will be appropriate in most cases for final compliance action.

If DOE determined that an environmental assessment is appropriate, DOE would notify the host state and host tribe of the determination to prepare an environmental assessment and would involve the public to the extent practical during its preparation; early public notice of the intent to prepare this document would be provided concurrent with tribal and state notification (10 CFR §1021.301(c); 40 CFR §1501.4(b)).

Before approving any site-specific plans, DOE would make the plans available to the host state and tribe for review and comment, in compliance with NEPA and DOE. Under the Secretary of Energy's NEPA policy statement, DOE ordinarily provides enhanced opportunities for interested persons to review and comment on environmental assessments concurrently with tribal and state review.

In accordance with DOE policy, the UMTRA Project intends to conduct public meetings on the site-specific plans in the affected site communities. The DOE would solicit input from the public, local organizations, and educational institutions on site-specific issues that should be identified, considered, and analyzed in the effort to meet ground water compliance.

2.0 ALTERNATIVES

This section describes the options (alternatives) for conducting the UMTRA Ground Water Project at the inactive UMTRA Project processing sites and summarizes the comparison of the potential impacts of the alternatives. These impacts are considered in detail in Section 4.0. This section also describes alternatives considered but eliminated from further analysis, site-prioritization methodology, risk assessment methodology, ground water characterization and remediation methods, waste management methods, and costs.

CEQ requires that an environmental impact statement "rigorously explore and objectively evaluate all reasonable alternatives" (40 CFR §1502.14(a)). Reasonable alternatives include those that are practical or feasible from a technical and economic standpoint using common sense, and are not simply desirable from the standpoint of the applicant (51 FR 15618). Reasonable alternatives can be outside the jurisdiction of the lead agency and potentially in conflict with existing federal law. When there are many potential alternatives, a reasonable number of examples covering the full spectrum of alternatives must be analyzed and compared (51 FR 15618).

Numerous alternatives were evaluated during the planning stages of the PEIS. Five alternatives, including the proposed action, were included in the published Notice of Intent to prepare the PEIS (57 FR 54374). These alternatives represented a preliminary list; public comment on these and other alternatives was part of prescoping and scoping meetings (DOE, 1994a). As a result of the scoping process and other planning activities, four alternatives, including the proposed action, were selected for analysis in this PEIS.

All these alternatives, except no action, would rely on at least one of three ground water compliance strategies to meet the EPA ground water compliance standards (Table 2.1). The simplest strategy is one in which no remediation is required, and there are two conditions where this strategy can be used. The first condition where no remediation would work is if the tailings have not contaminated the ground water or if the contamination is limited and does not meet the numerical EPA standards referred to as maximum concentration limits; i.e., the contamination is so low that it is below the level allowed by EPA. Second, if the concentrations of certain constituents exceed the maximum concentration limits or background concentrations, there are two situations in which the EPA has determined that cleanup is not required. One is the use of supplemental standards. One example of Supplemental Standards is where the ground water was of such poor quality prior to the milling operation that removing the tailings-related contamination from the groundwater would not raise the quality of the water such that it would or could be used (referred to as limited-use ground water). The second is the use of alternate concentration limits. An alternate concentration limit is a numerical concentration for a contaminant that is higher than the maximum concentration limit in the EPA standards or background, but for which it can be shown that human health and the environment would not be adversely affected. If alternate concentration limits are used, the DOE must demonstrate that the higher levels of contamination do not pose excessive health and environmental risks.

A potentially more complicated ground water compliance strategy is natural flushing. Once the surface tailings and other contaminated materials are contained in disposal cells, contamination of the groundwater should greatly diminish. At some of the sites, the natural processes of nature will attenuate the contamination over time. If these natural processes can reduce the contamination to acceptable numerical levels such as maximum concentration limits, background levels, or alternate concentration limits within 100 years, and meet the other criteria for the use of natural flushing as discussed in Section 1.4.1, its use is permitted by the EPA standards. Under this strategy the DOE must demonstrate through analysis that the constituents will be reduced by natural flushing within 100 years or less. One element of implementing natural flushing that is permitted by the EPA standards is the use of institutional controls. Institutional controls, if any, will be selected in cooperation with the Indian tribes, states, and local governments. If natural flushing is implemented, a monitoring program will be established. If it is determined that natural flushing does not work as predicted, DOE would then consider implementing the active ground water compliance strategy.

Table 2.1 Ground water compliance strategies that apply under each alternative

	Alternative			
Strategy	**Proposed action**	**No action**[a]	**Active remediation to background levels**	**Passive remediation**
Active ground water remediation methods	√		√[b]	
Natural flushing [c]	√			√
No ground water remediation				
- Sites that qualify for supplemental standards [d] or alternate concentration limits[e].	√			√
- Sites that meet maximum concentration limits or background levels (no impacts).[f]	√			√

[a]The analysis of the no action alternative is required by the CEQ and DOE.

[b]Active remediation methods would not be used at sites where contamination does not exceed background and likely would not be used at sites that qualify for supplemental standards based on the existence of limited use ground water.

[c]Natural flushing means allowing the natural ground water movement and geochemical processes to decrease contaminant concentrations.

[d]Supplemental standards applicable for certain site conditions, as identified in the EPA standards, that are protective of human health and the environment, and may be applied in lieu of prescriptive levels.

[e]Concentrations of contaminants that may exceed the maximum concentration limits; or, limits for those constituents without maximum concentration limits. If DOE demonstrates, and NRC concurs, that human health and the environment would not be adversely affected, DOE may meet an alternate concentration limit.

[f]"No remediation" at sites that do not exceed maximum concentration limits or background levels is not the same as "no action" because these sites would require activities such as site characterization to show that no remediation is warranted.

Finally, the most complex strategy is active remediation. If there is excessive contamination and if natural processes will not attenuate it as required by the EPA standards, active control or removal of the contamination is necessary. The classic approach is to pump the contaminated water and treat it to remove the contamination, but other, newer, more effective technologies may also be possible.

The process of selecting a site-specific ground water compliance strategy includes several levels of analysis that are not explicitly required by the current regulations, but will help in selecting the best strategy. One of these is to prepare a baseline risk assessment. The baseline risk assessments were prepared using existing ground water quality data collected during the Surface Project and limited additional data. They provide detailed analysis of human and environmental exposures to all of the known contaminants of concern, as well as data gaps, if any. Risks can then be evaluated to determine the appropriate strategy (risk assessments are described in more detail in Section 2.7 and Appendix B). Another key document is the site observational work plan. The site observational work plan addresses the ground water conditions at a site and documents how DOE will demonstrate compliance with the standards. It includes the various techniques that will be used to further characterize a site and is the basis for making the final recommendation to the NRC.

The four alternatives analyzed in this PEIS are as follows:

- Proposed action—DOE would use a consistent, risk-based decision process to comply with the EPA standards at the processing sites. The DOE would use active, passive, and/or no remediation ground water compliance strategies to meet the EPA ground water standards at the UMTRA Project sites. The site-specific ground water compliance strategies would be based on site conditions, potential risks, and input from the affected tribes, states, and public.

- No action—DOE would not conduct the UMTRA Ground Water Project. Contaminated ground water would remain as is, and no further action would be made to protect human health and the environment.

- Active remediation to background levels—DOE would use a combination of active remediation strategies at most sites to clean up ground water quality to as close to background levels as possible and meet the EPA ground water standards.

- Passive remediation—DOE would use natural flushing or no remediation strategies, including application of alternate concentration limits and supplemental standards, to meet the EPA ground water standards.

These four alternatives are discussed in detail in Sections 2.1 through 2.4. The EPA ground water standards are described in Section 1.4.1. The potential programmatic impacts of implementing the proposed action and alternatives are provided in Section 4.0.

This PEIS differs substantially from a site-specific environmental impact statement because multiple ground water compliance strategies, each with its own set of potential impacts, could be used to implement all the alternatives except the no action alternative. In a traditional environmental impact statement, the identification of alternatives leads directly to an impacts analysis. On the other hand, an impacts analysis for implementing alternatives in this PEIS involves an intermediate step of evaluating a ground water compliance strategy or strategies, the use of which would result in site-specific impacts. This PEIS impacts analysis assesses the potential impacts of the various ground water compliance strategies, then relates them to the alternatives to compare impacts.

2.1 PROPOSED ACTION (Preferred Alternative)

The proposed action, which is DOE's preferred alternative, would result in the selection of a ground water compliance strategy tailored for each site to achieve conditions that are protective of human health and the environment. The proposed action would consider the full range of ground water compliance strategies in a step-by-step approach, beginning with consideration of the "no remediation" strategy and proceeding, if necessary, to natural flushing with compliance monitoring and institutional controls, and to a more complex, active ground water cleanup methods, such as pump and treat or other engineered approaches to cleaning up contaminated ground water. For example, under the proposed action, if a site risk assessment and site observational work plan indicate that the strategy of "no remediation" would be in compliance with the EPA standards and be protective of human health and the environment, a more complex strategy involving active cleanup methods would not be necessary.

The proposed action is intended to establish a consistent risk-based framework for implementing the UMTRA Ground Water Project and determining appropriate ground water compliance strategies at the UMTRA Project former processing sites. The determination of site-specific ground water compliance strategies would take into account site-specific ground water conditions; human and environmental risks; participation of the tribes, states, and local communities; and cost. This approach is sufficiently flexible to allow for interim actions, such as an alternate water supply system, should these activities be necessary in order to reduce risk and/or support institutional controls. The proposed action would also allow the consideration of new ground water cleanup methods that become available.

The proposed action uses a logic framework to identify the appropriate ground water compliance strategy or strategies for a site (Figure 2.1). Each step in the decision process considers meeting the EPA standards and the protection of public health and the environment in determining the appropriate ground water compliance strategy.

The first step in the decision process would be to determine if the uranium processing activities at a specific site have resulted in ground water contamination exceeding background levels or maximum concentration limits (Figure 2.1). If ground water contamination has not exceeded these standards and is not expected to, remediation would not be required.

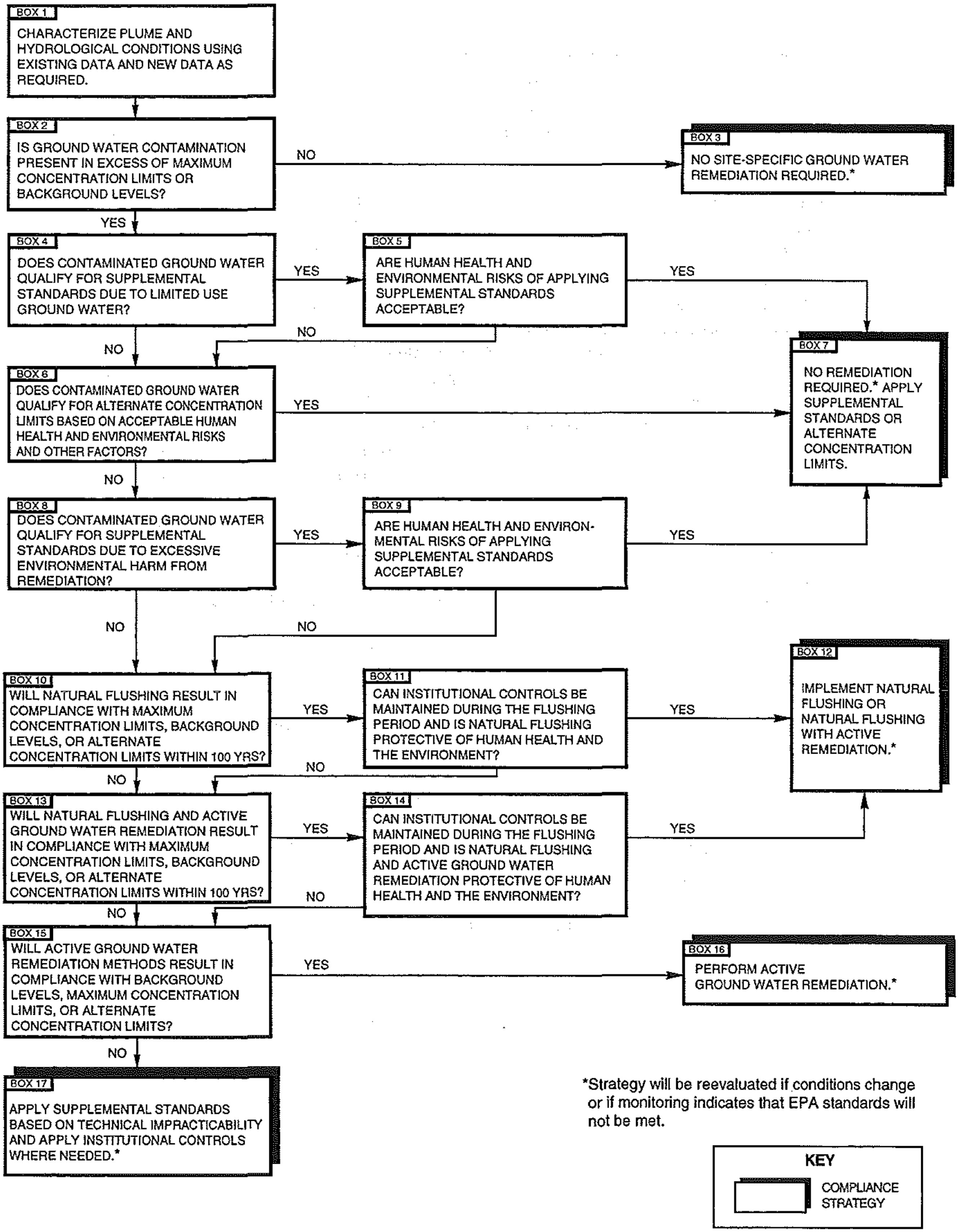


FIGURE 2.1
PROPOSED ACTION

If ground water has been contaminated by uranium processing activities and the contamination exceeds background levels or maximum concentration limits, the next step would be to determine if compliance with the EPA ground water standards could be achieved by applying supplemental standards based on the existence of limited use ground water. (Refer to Section 1.4.1 for a discussion of supplemental standards.) If limited use ground water were shown to exist and if supplemental standards were protective of human health and the environment, no site-specific remediation would be required. If supplemental standards based on limited use were not protective, the next step would be to determine whether alternate concentration limits would apply. (Refer to Section 1.4.1 for a discussion of alternate concentration limits.) If alternate concentration limits were protective of human health and the environment, alternate concentration limits would be applied. If not, it would be necessary to determine whether the contaminated ground water plume would qualify for supplemental standards based on the criterion that remediation would cause more environmental harm than benefit. At some sites where supplemental standards or alternate concentration limits may be applied, ground water monitoring and institutional controls may be required to ensure that the application of alternate concentration limits or supplemental standards would continue to be protective of human health and the environment. In addition, when limited use ground water applies, supplemental standards "shall ensure that current and reasonably projected uses of the affected ground water are preserved" (60 FR 2854). The use of supplemental standards would be determined on a site-by-site basis and the DOE would abide by the EPA ground water standards when proposing the use of supplemental standards. All proposed supplemental standards would require NRC concurrence.

If supplemental standards would not be protective, the next step would be to determine whether natural flushing would bring the contaminated ground water into compliance (i.e., within maximum concentration limits, background levels, or alternate concentration limits) within 100 years. Natural flushing is a ground water remediation strategy by which natural ground water processes result in compliance with the EPA ground water standards. (Refer to Section 1.4.1 for a discussion of EPA standards related to natural flushing.) Natural flushing could be used if it were determined that institutional controls could be implemented, maintained, and enforced during the natural flushing period; that this strategy was protective of human health and the environment; and that all other conditions, as described in Section 1.4.1, are met.

If natural flushing would not be protective, it would be necessary to determine whether natural flushing combined with active remediation methods would meet the EPA ground water standards and would be protective of human health and the environment. If so, this two-part strategy would be implemented. When combined with natural flushing, active remediation methods could be used for a short time to remove the most contaminated ground water that may occur in a restricted area; then natural flushing would be applied. Another option would be to use low-operation and low-maintenance active methods, such as gradient manipulation or geochemical barriers, in conjunction with natural flushing.

Site characterization data may show that natural flushing combined with active remediation would not result in ground water quality that is protective of human health and the environment. That being the case, the next step in the framework would be to determine if active ground water remediation techniques would meet the EPA ground water standards and if so, to implement these techniques. Several methods of active ground water remediation could be used, including gradient manipulation, ground water extraction, and *in situ* ground water treatment. The active remediation methods could be used individually or in combination with other cleanup methods. Section 2.8 and Appendix C provide details on active ground water remediation methods. If active remediation resulted in compliance with the EPA standards, remedial action would be complete. If these methods did not result in compliance, supplemental standards based on technical impracticability of remediation would be applied, along with institutional controls where necessary.

2.2 NO ACTION

The regulations for preparing an environmental impact statement require that the no action alternative be assessed (40 CFR §1502.14(d)), even if the agency is under a legislative mandate to act (51 FR 15618). The analysis of the no action alternative "provides a benchmark, enabling decision makers to compare the magnitude of environmental effects of the action alternatives" (51 FR 15618).

Under the no action alternative, no further activities would be conducted to comply with the EPA ground water standards (40 CFR §192) at the inactive UMTRA Project processing sites. The UMTRA Surface Project would be completed but the Ground Water Project would be terminated and the contaminated ground water would be left as it is. DOE would not collect ground water data to continue characterization of ground water, no monitoring of contaminated ground water would take place, and no institutional controls would be used.

The no action alternative would comply with the EPA ground water standards only at the site where there is no ground water contamination (the Lowman, Idaho, site).

2.3 ACTIVE REMEDIATION TO BACKGROUND LEVELS

Under this alternative, the DOE would attempt to clean up ground water to background levels at the UMTRA Project processing sites, using active ground water remediation methods. This attempt would be limited by the technology available. Therefore, it may not be possible to restore some contaminated ground water to background levels. In these cases, the DOE would attempt to reduce contamination to levels as closely as possible to background levels. The rationale behind this alternative is that ground water at most of the uranium processing sites was of better quality before the processing activities occurred and that the ground water should be restored to its preprocessing quality. At most UMTRA Project processing sites, implementation of this alternative would require the use of active ground water remediation methods such as gradient manipulation, ground water extraction and treatment, or *in situ* ground water treatment (active ground water remediation methods are summarized in Section 2.8). Active remediation methods would be used at the UMTRA Project processing sites regardless of the health and environmental effects and regardless of cost and time. Because active remediation methods would be required at most UMTRA Project processing sites, this alternative would likely reduce the potential risks associated with the ground water contamination and would be protective of human health and the environment.

If this alternative were implemented, DOE would meet the EPA ground water standards at the UMTRA Project sites. Active ground water remediation methods would not be used at sites where the ground water quality beneath the site is currently at background levels and likely would not be used at sites that qualify for supplemental standards based on the existence of limited use ground water.

Under the active remediation to background levels alternative, alternate water systems or interim actions could be used should they be necessary to reduce risk and/or to support an institutional control.

2.4 PASSIVE REMEDIATION

The implementation of this alternative would result in the use of only passive remediation strategies to meet the EPA ground water standards. The passive remediation strategies are 1) performing no remediation at sites that meet supplemental standards or alternate concentration limits, or are at background levels or below maximum concentration limits; and 2) relying on natural flushing. This alternative uses site characterization and risk assessments to determine the most appropriate passive remediation strategy for each site. However, risk assessment and other data may indicate that passive remediation strategies alone would not be protective of human health and the environment at all processing sites.

This alternative is distinct from the no action alternative because, as indicated in Section 2.2, under the no action alternative, activities would not be conducted to restore contaminated ground water at the UMTRA Project sites. In addition, the Ground Water Project would be terminated and the contaminated ground water would be left as is. Under the passive remediation alternative, site characterization would take place before the determination of the appropriate ground water compliance strategy. Ground water monitoring would take place where needed. In addition, institutional controls would be used, if necessary, to protect human health and the environment.

In general, if this alternative were implemented, DOE would follow the same initial steps as for the proposed action (Figure 2.1). However, the final step for this alternative would be to determine whether natural flushing would result in meeting background levels, maximum concentration limits, or alternate concentration limits. Institutional controls and monitoring generally would be required to restrict access to contaminated ground water (refer to Section 1.4.1 for a discussion of natural flushing and institutional controls). For sites where natural flushing would reduce the concentrations of contaminants to below the standards in less than 100 years and be protective of human health and the environment, the EPA ground water standards would be met.

Under the passive remediation alternative, active remediation would not be conducted at a site, even if compliance with the EPA ground water standards would not be met. At sites that would not meet standards within 100 years, institutional controls and monitoring would be required for more than 100 years. This would result in noncompliance with the EPA ground water standards and may not protect human health and the environment. The passive remediation alternative may not be protective of beneficial uses of the ground water, such as irrigation or livestock watering.

Under the passive remediation alternative, alternate water systems or interim actions could be used should they be necessary to reduce risk and/or to support an institutional control.

2.5 COMPARISON OF ALTERNATIVES

In accordance with CEQ regulations (40 CFR §1502.14), this document compares the four alternatives and summarizes their potential impacts. The comparison of alternatives below summarizes the detailed comparison found in Section 4.4.

The qualitative analysis of potential impacts of the ground water compliance strategies (Section 4.2) and of the no action alternative (Section 4.3) were used to compare the potential impacts of the alternatives (Section 4.4). The assumptions used to compare the alternatives also appear in Section 4.4.

The potential impacts of the alternatives can be divided into short-term and long-term impacts. Short-term impacts are associated with site characterization and the construction of ground water facilities. Long-term impacts are those that could occur if the ground water was not remediated or if ground water remediation took many years.

Short-term potential impacts

The proposed action and the active remediation to background alternative would require site characterization, monitoring, and construction of remediation facilities. The passive remediation alternative would require site characterization and monitoring.

Potential impacts to air quality, noise levels, visual resources, transportation systems, utilities, and energy supplies would occur principally during site characterization and during the construction of ground water remediation facilities for the proposed and the active remediation to background levels alternatives. As indicated in Section 4.4, the alternatives would have little or no impact on these resources due to the short duration and small scale of the ground disturbance activities. Site characterization, construction, and monitoring activities have the potential to disturb sensitive habitats, species, and cultural resources. However, these impacts potentially can be avoided by conducting site characterization and remediation activities in areas away from these resources. In addition, if impacts to these resources occurred, their effects could be mitigated. Therefore, the potential for site characterization and construction activities to adversely affect these resources would be considered relatively minor. Potential short-term impacts to land use could also occur, but would also likely be minor.

Long-term potential impacts

Based on the analysis in Section 4.0, long-term adverse impacts could arise under the following circumstances:

- If the contaminated ground water did not meet EPA standards and was not controlled. This would occur under the no action alternative.
- If the ground water compliance strategy were not protective of human health and the environment. This could occur under the passive remediation alternative.
- If institutional controls were in place for many years. This could occur under all the alternatives except the no action alternative.

Implementing the no action alternative would not comply with the EPA standards at all UMTRA Project processing sites. As a result, significant long-term adverse impacts to human health and the environment could occur under the no action alternative. For example, the public could be exposed to site-related hazardous contaminants by drinking contaminated ground water or surface expression of ground water, ingesting contaminated livestock and/or plants, or ingesting contaminated fish and/or wildlife. Adverse impacts to wildlife could occur if the contaminants entered the food chain and/or affected sensitive resources such as wetlands or threatened and endangered species.

Potentially adverse impacts would be less likely under the proposed action or the active remediation to background alternative because all UMTRA Project sites would comply with the EPA standards. In addition, surface and ground water monitoring would take place before and during implementation of the proposed action and the active remediation to background alternative to ensure that protective measures could be maintained or implemented, if necessary.

Implementation of the passive remediation alternative also could result in the exposure of humans and the environment to site-related hazardous contaminants. The potential occurrence of such impacts is less than from the no action alternative, but such impacts could occur at sites where hydrogeological data and risk assessments have demonstrated that the use of passive ground water remediation strategies would not be protective of human health and the environment. For example, this could occur at sites where institutional controls are not viable or would not effectively restrict access to contaminated ground water or at sites where the potential ecological risk from contaminated surface expression of ground water (now or in the future) cannot be avoided or prevented with passive remediation strategies. These potential long-term impacts would have a low probability of occurring under the proposed action or the active remediation to background levels alternatives.

Institutional controls can be used in conjunction with natural flushing for up to 100 years. These controls may need to be used even longer with the passive remediation alternative because contaminant plumes may still exist after 100 years of natural flushing. The use of institutional controls could result in long-term land use and socioeconomic impacts, as discussed in Sections 4.4.6 and 4.4.11. The passive remediation alternative could have the greatest impact in this area, followed by the proposed action, then the active remediation to background alternative.

In summary, the proposed action and the active remediation to background alternatives are most effective at protecting human health and the environment because under these alternatives all of the UMTRA Project sites would comply with the EPA standards. Implementing the proposed action would potentially result in fewer short-term impacts associated with construction than implementing the active remediation alternative. The proposed action would potentially be more cost-effective because it would use passive remediation strategies such as natural flushing or no remediation at sites where these strategies are shown to be protective of human health and the environment and meet the EPA standards. The active remediation alternative would be the most costly because of its widespread use of active ground water compliance methods. Under this alternative, active methods would be used at sites where active remediation is justified under the proposed action based on site-specific risk assessments. In addition, active remediation would also be used at many sites where no additional risk reduction would occur as a result of active remediation.

2.6 ALTERNATIVES ELIMINATED FROM DETAILED ANALYSIS

The CEQ regulations require that an environmental impact statement 1) evaluate all reasonable alternatives, 2) briefly discuss those alternatives eliminated from detailed impact analysis in the environmental impact analysis, and 3) provide the reasons for their elimination (40 CFR §1502.14(a)).

Reasonableness is defined as practical or feasible from a common sense, technical, and economic standpoint (51 FR 15618). Four alternatives were considered early in the PEIS planning stages but were eliminated from further evaluation. A fifth alternative, use of tribal and state standards, was considered as a result of comments received on the draft PEIS, but was eliminated from further consideration. All these alternatives and the reasons for their elimination are provided in the following subsections.

2.6.1 Delay the UMTRA Ground Water Project

Delaying the Ground Water Project until the Surface Project is completed was not considered a viable alternative because surface remediation is complete at 18 sites and resources have become available to address ground water compliance. To further delay ground water remediation at some of the processing sites may not be protective of human health and the environment.

2.6.2 Use existing data to make Ground Water Project decisions

Under this alternative, no new site characterization or risk assessment data would have been collected at any of the sites. The UMTRA Ground Water Project would have proceeded using only existing data. Existing site characterization data include geologic, hydrogeologic, geochemical, geotechnical, and radiological conditions at the processing sites. These data were collected for the purposes of designing and implementing surface remediation. This information may not have fully characterized ground water conditions, leading to the possibility of making incorrect decisions regarding site-specific ground water compliance; therefore, this alternative was not considered further.

2.6.3 Provide clean water at the point of use

This alternative would have required the DOE to provide an alternate water source at the point of any use in situations where ground water used by humans has become or soon would become contaminated. Clean water sources could have been bottled water, connection to a municipal water supply, or new wells tapping uncontaminated ground water resources. Under this alternative, the DOE would not have complied with EPA standards.

This alternative was considered because it meets the immediate purpose and need of protecting human health and agricultural applications. It was eliminated from detailed study for the following reasons:

- A basic assumption in regard to this alternative is that the DOE would provide an alternate water source at the point of human use (e.g., domestic water sources, livestock watering, and/or crop irrigation) but would do nothing to protect the biological communities from the contaminated ground water. Therefore, use of this alternative would not be protective of the environment since contaminated ground water could discharge into rivers, streams, wetlands, and other biological systems. Furthermore, these biological systems would not be monitored so the degree of contamination, if any, would not be known. This raises the possibility of contaminants entering the biological foodchain which could include humans.

- The use of this alternative would require ground water monitoring to determine the location of the plume over time and changes in the level of contamination to determine if the plume is nearing points of use not previously protected. In some cases, this monitoring would be needed for a very long period of time because plumes at some of the UMTRA Project sites move slowly.

- This alternative would not meet the EPA standards at all sites. In one sense, this alternative would have to continue until the threat to human health no longer exists. The EPA standards stipulate that ground water contaminants must meet the standards within 100 years. Under this alternative, meeting the standards within 100 years may not occur at all sites.

- Treatment at the point of use is not excluded from the alternatives analyzed in the PEIS (except no action). If the drinking water (or other beneficial uses) is threatened at a given site during the Ground Water Project, DOE may provide an alternate source.

- Treatment at the point of use that includes institutional controls is part of the passive remediation alternative. Sites that require institutional controls for the passive remediation alternative also would require institutional controls under the treatment at the point of use alternative, so as to reduce the likelihood of using contaminated ground water.

2.6.4 Achieve ground water compliance without a programmatic approach

This alternative would have required the UMTRA Ground Water Project to proceed without a programmatic approach. This would have meant that ground water compliance would have been treated as discrete tasks for each site. Compliance with EPA's ground water standards would have been met at all processing sites. All NEPA and technical documents would have been produced independently of one another. Scheduling of site activities would have been based on preliminary risk prioritization data.

This alternative was eliminated from further analysis because it would have had many variables and the determination of potential environmental impacts would not be meaningful. In addition, it is not consistent with CEQ regulations, which consider related activities a single course of action (for example, the UMTRA Ground Water Project) that must be evaluated in a single impact statement (40 CFR §1502.4(a)).

2.6.5 Use tribal and state standards

Even though the UMTRCA requires DOE to meet the EPA standards, this alternative would require the UMTRA Project to use tribal and state standards, where they exist, rather than EPA standards. Because the UMTRA Project sites are in 10 different states and on or near lands of four different tribes, the UMTRA Project could be subject to 14 different sets of standards administered by 14 different agencies. This approach would be unacceptable because:

- The standards for specific constituents likely vary from agency to agency, which could lead to unequal treatment of the sites.
- Some agencies may have standards for specific constituents while others may not have a standard for that specific constituent. This could also lead to unequal treatment of the sites.
- Jurisdictional problems would likely arise under this alternative. For example, an UMTRA site may be on land under the jurisdiction of one agency, but a contaminated ground water plume may cross the border into the jurisdiction of another agency.
- This alternative would likely increase remedial action costs due to the DOE's having to address so many sets of standards.
- Preparing site-specific ground water compliance documents and implementing the site-specific ground water compliance strategies would be difficult, given the large number of varying standards that would have to be addressed.

2.7 SITE PRIORITIZATION AND RISK ASSESSMENT

2.7.1 Site prioritization

Site prioritization ensures that appropriate, relevant, and objective considerations are given to each site during planning stages. The cumulative scores of each site are ranked to determine which sites have the greatest urgency for early actions.

The prioritization system developed for the UMTRA Ground Water Project is based on the modified Environmental Restoration Priority System which used multiattribute utility analysis to prioritize sites. This system is described in detail elsewhere (DOE, 1991a) and is summarized here.

This prioritization approach was shared in draft with all the affected tribes and states. Comments were rigorously encouraged. The DOE conducted meetings on the application of this prioritization methodology with three states and two tribes.

The six criteria below were used to prioritize the sites; for each UMTRA site, each criteria was scored from 1 to 7. A score of 1 indicates conditions defined by the factor are acceptable, while a score of 7 indicates highly unfavorable conditions.

<u>Population health risk</u>

This criterion is based on annual health risks to potentially affected populations (i.e., populations consuming ground water directly or indirectly). It can be extrapolated from individual risks calculated in ground water risk assessments, or can be determined by using EPA Hazard Ranking Scores for the ground water exposure pathway.

On the population health risk scale, a score of 7 is equivalent to the occurrence or likely occurrence of 10 adverse health effects per year. The scale decreases logarithmically to 1, which signifies an annual population risk of one in 10,000,000.

<u>Individual health risk</u>

This criterion is based on increased individual risks over a lifetime from direct or indirect consumption of ground water. These values are calculated from worst-case, point-of-exposure wells. If the water quality in the area is unsuitable for drinking, another pathway (such as crop irrigation or livestock watering) may be calculated.

These risks are based on the EPA's Risk Assessment Guidance for Superfund documents and produce results in the form of a hazard index and carcinogenic risk. These scores are converted to a logarithmic scale of 1 to 7, where 1 signifies an individual lifetime risk of one in 10,000,000, and 7 signifies a risk of one in 10.

<u>Timing</u>

Timing is an important factor in prioritizing ground water restoration sites because it quantitatively incorporates the current or anticipated use of ground water. Sites where affected ground water is in use should have higher priority than sites where alternate water supplies are abundant, accessible, and inexpensive. This criterion makes the risk estimates more meaningful since it ties them to actual site factors (such as probability of ground water use).

Additionally, hydrologic factors such as aquifer flushing time, contaminant migration rate, or increased plume spread can be incorporated into the timing criterion.

<u>**Environmental risk**</u>

The baseline environmental risk scores are determined from the product of two factors:

- The sensitivity of the environmental resource at risk

- The magnitude of the threat associated with the contaminated ground water.

The definition for sensitivity of resources was adapted from the EPA's Final Hazard Ranking System (40 CFR Part 300) and includes scenic or wild rivers, unique riparian habitats, wetlands, threatened or endangered species, spawning areas, or any critical habitat. The threat to these resources is based on largely qualitative criteria (including criteria for exceedance of ambient water quality and observed contaminant uptake or toxicity in biota) and threats to the population abundance.

<u>**Socioeconomic impact**</u>

Socioeconomic impact scores are derived from three components:

- Public concern
- Cultural/traditional impacts
- Community losses/opportunity costs.

The first factor scores public and political interest. This is significant on the UMTRA Project because many stakeholders are very concerned about ground water restoration.

The second factor, cultural impacts, is significant primarily to tribal sites. It recognizes the spiritual values the Hopi Tribe and Navajo Nation associate with their ground water.

The last factor is used to score economic impacts to a community that loses the use of an affected aquifer. This factor relates to the size of the contaminant plume as well as the demand for its use.

<u>**Regulatory noncompliance**</u>

The primary criterion in this factor was compliance with applicable ground water standards, including tribal or state laws addressing ground water.

After each factor was scored, the scores were weighted as follows: 10 percent for population risk; 30 percent for individual risk; 20 percent for timing factors; 15 percent for environmental impacts; 10 percent for socioeconomic impacts; and 15 percent for regulatory impacts.

Sites were assigned to one of five groups based on this prioritization, allowing for flexibility in planning compliance activities. Category I sites with the highest priority are New Rifle, Old Rifle, and Gunnison, Colorado; Tuba City, Arizona; and Riverton, Wyoming. The Gunnison Category 1 classification does not take into account the implementation of the alternate water supply. Category II sites with the next highest priority are Monument Valley, Arizona; Lakeview, Oregon; Shiprock, New Mexico; and Durango, Colorado. Category III sites are Naturita, Slick Rock, and Grand Junction, Colorado; and Green River and Salt Lake City, Utah. Category IV sites are Bowman and Belfield, North Dakota; Canonsburg, Pennsylvania; Falls City, Texas; and Maybell, Colorado. Category V sites are Ambrosia Lake, New Mexico; Mexican Hat, Utah; Lowman, Idaho; and Spook, Wyoming. The UMTRA Ground Water Project site prioritization system took into account the likelihood that exact scores, and therefore priority, may change as additional data are gathered.

The site prioritization groups would be considered when site-specific decisions are being made. Ground water remediation at the sites would be further prioritized based on additional health or environmental risk information. The following factors would be taken into account when determining the risk at a site:

- Is the contaminated ground water likely to be used soon?
- How much contamination is present?
- How toxic is the contaminated ground water?
- Can access to the ground water be controlled?

Prioritization is one element of the Ground Water Project. It would be applied objectively to the maximum extent possible.

2.7.2 Site-specific risk assessments

The purpose of the UMTRA Ground Water Project baseline risk assessments is to determine whether there is current use of the contaminated ground water and whether ground water contamination at the former processing sites has the potential to adversely affect public health or the environment. The results of the site-specific baseline risk assessments are or would be used to:

- Evaluate potential current and future public health and ecological risks at the sites.

- Determine the need for an alternate water supply, based on the potential for adverse human health effects.

- Identify additional data, if any, needed to characterize risks at UMTRA sites.

- Determine current and potential future land uses at and near the sites.

- Inform the public of current and/or future potential public health and ecological risks.

- Help determine site-specific ground water compliance strategies.

- Determine whether access to ground water should be restricted through the use of institutional controls.

As indicated in Section 2.1 and as shown in Figure 2.1, the proposed action is a health and environmental risk-based approach for implementing the Ground Water Project. The risk assessments and the ground water characterization data would be used to help determine the appropriate ground water compliance strategies that would be implemented at each UMTRA Project site.

The baseline risk assessments have been or will be made available to the public and libraries near the sites. If the risk assessment identified a significant health risk associated with short-term use of ground water near the sites, mechanisms for restricting access to the ground water would be discussed.

Because the baseline risk assessments are being conducted in the early stages of the Ground Water Project, they may be prepared before comprehensive characterization of the contaminant plume is complete at some sites. The baseline risk assessments identify data gaps and recommend additional data collection efforts. After site characterization is completed, risk assessments may be updated, if necessary.

Risk assessments would be used in deciding how to meet the UMTRA ground water protection standards. In developing site-specific ground water compliance strategies under the proposed action, the baseline risk assessments would be used to determine if a given strategy would be protective of human health and the environment. As indicated on Figure 2.1, protection of human health and the environment is considered in the application of all ground water compliance strategies. For example, if supplemental standards based on limited use ground water were considered for a site, the risk assessment would analyze any potential health effects of consuming contaminated ground water, and consider potential adverse effects on other beneficial uses (e.g., agricultural or industrial). The assessment also would address the potential impacts of contaminated ground water on area plant and animal communities. If supplemental standards based on limited use are determined to be protective of human health and the environment and all other requirements can be met, this strategy may be proposed for a site.

Risk assessments also could be used on the Ground Water Project to assess the risks of natural flushing. As indicated in Section 1.4.1, the use of natural flushing is permitted if it would result in meeting background levels, maximum concentration limits, or alternate concentration limits within 100 years; if institutional controls would protect public health and the environment from the contaminated ground water; and if ground water is not currently or projected to become a source of public drinking water. The risk assessment would be an important tool in determining the protectiveness of proposed alternate concentration limits; determining if the public would be protected from exposure to contaminated ground water; determining the potential for contaminated ground water to adversely affect biological resources; and determining if the contaminated ground water could be used as drinking water or for other beneficial uses.

Appendix B describes the human health and ecological risk assessment methodologies used on the UMTRA Ground Water Project.

2.8 GROUND WATER CHARACTERIZATION AND REMEDIATION METHODS

The nature and extent of ground water contamination must be evaluated before a ground water compliance strategy can be determined. The former processing sites must be characterized to the extent necessary to 1) define the physical, chemical, and biological conditions at the sites; 2) identify the sources and extent of contamination related to processing activities; and 3) obtain additional data which will be used together with historical data in evaluating potential impacts to human health and the environment. A ground water compliance strategy for a particular site would be selected only after adequate hydrogeological and geochemical characterization is completed. Hydrogeological and geochemical characterization activities would reduce uncertainties to the extent practical, to ensure the compliance strategy selected would be protective of human health and the environment.

At UMTRA Project sites, inorganic contaminants are the principal constituents that have been found in underlying aquifers. Hazardous constituents that have exceeded maximum concentration limits in ground water at UMTRA Project sites include arsenic, cadmium, chromium, lead, molybdenum, nitrate, selenium, radium-226 and -228, net gross alpha, and uranium. Additional metals that do not have maximum concentration limits have exceeded background concentrations at some sites. This section summarizes ground water characterization requirements and processes. These characterization methods may be implemented for all alternatives except the no action alternative. More detailed descriptions of ground water characterization methods are presented in Appendix C.

2.8.1 <u>Site hydrogeologic and geochemical characterization</u>

<u>Ground water characterization</u>

Under the proposed action, ground water characterization for the UMTRA Ground Water Project would be consistent with the requirements of Subpart B and Subpart C of the EPA ground water protection standards. In support of the proposed action, three programmatic documents would provide guidance for ground water characterization and compliance and ensure project continuity and consistency: the *Technical Approach to Groundwater Restoration* (DOE, 1993a), the *Guidance Document for Preparing Water Sampling and Analysis Plans for UMTRA Sites* (DOE, 1993b), and the *UMTRA Project Technical Assistance Contractor Quality Assurance Implementation Plan for Surface and Ground Water* (DOE, 1994b). These documents would also provide guidance for the Ground Water Project if either the active remediation to background or passive remediation alternative became the proposed action. If the no action alternative became the proposed action, these documents would not be used because future work on the Ground Water Project would cease.

The *Technical Approach to Ground Water Restoration* provides technical guidance for implementing the Ground Water Project. This document addresses the regulatory basis and requirements for ground water compliance, ground water characterization and remediation methodologies, and the requirements for meeting NRC concurrence.

The *Guidance Document for Preparing Water Sampling and Analysis Plans for UMTRA Sites* provides a consistent technical approach for water sampling and monitoring activities to be performed under site-specific water sampling and analysis plans. The plans would identify and justify specific sampling locations, ground water constituents for analysis, detection limits, and sampling frequency for the ground water and surface water sampling locations.

The *Quality Assurance Implementation Plan* describes the policy, organization, functional activities, and quality assurance and quality control protocols for environmental characterization. It provides specifications for collecting and analyzing environmental samples and assessing data. It also addresses quality issues associated with data and samples related to geology, hydrology, chemistry, biology, and engineering.

Assuming that one of the PEIS alternatives other than the no action alternative is implemented, the technical guidance in these three programmatic documents would be used to prepare site observational work plans. The site observational work plan would present the initial evaluation of existing information related to each site, a conceptual site model of the hydrogeological and geochemical processes, and additional data needed to adequately characterize the ground water conditions. Further data collection would be of sufficient quality and quantity to support future project planning and the necessary activities associated with the ground water compliance strategy selection and implementation.

The impacts of the proposed ground water compliance strategy would be assessed in site-specific environmental documents. Baseline risk assessments have been prepared for most sites. When relevant and applicable, these assessments would be modified and updated as additional monitoring and site characterization data are obtained. Site-specific remedial action plans would be prepared for sites where an active ground water remediation strategy would be most appropriate, or the Surface Project remedial action plan would be modified.

The observational method would be used during the planning for and collection of site characterization data. The observational method is an approach that would establish a ground water characterization plan and remedial action based on most probable site conditions; identify reasonable variations from those conditions; identify parameters for detecting variations from the most probable conditions during characterization and compliance; and provide plans for addressing potential variations (Peck, 1969). The observational method would be an effective and economical means to manage uncertainties associated with remediating ground water resources.

Examples of currently available data for the UMTRA Project sites include information on hydrogeologic properties, background ground water quality, contaminant sources, hazardous constituents in ground water, and ground water use, value, and alternative supplies. The extent of ground water characterization during the Surface Project depended on the preferred disposal alternative. Processing sites with disposal cells within their boundaries were characterized in greater detail to justify their selection, provide data for disposal cell design, define the extent of surface contamination, and generate a defensible ground water protection strategy for surface remediation that was protective of human health and the environment. The processing sites where surface remediation activities were completed or were in progress before the EPA ground water regulations were issued generally were characterized to a lesser extent.

For processing sites where contaminated materials were or will be removed off the site, characterization efforts consist of defining tailings-related ground water contamination and determining if conditions at the processing site would adversely affect human health and the environment.

Site-specific ground water characterization would require short-term activities on or near the site. To carry out characterization activities, a crew of 10 or fewer people would be on the site temporarily to conduct activities such as drilling monitor wells, constructing access roads, and excavating test pits. Support vehicles and heavy equipment (for example, drilling rigs) may use roads around the site for brief periods. Certain ground water characterization activities would require electrical power. For example, the pumps used for long-term aquifer tests would require a continuous electrical power supply, which could be drawn from a nearby utility line.

2.8.1.1 Hydrogeologic characterization

Hydrogeologic characterization is important in defining the ground water flow system and the extent of contamination related to uranium processing activities at the UMTRA Ground Water Project sites. Hydrogeologic characterization efforts would also be essential in developing and evaluating ground water compliance strategies.

Hydrogeologic characterization would include the following:

- A description of the hydrogeologic characteristics of the site and surrounding land

- A determination of aquifer hydraulic characteristics

- The quantity of ground water and the direction of ground water flow

- A determination of ground water recharge and discharge areas that may influence human health and the environment. Ground water discharge areas would include surface water bodies and water supply wells.

- The proximity and withdrawal rates of ground water users

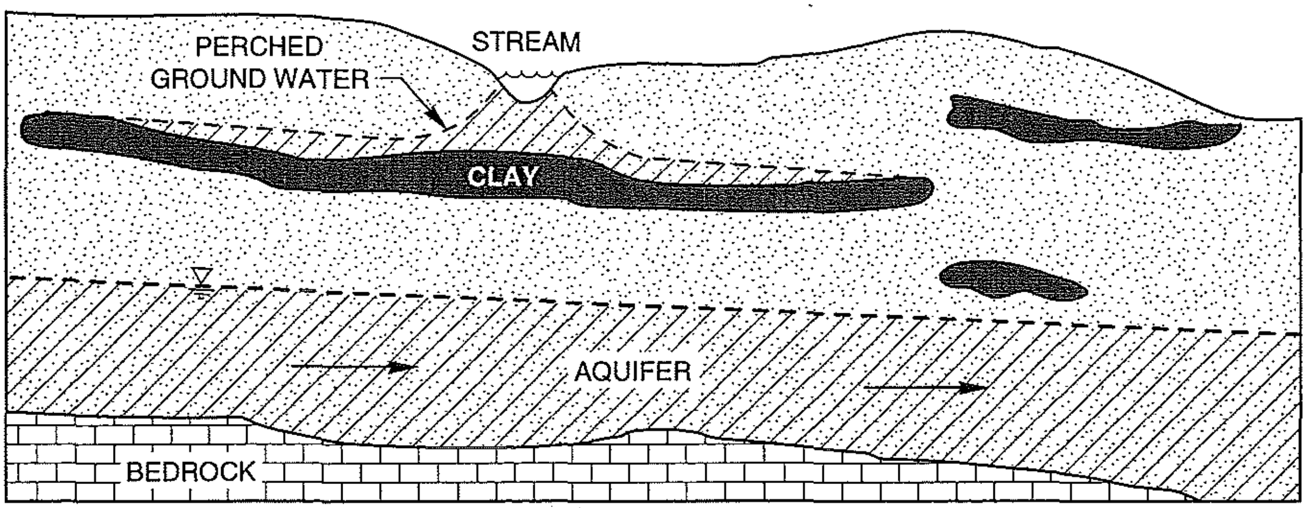
- The current and future uses of ground water in the region surrounding the site.

Most hydrogeologic information is obtained from boreholes drilled for the installation of monitor wells. Geophysical methods may also be used to evaluate subsurface hydrogeologic conditions in the vicinity of the UMTRA Project sites. Borehole information and geophysical methods (under the appropriate conditions) can be used to characterize hydrogeologic conditions such as depth to bedrock, presence of sand and clay layers, and fracture zones that may control ground water flow and contaminant migration. Examples of some hydrogeological characterization features are shown in Figure 2.2.

Monitor wells are used for static water level measurements, ground water quality sampling, and aquifer testing (for example, aquifer pumping tests or water displacement tests). Monitor wells would be designed and installed to provide representative ground water quality samples and aquifer test results. Ground water flow patterns and velocities in the vicinity of the sites would be characterized on the basis of ground water elevations obtained from monitor wells and aquifer test data. Hydraulic parameters that describe the way ground water moves through the aquifer (including transmissivity, hydraulic conductivity, and storativity) would be calculated from aquifer test data. Figure 2.3 shows examples of a monitor well and an extraction well.

Ground water models could be used to analyze and predict ground water and contaminant plume movement. Models would be useful in determining points of exposure at land surface, estimating arrival times at specific downgradient locations or points of exposure, and estimating contaminant concentrations at points of compliance or points of exposure. These models would support risk assessments and ground water compliance strategy development.

Ground water models could also be used in remediation activities. For example, models could be used to assess ground water compliance strategies, compare long-term effects of ground water remediation designs, and optimize performance of aquifer remediation systems.



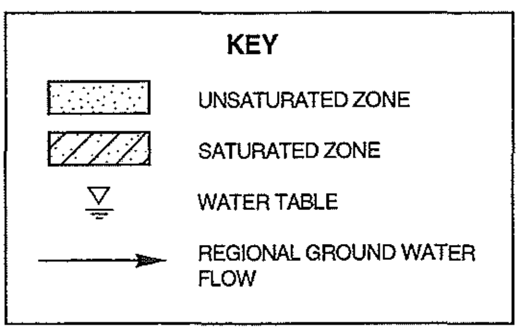


FIGURE 2.2
HYPOTHETICAL CROSS SECTION OF AQUIFER MATRIX, PERCHED GROUND WATER, AND REGIONAL GROUND WATER

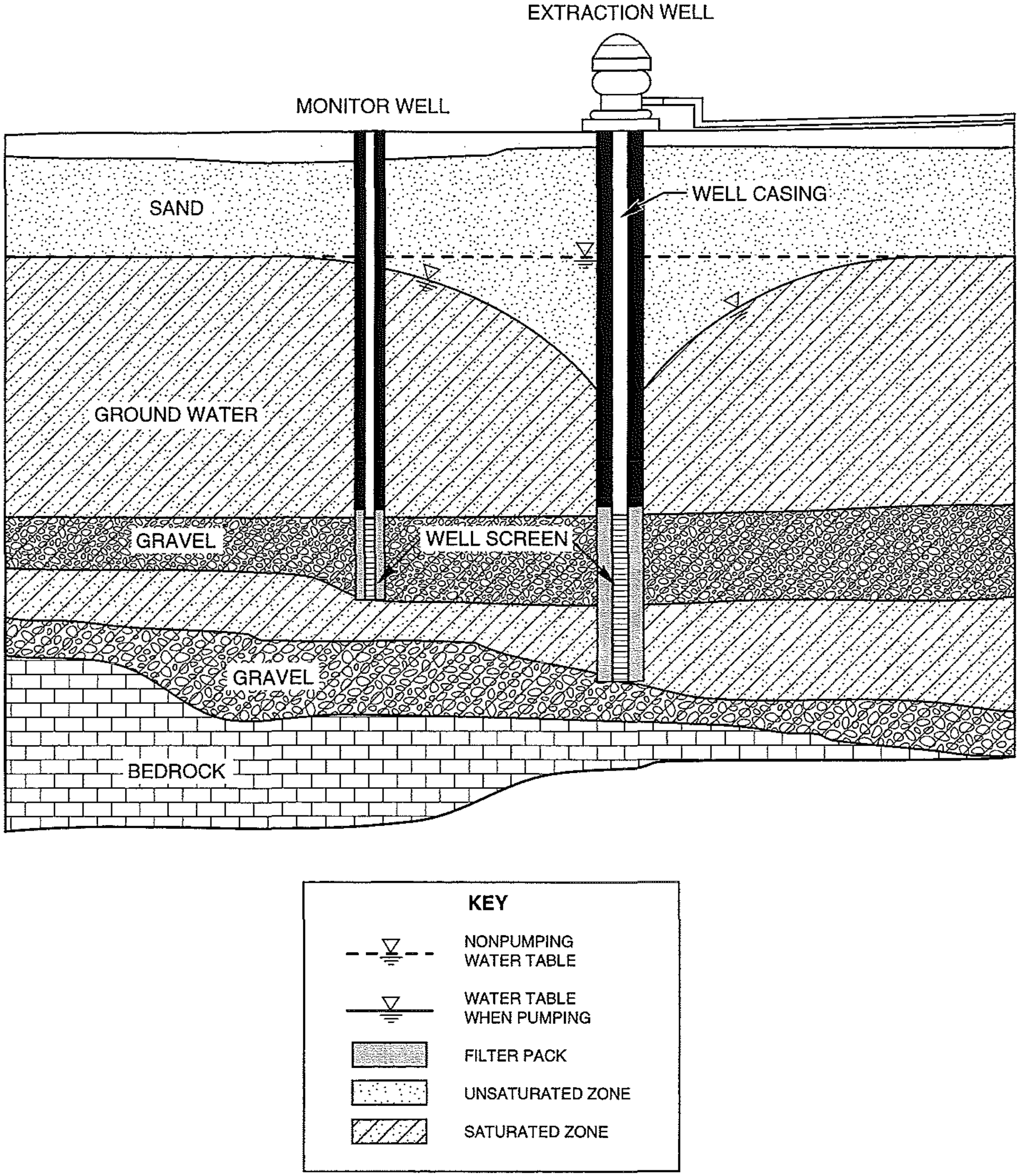


FIGURE 2.3
SCHEMATIC DIAGRAM OF A MONITOR WELL AND AN EXTRACTION WELL

MAC: NONSITE/PEIS95/EXTRWELL

Site-specific environmental impact statements, environmental assessments, and remedial action plans for the Surface Project have previously described existing and potential future water uses in the vicinity of the processing sites. As the UMTRA Ground Water Project progresses, water uses and alternative supplies would be monitored and addressed as needed.

2.8.1.2 Geochemical characterization

Geochemical characterization is important in defining ground water contaminants related to uranium processing activities and in determining contaminant interactions with the aquifer matrix. Geochemical characterization efforts are essential to developing ground water compliance strategies because the geochemical composition of the aquifer matrix affects the quality of ground water and the rate of contaminant migration.

The scope of geochemical characterization would include the following:

- A review of the historical record of chemicals used in the milling operation
- A determination of the source of contamination and its cumulative impact on the ground water quality
- A determination of the contaminated and uncontaminated ground water quality
- A determination of the geochemistry of the sediment or rock that contains the ground water (known as the aquifer matrix material).

<u>Ground water quality</u>

Existing ground water characterization data would be used to determine the need, if any, to collect additional data for ground water characterization and risk assessments. In some cases, additional background and downgradient ground water quality characterization data would be collected to reduce uncertainties in the conceptual risk model.

Background ground water quality is the water quality in an aquifer that would be expected at a site if contamination from the uranium processing had not occurred. Background ground water quality is determined from hydrologically upgradient locations or adjacent areas that have not been affected by uranium processing activities. Some UMTRA Project sites have naturally poor background ground water due to their proximity to uranium ore bodies. An assessment of background ground water quality would provide a comparison for determining the magnitude and extent of ground water contamination caused by processing. At processing sites with surface water in the area, background surface water quality would also be defined upstream. See Appendix B for an expanded discussion regarding the determination of background water quality.

The distribution of hazardous constituents in the unsaturated zone, ground water, and surface water would be defined on the site and downgradient from the processing sites. Figure 2.4 shows an example of a ground water contaminant plume moving downgradient from a processing site. This information would be used to predict contaminant migration for each site, assess risk, and select ground water compliance strategies.

Geochemistry of aquifer matrix material

Through the geochemical processes of dissolution, precipitation, adsorption, desorption, and ion exchange, geochemical interactions between the ground water contamination and the aquifer matrix influence the rate at which chemical elements and compounds migrate through the aquifer (Table 2.2). Therefore, geochemical characterization of the aquifer matrix would allow for more accurate predictions of contaminant migration velocities. Contaminant migration velocity estimates would be critical for selecting natural flushing versus active ground water remediation and for assessing active remediation designs. Therefore, a detailed knowledge of the aquifer matrix chemistry would play an important role in ground water compliance.

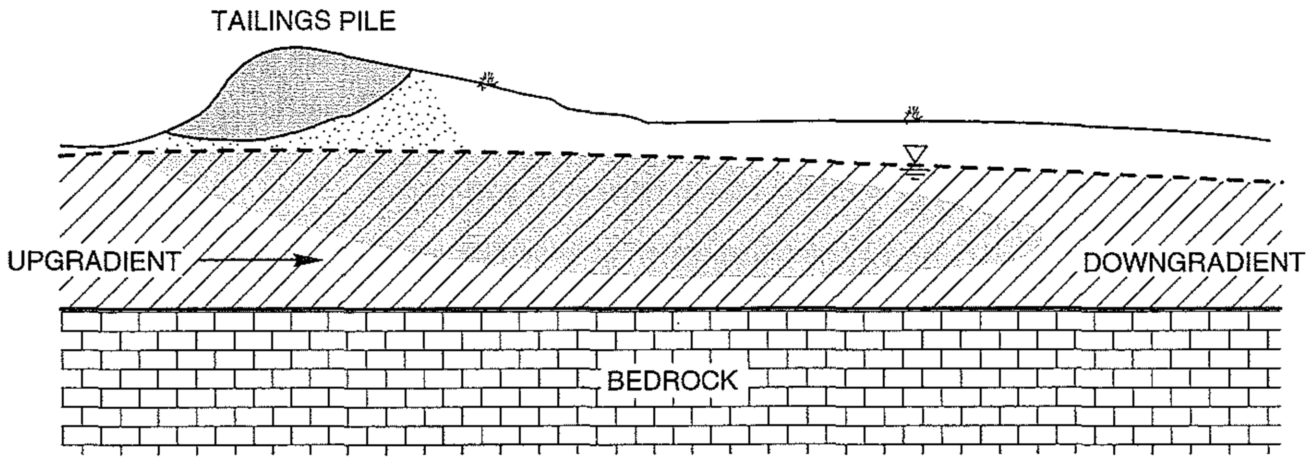
Geochemical characterization methods

Water quality would be assessed by collecting and analyzing water samples from ground water monitor wells, springs, seeps, and surface water bodies. Some basic ground water quality characteristics could be determined in the field. Concentrations of major and minor chemical components in the ground water would be determined in the laboratory. Ground water quality would be evaluated using statistical procedures such as those recommended by EPA (EPA, 1989).

The geochemistry of the aquifer matrix material is characterized to determine mechanisms and the nature of ground water constituent interactions with aquifer matrix material. These data could be used in geochemical models to predict interactions and changes in contaminated ground water as it moves downgradient. Where the ground water compliance strategy depended on the aquifer matrix geochemistry, geochemical modeling could be used in conjunction with ground water flow and contaminant transport models to assess contaminant mobility in the ground water and to predict reactions with minerals in the unsaturated and saturated zones.

2.8.2 Ground water remediation methods

Two ground water compliance strategies are described in this section: natural flushing and active ground water remediation. Natural flushing is passive because it does not involve manipulation of ground water flow, quantity, or quality. Natural flushing means letting the natural ground water processes reduce the contamination in ground water. This process is commonly referred to as natural attenuation and often involves some or all of the geochemical



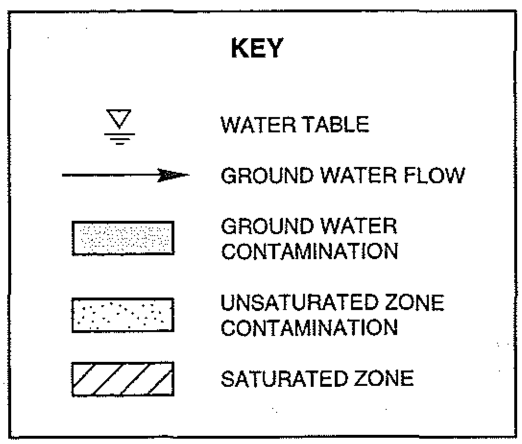


FIGURE 2.4
HYPOTHETICAL CROSS SECTION OF GROUND WATER CONTAMINATION PLUME

MAC: NONSITE/PEIS95/GWCONTPLU

Table 2.2 Geochemical processes that control contaminant migration through an aquifer

Process	Definition
Dissolution	The process of dissolving minerals from the aquifer matrix.
Precipitation	The separation of chemical constituents from ground water to form new minerals on the aquifer matrix.
Adsorption	The adhesion of chemical constituents on minerals within the aquifer matrix.
Desorption	The removal of a chemical constituent from the aquifer matrix by the reverse of adsorption.
Ion exchange	The replacement of adsorbed chemical constituents by constituents in the ground water.
Biological	The process of transforming chemical compounds into different chemical compounds.

processes identified in Table 2.2. To effectively meet EPA standards, natural flushing must reduce contamination to background levels, to maximum concentration limits, or to alternate concentration limits within 100 years. Active remediation methods involve the engineered manipulation of ground water flow, quantity, or quality to achieve ground water quality standards in a specified period of time. Active remediation methods could be used in combination with natural flushing to minimize remediation costs and to expedite remediation.

__Natural flushing__

Natural flushing allows the natural ground water movement and geochemical processes (Table 2.2) to decrease contaminant concentrations. EPA ground water standards require that natural flushing must reduce contamination to levels within regulatory limits within 100 years. To select natural flushing at a specified UMTRA Project ground water site, investigations described in Section 2.8.1 would take place to demonstrate its potential effectiveness at achieving EPA ground water standards in 100 years (Figure 2.5). Under Subpart B of the EPA ground water standards, natural flushing may be used if compliance with the standards would occur within a period of 100 years or less; if adequate monitoring and institutional controls were established and maintained throughout the flushing period; if institutional controls resulted in conditions that were protective of human health and the environment; and if the ground water

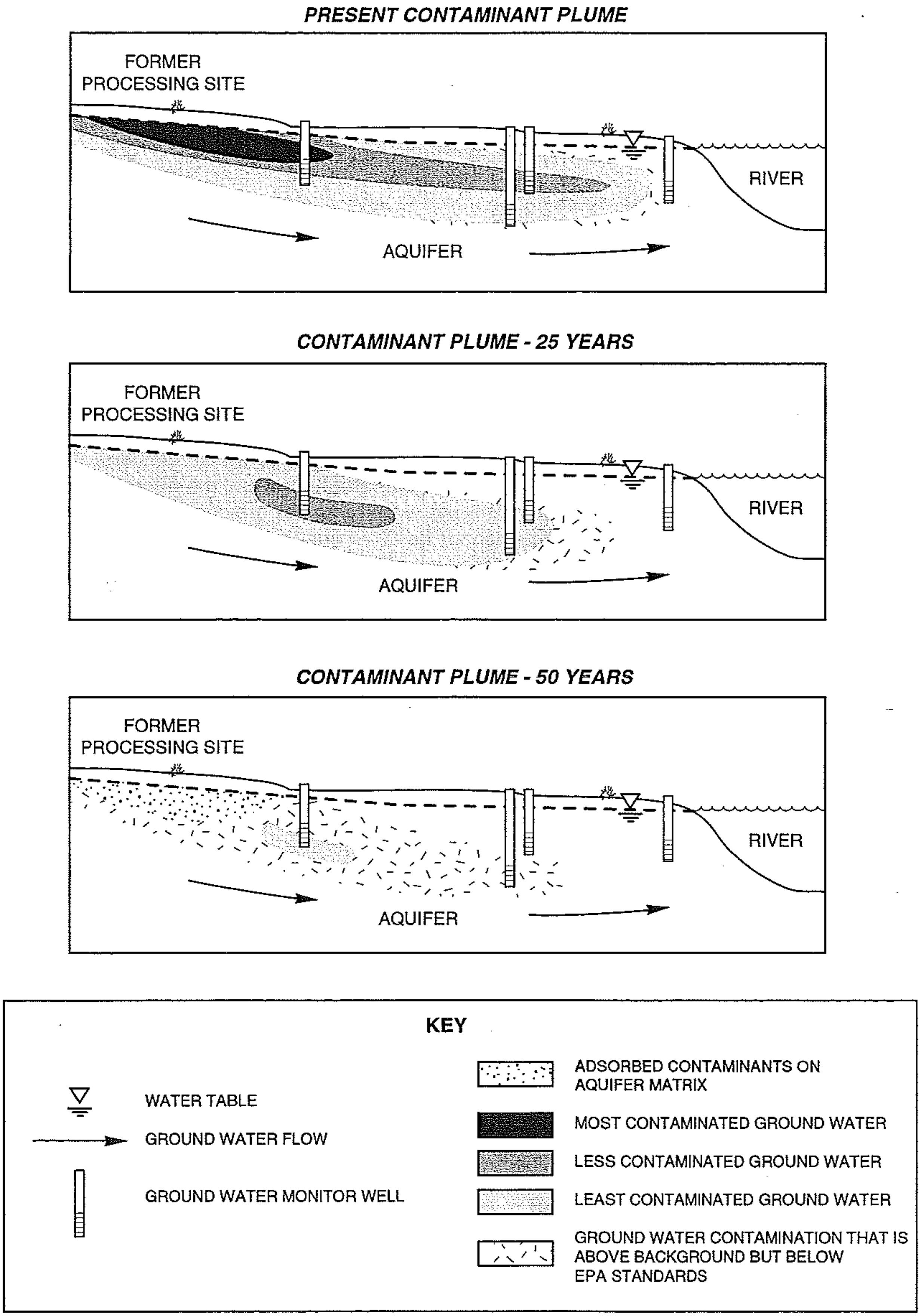


FIGURE 2.5
HYPOTHETICAL CROSS SECTION VIEW OF NATURAL FLUSHING

were not currently nor projected to be a source for a public drinking water system.

Active ground water remediation methods

Active ground water remediation includes several methods that could be used in the Ground Water Project. These methods are described in detail in Appendix C and are summarized below.

Gradient manipulation—Gradient manipulation uses either wells or trenches to add water to an aquifer to increase ground water velocity in a specific direction. Gradient manipulation could be used to accelerate the process of natural flushing. Conversely, gradient manipulation could be used to temporarily prevent discharge of a contaminant plume into surface water bodies by creating a hydraulic diversion to contaminated ground water flow. Gradient manipulation could be used in conjunction with natural flushing to decrease concentrations over a unit area at a faster rate and to temporarily prevent the migration of contaminants into areas where ground water was not previously contaminated or where institutional controls cannot be effectively applied.

Contaminant isolation—Ground water contamination sources are the tailings and associated highly contaminated water or adsorbed hazardous constituents in the unsaturated zone above the water table. Zones of highly contaminated ground water below a processing site are the result of the contamination source. Ground water contamination sources could be mitigated or eliminated through engineered measures to control or contain their hazardous constituents.

Hydrologic, geochemical, and reactive barriers could be used to keep a contaminant source from entering the ground water. These technologies could prevent hazardous constituents from migrating into the ground water. In areas of highly contaminated ground water under a former tailings pile, a barrier could be used for more efficient ground water extraction (Figure 2.6). Because of the expense involved, these techniques would be limited to small areas of highly contaminated material or ground water.

Ground water extraction—Ground water extraction controls movement of contaminated ground water and removes it from the aquifer. In many cases, it would be necessary to extract ground water only from the most highly contaminated zones (Figure 2.7). Ground water flow information and ground water hydraulic parameters would be used in conjunction with optimization codes to design the extraction network including well numbers, depths, spacing, and pumping or injection rates. With the aid of ground water models, the time required for the remedial actions could be estimated.

Well systems could be used to extract contaminated ground water for treatment or to create hydraulic barriers to ground water flow and increase the efficiency of extraction. These wells would then be pumped at specified rates to control the movement of contaminated ground water. In some cases, it could be

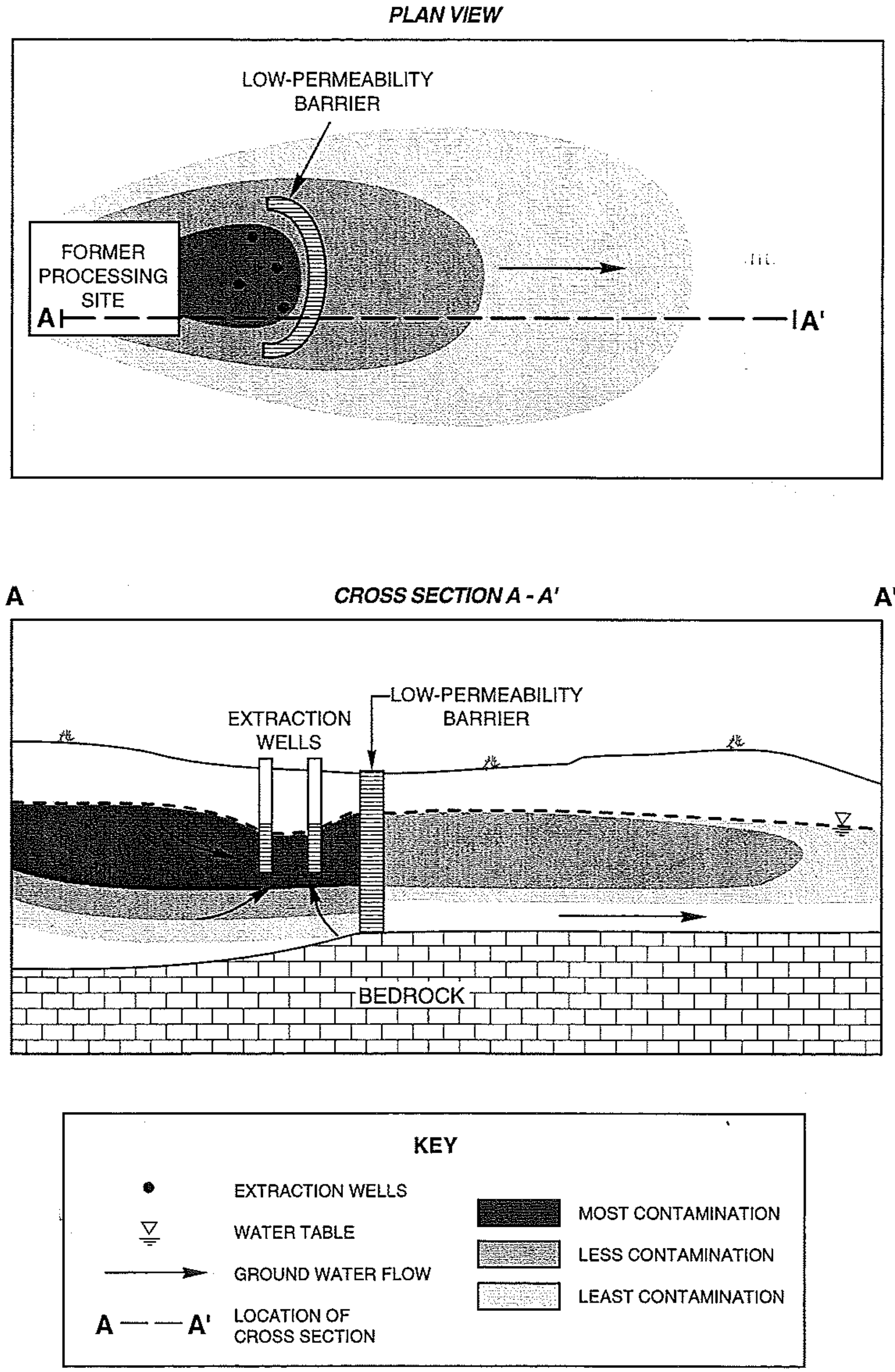


FIGURE 2.6
LOW-PERMEABILITY BARRIER TO ENHANCE GROUND WATER EXTRACTION

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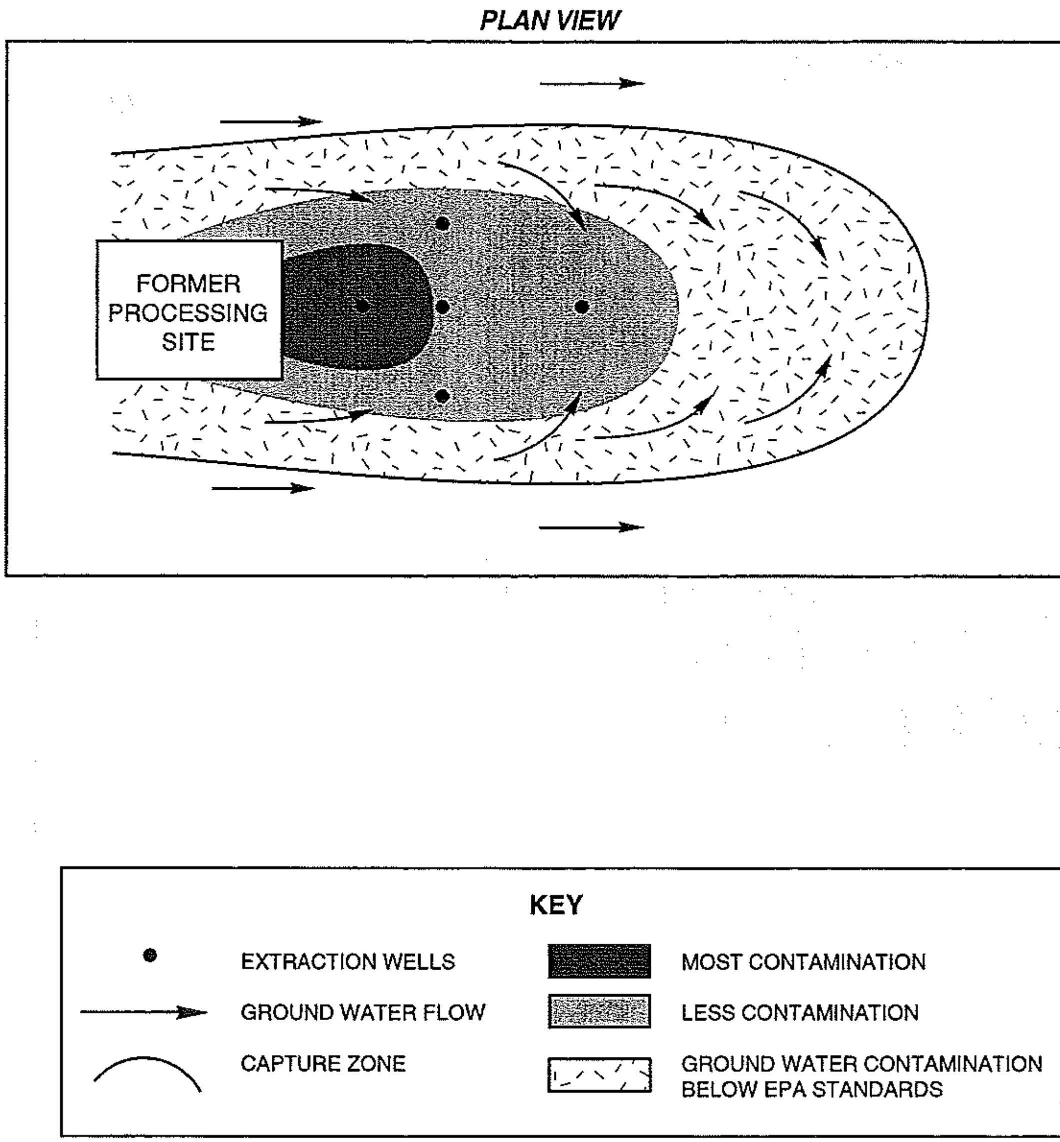

FIGURE 2.7
HYPOTHETICAL VIEW OF GROUND WATER EXTRACTION

necessary to combine periods of well pumping with periods of no pumping. When pumping has stopped, contaminants can diffuse out of less permeable (fine grain) zones or desorb from the aquifer matrix until equilibrium concentrations are reestablished in the ground water. Subsequent pumping would remove the minimum volume of contaminated ground water at the maximum possible concentration.

In shallow ground water systems, a well point network consisting of closely spaced, shallow wells connected to a pipe with a centrally located suction lift pump could be used. These systems can create an effective hydraulic barrier by capturing contaminated ground water. Well point networks would be used mainly for shallow water table aquifers because the maximum drawdown obtainable by suction lift is limited to approximately 25 feet (ft) (8.0 meters [m]) at sea level. Because well points are smaller in diameter and shallower than monitor wells, they are simpler and cheaper to install. This method is temporary (i.e., when the pumping is stopped the barrier ceases to function).

The land application option of ground water disposal would use extracted ground water for agricultural irrigation. Extracted ground water would undergo treatment before use as irrigation water when necessary. This option would be used at processing sites located close to agricultural lands. Processing sites with ground water contaminant plumes containing nitrates would be the most likely candidates for this type of water disposal design.

<u>Contaminated ground water treatment</u>—Once contaminated ground water is extracted from an aquifer, it may be necessary to treat it to protect human health and the environment. The need for treating extracted contaminated ground water before it is discharged depends on the concentrations of contaminants in the extracted ground water and the regulations regarding discharge of effluent to the surface and ground water. Once treated, ground water could be discharged to surface water bodies, recharged back into a shallow aquifer, or used as irrigation water for agricultural purposes.

Contaminants in water and wastewater could be removed by physical, chemical, and biological methods. These methods are discussed in detail in Appendix C.

<u>*In situ* ground water treatment</u>—*In situ* (in place) treatment uses chemical agents in the affected soil or ground water to degrade, remove, or immobilize the contaminants. It also includes methods for delivering solutions to the subsurface and for controlling the spread of contaminants and chemical agents beyond the treatment zone.

In situ treatment processes are generally divided into three categories: biological, chemical, and physical. *In situ* bioremediation accelerates or enhances the rate of microbial reactions to transform the contaminants into benign or insoluble compounds. At UMTRA Project sites, *in situ* treatment could be used to reduce nitrates through denitrification or to remove metals using sulfate. With chemical *in situ* treatment, specific chemicals are injected into the soil or ground water to degrade, immobilize, or release contaminants that are in the ground water or attached to the soil particles. Physical *in situ* methods physically change the soil or ground water using heat, electric energy, or other means to immobilize or to expedite the release or movement of contaminants from the soil or water. In most instances, *in situ* treatment would be combined with aboveground treatment to achieve the most cost-effective treatment at the UMTRA Project sites.

In some cases, geochemical barriers may be effective in eliminating or reducing ground water contamination. A subsurface permeable barrier would be placed to intercept the flow of contaminated ground water for shallow ground water systems. As the ground water passes through the barrier, the contaminants interact with the barrier material and are removed from the ground water by precipitation or adsorption.

2.9 WASTE MANAGEMENT METHODS

Various types of wastes may be generated during ground water characterization, monitoring, and remediation. The UMTRA Project would follow the *Technical Approach for the Management of UMTRA Ground Water Investigation-Derived Wastes* to manage field-generated wastes from well drilling, well development, sampling, testing, ground water monitoring, and remediation (DOE, 1994c). This report also provides details on the regulatory requirements for managing and disposing of ground water investigation-derived wastes. The information below summarizes this report (DOE, 1994c). When a ground water compliance strategy is determined and has the potential to form waste material, the management and regulation of this waste would be analyzed on a site by site basis in the site-specific environmental document.

The proposed action, the active remediation to background alternative, and the passive remediation alternative have the potential of generating the following materials that may be contaminated:

- Well development water—Well development water is generated when new wells are drilled for site characterization, installation of a monitoring system, and active remediation field operations. If necessary, well development water would be treated, and either reinjected into the ground water, applied to the land, or transported to an open UMTRA Project cell or other licensed facility for disposal in a manner consistent with UMTRA Project standards and/or DOE orders.

- Drill cuttings and drilling muds—Drill cuttings and drilling muds are the soil and rock brought to surface by the drill when drilling a well. These materials are generated during site characterization, installation of a monitoring system, and drilling during active remediation. Drill cuttings and drilling muds would be analyzed and either applied to the land or transported to an open UMTRA Project cell or other licensed facility for disposal in a manner consistent with UMTRA Project standards and/or DOE orders.

- Purge water—Purge water is generated prior to ground water sampling. Ground water sampling from wells would occur during site characterization and monitoring. Purge water would be analyzed and either be evaporated, applied to the land, or discharged in a manner consistent with UMTRA Project standards and/or DOE orders.

- Sludge and brine—Sludge and brine result from the treatment of contaminated ground water. Sludge and brine could be generated during site characterization or active remediation field operations. Sludge and brine would be analyzed and disposed of at an open UMTRA Project cell or at an alternate disposal site in a manner consistent with UMTRA Project standards and/or DOE orders.

- Ground water and soils—Contaminated ground water and soils may be generated during active remediation field operations. If necessary, contaminated ground water would be analyzed and treated. Ground water would then either be reinjected into the ground water, applied to the land, or discharged to a surface water body in a manner consistent with UMTRA Project standards and/or DOE orders. Soils would either be applied to the land or transported to an open UMTRA Project cell for disposal in a manner consistent with UMTRA Project standards and/or DOE orders.

Prior to disposal in an UMTRA Project disposal cell, wastes would be evaluated to ensure they would not compromise the cell design. If the quantity of liquid wastes exceeds the design parameters of a disposal cell, the liquid waste quantity would be reduced. Waste that could not be accommodated in an UMTRA Project disposal cell would be disposed of at a licensed disposal facility.

All these materials would have the potential of being contaminated with constituents typical of uranium mill processing and being considered residual radioactive materials. These materials would be managed in accordance with the requirements of the UMTRCA, the DOE, EPA, and the appropriate Indian tribes and states. Current data from most sites do not suggest contaminated materials from sources other than uranium processing activities would be encountered, although at some sites naturally occurring ore bodies may be encountered. However, all contaminants from non-UMTRA sources, if encountered, would be managed in accordance with the appropriate requirements.

2.10 COST ESTIMATE METHODS

Since a budget must be developed to obtain yearly federal appropriations, assumptions concerning site-specific compliance strategies must be made in advance to derive a cost estimate that will support budget submittals. These assumptions are for budgetary reasons only and in no way indicate that site-specific ground water compliance strategy decisions have been made prior to completion of the PEIS or a site-specific environmental document.

In estimating costs for each of the three ground water compliance strategies (no remediation, natural flushing, and active remediation), certain generic activities are assumed to support all three. However, the duration, complexity, and cost range of these generic activities vary with the type of compliance strategy selected. These activities include 1) preparing baseline risk assessments, site observational work plans (considered part of detailed site characterization), environmental assessments, and remedial action plans or modifications; 2) conducting a limited monitoring program until implementation of a compliance strategy or closeout activity; 3) performing some type of closeout activity, such as a certification report, a modification to the long-term surveillance plan, and/or licensing; and 4) performing program support activities. The cost estimates include escalation and contingency.

Activities for the no remediation compliance strategy would include those listed above plus, in certain cases, additional site characterization, wells, and revisions to the site observational work plans. Activities for the natural flushing compliance strategy would include longer durations of the same activities plus various phases of monitoring (calibration monitoring and verification monitoring) and a longer period to close out the site following verification monitoring and prior to turning the site over to another DOE project for compliance monitoring. Natural flushing also would include institutional controls. In addition to the above, active compliance strategy sites require detailed construction estimates. In developing these estimates, the Project used a software package called the "G-2 Estimator" in conjunction with environmental construction databases based on UMTRA Surface Project experience. All major cost elements were priced separately using historical data and supplier quotes. Cost elements included utility installation, numbers of wells required, collection systems, installation of water treatment plants, plant operations, testing, land application of treated or untreated water, closure, demobilization, and site restoration. The plant size and length of operations were generated on a site-specific basis using current assumptions on technical parameters of the plume, soil, and contaminants.

Each activity was individually reviewed. Cost estimates were developed based on related historical actuals (approximately 10 years on the UMTRA Surface Project), similar experience on other projects, and/or best professional estimates. The activities were then tailored to each site based on such site-specific attributes as the estimated volume of the plume and contaminants present. A critical path method analysis was then used to develop sequential logic for each compliance strategy, since some activities occur concurrently while others are sequential, and then summarized to develop an overall schedule. The overall Project schedule supported development of non-site-specific Project support activities, processes, or deliverables. The non-site-specific cost estimates were allocated against activities each year and combined to develop a total Project cost.

The last step in developing the cost estimates was to apply contingency to the base estimates to cover uncertainties. Acceptance of the proposed strategies used for the federal budgeting exercise accounts for the largest share of the Project's identified contingency. Other uncertainties to the UMTRA Project's estimates include 1) delays in state-share funding; 2) perturbations and delays in federal funding; 3) lack of access to existing site wells or the inability to drill new wells due to lack of access; 4) changes in currently understood plume size and contaminant concentrations; and 5) unknowns. The basis of estimates has attempted to cover a portion of the above risks; however, each time a project estimate is made, the DOE reexamines contingency application.

The basis of estimates for costs is reviewed several times during the fiscal year beginning in January. The estimates are continually reviewed for reasonableness, adaptability to the technical and political environment, and sound estimating practices.

3.0 AFFECTED ENVIRONMENT

This section describes the environment that could be affected by implementing any of the alternatives described in Section 2.0. Section 4.0 analyzes the potential impacts of implementing these alternatives. Section 3.1 describes the resources that may be affected during the Ground Water Project; this information was derived from NEPA documents and other reports generated during the Surface Project. Section 3.2 describes the UMTRA Project sites. Site-specific NEPA documents that would tier off this PEIS would provide additional details about the affected environment.

3.1 ENVIRONMENT OVERVIEW

The UMTRA Project processing sites were active for varying lengths of time from the 1940s into the 1970s. These sites, the surrounding areas, and the underlying ground water comprise the affected environment for this PEIS.

Land contaminated with uranium mill tailings and other hazardous constituents ranged from 21 ac (8 ha) at the Spook, Wyoming, site to 612 ac (248 ha) at the Ambrosia Lake, New Mexico, site (Table 3.1). In total, about 3900 ac (1600 ha) of land were contaminated at the sites. The amount of contaminated materials ranged from approximately 85,000 cubic yards (yd^3) (65,000 cubic meters [m^3]) at the North Continent Slick Rock, Colorado, site to 5,764,000 yd^3 (4,407,000 m^3) at the Falls City, Texas, site. The total amount of contaminated material at the sites is approximately 39,000,000 yd^3 (30,000,000 m^3).

The stabilization of the surface contamination at the sites was almost evenly divided between on-site and off-site disposal (Table 3.1). Most sites that had or will have uranium tailings transported off the site are either in urban settings or in river floodplains.

Surface remediation of the sites has been in progress since the mid-1980s. Canonsburg, Pennsylvania, the first site to undergo remediation, was completed in December 1985 (Table 3.1). Surface remediation is completed at 18 sites, and is under way at 4 sites. The Canonsburg, Shiprock, and Salt Lake City disposal cell designs were based on EPA standards that were remanded, in part, in 1983. The EPA has determined, based on information from the DOE, that modifications of these disposal cells are not warranted; the final determination will be made by DOE with the concurrence of the NRC (60 FR 2854).

3.1.1 Resources

This section summarizes the environmental resources at or near the processing sites. In general, "near" refers to a location where the resource has the potential to be affected by site-related contamination or remedial action.

Table 3.1 UMTRA Project surface remedial action status

UMTRA Project Site		On-site disposal	Off-site disposal	Cubic yards of contaminated materials (thousands)	Cubic meters of contaminated materials (thousands)	Acres of contaminated land	Hectares of contaminated land	Estimated amount of contaminated ground water[a] Gallons (millions)	Estimated amount of contaminated ground water[a] Cubic meters (thousands)
Monument Valley, AZ	5/94		√	942	720	83	34	1200	4,500
Tuba City, AZ	5/90	√		785	600	327	132	780	3,000
Durango, CO	5/90		√	2534	1937	127	51	100	380
Grand Junction, CO	8/94		√	4655	3559	114	46	330	1,300
Gunnison, CO	12/95		√	719	550	68	28	1900	7,000
Maybell, CO	7/97[b]	√		3500	2700	214	87	230	870
Naturita, CO	9/97[b]		√	547	418	247	100	100	380
Old Rifle, CO	10/96		√	661	505	88	36	70	260
New Rifle, CO	10/96		√	3474	2656	238	96	600	2,300
UC Slick Rock, CO	12/96[b]		√	488	373	92	37	26	100
NC Slick Rock, CO	12/96[b]		√	85	65	47	19	12	50
Lowman, ID	6/92	√		128	98	30	12	0	0
Ambrosia Lake, NM	6/95	√		3759	2874	612	248	320[c]	1,200
Shiprock, NM	9/86	√		1600	1200	130	53	160	610
Belfield, ND	—[d]		√	58	44	31	13	4.7	18
Bowman, ND	—[d]	√		128	98	71	29	58	220
Lakeview, OR	10/89		√	926	708	116	47	1200	4,500
Canonsburg, PA[e]	12/85	√		226	173	79	32	5.3	20
Falls City, TX	6/94	√		5764	4407	593	240	1200	4,500
Green River, UT	10/89	√		382	292	48	19	180	680
Mexican Hat, UT	1/95	√		2810	2150	250	101	110[c]	420
Salt Lake City, UT	6/89		√	2710	2070	128	52	350	1,300
Riverton, WY	11/89		√	1793	1371	140	57	500	1,900
Spook, WY	11/89	√		315	241	21	8	1000	3,800
Total		11	13	38989	29809	3894	1577	10,436	39,318

[a]From TAC, 1995.
[b]Anticipated completion date.
[c]Areas of saturation of contaminated ground water in geologic formations beneath the site that previously did not contain ground water.
[d]At the request of the state, DOE plans to revoke the designation of these two sites and surface remediation will not take place
[e]Includes Burrell, Pennsylvania, vicinity property disposal cell volume and area.
UC—Union Carbide. NC—North Continent.

3.1.1.1 Human health

The human environment at each UMTRA Project site includes everyone who lives in or near the direction of the contaminated ground water plume. The Surface Project addresses human exposure to the tailings, and the Ground Water Project addresses human exposure to ground water contamination.

3.1.1.2 Climate

All UMTRA Project sites except the Canonsburg, Pennsylvania, site and the associated Burrell vicinity property are in the western United States, generally in arid or semiarid environments. Fifteen sites are in dry climates and receive less than 12 inches (30 centimeters [cm]) of precipitation annually; six sites receive 12 to 20 inches (30 to 50 cm) annually; and three sites receive more than 20 inches (50 cm) annually (Table 3.2).

3.1.1.3 Surface water

Twenty-two sites are near surface water bodies, including major rivers such as the Colorado, Dolores, San Juan, and Yampa Rivers (Table 3.2). Perennial streams and ponds occur near a few sites. Ephemeral and intermittent washes and arroyos occur near many of the sites.

3.1.1.4 Ground water

Ground water contamination in varying degrees has been observed at all but one of the sites. Lowman, Idaho, is the only site where ground water contamination does not exist. Milling at the Mexican Hat, Utah, and the Ambrosia Lake, New Mexico, sites created areas saturated with contaminated ground water in geological formations that previously did not contain ground water; however, contamination of naturally occurring ground water has not been observed. Seepage of contaminated water has affected the naturally occurring underlying aquifers at the remaining 21 sites. Some of the more common hazardous constituents that exceed maximum concentration limits at UMTRA sites include uranium, molybdenum, and selenium. Table 3.3 shows constituents that have exceeded maximum concentration limits at least twice. This summary includes only the constituents for which EPA has established an UMTRA Project maximum concentration limit; other constituents associated with uranium processing exceed background levels at some sites and may be detrimental to human health and the environment. Ground Water Project documents that will address all site-specific constituents of concern include the baseline risk assessments and site observational work plans.

The estimated total amount of contaminated ground water at the UMTRA sites is 10,436,000,000 gal (39,318,000 m^3) (Table 3.1). The volume of contaminated ground water ranges from none at the Lowman site to approximately 1,900,000,000 gal (7,000,000 m^3) at the Gunnison site. At sites with contaminated ground water, the percent of off-site contamination

Table 3.2 Resources at UMTRA Project processing sites

	Site characteristics								
		Setting							
UMTRA Project Site	Tribal lands	Urban	Suburban	Rural	Annual precipitation (inches/cm)	Wetlands	Surface water	Cultural resources	Threatened and endangered species
Monument Valley, AZ	√			√	6/15	√	√	√	
Tuba City, AZ	√			√	6/15				
Durango, CO			√		19/48		√		√
Grand Junction, CO		√			8/20	√	√		√
Gunnison, CO			√		11/28	√	√		√
Maybell, CO				√	13/33	√	√	√	√
Naturita, CO				√	9/23	√	√	√	√
Old Rifle, CO			√		11/28	√	√		√
New Rifle, CO			√		11/28	√	√		√
Slick Rock, CO (Union Carbide)				√	7/18	√	√	√	√
Slick Rock, CO (North Continent)				√	7/18	√	√	√	√
Lowman, ID				√	27/69	√	√		
Ambrosia Lake, NM				√	9/23			√	
Shiprock, NM	√		√		6/15	√	√		√
Belfield, ND			√		16/41	√	√	√	√
Bowman, ND				√	16/41	√	√	√	√
Lakeview, OR			√		17/43	√	√		
Canonsburg, PA		√			37/94		√	√	
Falls City, TX				√	30/76	√	√		√
Green River, UT				√	6/15		√	√	
Mexican Hat, UT	√			√	6/15	√	√		
Salt Lake City, UT		√			15/38	√	√		
Riverton, WY	√[a]			√	8/20	√	√	√	
Spook, WY				√	11/28		√		√
Total	5	3	7	14		18	22	11	14

[a]Tribal lands adjacent to the site.

Table 3.3 Constituents that have exceeded UMTRA Project maximum concentration limits at least twice in ground water beneath UMTRA Project processing sites (1990-1995)

	Hazardous constituent[a]													
UMTRA Project Site[b]	Off-site migration	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Molybdenum	Net gross alpha	Nitrate	Radium-226/228	Selenium	Silver	Uranium
Monument Valley, AZ	√								√	√	√			√
Tuba City, AZ	√							√	√	√	√	√		√
Durango, CO				√		√		√	√		√	√		√
Grand Junction, CO	√							√	√					√
Gunnison, CO	√								√		√			√
Maybell, CO		√		√				√	√	√	√	√		√
Naturita, CO	√	√						√	√		√	√		√
Old Rifle, CO	√	√						√	√		√	√		√
New Rifle, CO	√	√		√				√	√	√	√	√		√
Slick Rock, CO (UC)	√							√	√	√	√	√		√
Slick Rock, CO (NC)	√								√		√			√
Lowman, ID														
Ambrosia Lake, NM[c]	√							√	√	√		√		√
Shiprock, NM	√			√					√	√	√	√		√
Lakeview, OR	√	√						√	√					
Canonsburg, PA									√					√
Falls City, TX	√	√		√	√	√	√	√	√	√	√	√		√
Green River, UT	√							√	√	√	√	√		√
Mexican Hat, UT[c]	√	√			√					√				
Salt Lake City, UT	√							√	√					√
Riverton, WY	√							√	√		√			√
Spook, WY	√			√	√			√	√	√	√	√	√	√
Total	18	7	0	6	3	2	1	15	20	11	15	12	1	19

[a]Some of the constituents that exceed the maximum concentration limits may be naturally occurring and not from uranium milling activities. For regulatory compliance purposes, the mean exceedance would be used with all alternatives except no action.

[b]The Belfield and Bowman, North Dakota, processing sites are not shown. They will not be remediated by DOE since the state has declined to provide their statutorily required cost-sharing to remediate the sites.

[c]Areas of saturation of contaminated ground water were created in geological formations beneath the site that previously did not contain ground water.

UC - Union Carbide.
NC - North Continent.

ranged from none at the Belfield, Canonsburg, and Slick Rock Union Carbide sites to 98 percent at the Gunnison site.

3.1.1.5 Ecological resources and wetlands

Most UMTRA Project sites are in areas dominated by desert shrub or desert grassland plants. Riparian plant communities along rivers, streams, washes, and arroyos occur at or near most sites. Threatened, endangered, and other species of concern occur at or near 14 sites, including several species of plants, endangered fish, and birds such as the bald eagle and peregrine falcon. Wetlands have been identified at or near 18 sites (Table 3.2). Wetlands at 10 of these sites have been or will be affected by the Surface Project; these impacts have been or will be mitigated.

3.1.1.6 Land use

Land use in and around UMTRA Project sites in urban areas ranges from industrial and commercial to residential and public. In rural settings, land use includes farming and ranching. Some rural lands are managed by the Bureau of Land Management.

3.1.1.7 Cultural/traditional resources

Areas at or near 11 of the UMTRA Project sites contain cultural resources (Table 3.2). These include archaic Native American lithic scatters, Anasazi ruins, and limited property from historical industrial and mining activities. In addition, water resources, including ground water and seeps, have traditional value to Native Americans. Many UMTRA Project sites fall within or near boundaries of tribal lands. Cultural resource investigations conducted primarily for the UMTRA Surface Project have identified cultural resources at two sites associated with tribal lands (Monument Valley, Arizona, and Riverton, Wyoming). Other resources of cultural interest to Native Americans may occur on other sites located on tribal lands (such as Tuba City, Arizona; Shiprock, New Mexico; and Mexican Hat, Utah) or lands associated with historic Indian occupation. More detailed information on cultural resources would be included in site-specific Ground Water Project environmental documents. Additional cultural resource investigations would be conducted, if required, prior to any site-disturbing activities associated with ground water compliance actions.

3.1.1.8 Transportation

Existing transportation networks at and near the processing sites accommodate local uses. All sites are accessible to vehicles. Remote areas that may be affected by the Ground Water Project may not be readily accessible to vehicular traffic.

3.1.1.9 Social and economic resources

Of the designated UMTRA Project sites, three are in cities, seven are at the edge of towns or cities, and 14 are in rural areas or remote settings (Table 3.2); five sites are on tribal lands representing four Native American tribes. Typically, the population characteristics and economies of the more rural, sparsely populated site areas are related primarily to agricultural activities such as ranching, grazing, and dryland farming, or to mining and energy exploration and development. Two sites in forested areas also are involved in forest-related uses such as logging. Suburban or urban sites have more diverse population and economic bases that include light industrial and commercial activities; residential areas also are located near these sites. Site ownership includes private, tribal, and public lands managed by the U.S. Forest Service and the Bureau of Land Management.

3.1.1.10 Environmental justice

Achieving environmental justice is part of DOE's mission. DOE identifies and addresses the disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. For the UMTRA Ground Water Project, the potential exists for disproportionately high and adverse effects on five sites that are on or partially on tribal lands. The sites on tribal lands are the Tuba City and Monument Valley, Arizona, sites; Shiprock, New Mexico, site; and the Mexican Hat, Utah, site. The contaminated ground water at the Riverton, Wyoming, site has migrated off-site and underlies tribal lands. This PEIS addresses the potential programmatic effects of the ground water compliance strategies and alternatives. Site-specific NEPA documentation would further analyze potential effects.

3.1.2 <u>Policy issues context</u>

The policy issues identified below define the fiscal and regulatory context of the UMTRA Ground Water Project. These issues may affect or be affected by implementing the proposed action or alternatives.

3.1.2.1 Fiscal context

The UMTRA Project participates in the federal budget development process by requesting annual requirements which are included in the annual budget requests from DOE that the President submits to Congress. Because Congress cannot appropriate funds without a fully justifiable estimate, assumptions concerning site-specific compliance strategies must be made so as to derive cost estimates that will support budget submittals. These assumptions are for budgetary purposes only and in no way indicate that site-specific ground water compliance decisions have been made prior to completion of the PEIS or site-specific environmental documents.

With input from UMTRA Project contractors, budget development is managed by the DOE in accordance with DOE orders and guidance. Budget development includes preparing a "bottom-up" budget for the annual field budget submittal, developing and controlling contingencies, and examining and reestimating budget requirements through Project completion. The budget development process ensures that the DOE adequately plans for its fiscal year requirements and conducts and assesses the long-range planning needed to complete the Project. To accomplish these objectives, a total Project (or life-cycle) budget is developed each year with input from all Project participants/contractors. Although congressional appropriations are for only one year, the estimated budget for the entire UMTRA Project must be presented to DOE Headquarters, the Office of Management and Budget, and finally, to Congress to identify future budget requirements. The current Ground Water Project cost projection is $497 million with a completion date of 2014; these estimates are based on the fiscal year 1997 field budget.

At times, the field budget submitted by the UMTRA Project is not fully funded. This can be the result of budget changes as program priorities are balanced at the DOE Headquarters level. Reductions in the requested funds can and often do affect the Project schedule, such as pushing work further into the future. These schedule slips have the potential to increase the overall Project cost due to escalation; schedule slips that extend work beyond the currently identified completion date can add additional Project management costs. Section 2.10 describes the basis for estimates of the ground water compliance strategies analyzed in Section 4.0.

3.1.2.2 Regulatory context

Section 1.4, Regulatory Compliance, describes the EPA, NRC, DOE, Executive Order, and tribal law requirements with which the UMTRA Project must comply.

3.2 SITE DESCRIPTIONS

Numerous documents, including environmental impact statements, environmental assessments, and remedial action plans, have been published or are being prepared that describe the existing site environment and surface remediation construction conditions at the UMTRA Project sites. These documents form the basis for the site descriptions presented in this document. The descriptions focus on factors most relevant to ground water remediation, including existing ground water data, local population and private well information, and other sensitive resources (for example, surface water bodies and wetlands) that may be affected by contaminated ground water. Descriptions of ground water quality were based on the *1992 Annual Environmental Monitoring Report* (DOE, 1993c) for sites where remedial action is under way or complete. Other ground water quality information was obtained from the latest site-specific Surface and Ground Water Project documents.

The discussion of ground water is limited to ground water in the uppermost aquifer, background ground water quality, and water-bearing units and aquifers that have been contaminated by milling activities. At some sites, contaminated ground water has migrated downward into previously unsaturated geologic formations above the natural water table. These formations contain small zones of saturation that resulted from milling activities. At most of the remaining sites, milling-related contaminants have entered only the shallow aquifers beneath the sites. Deeper aquifers are discussed only if they represent the uppermost aquifer or have been contaminated. Background ground water quality at some UMTRA Project sites is naturally poor due to uranium ore bodies and past mining activities, and natural highly mineralized aquifer matrix material.

3.2.1 Monument Valley, Arizona

The Monument Valley UMTRA Project site is in Apache County, Arizona, in an isolated setting along Cane Valley Wash on tribal land. The county per capita income is $5399; the population is predominantly Native American (DOC, 1990). The site is approximately 13 miles (mi) (21 kilometers [km]) east of the scenic Monument Valley tribal park. Comb Ridge, the most prominent topographic feature, is east of the site. The Monument Valley tailings site consisted of two tailings piles, windblown-contaminated soil, and piles of debris. The total amount of contaminated material at the site was 942,000 yd^3 (720,000 m^3) on 83 ac (34 ha). All the contaminated material has been moved to the Mexican Hat, Utah, disposal cell 17 road mi (27 km) to the north, and surface remedial action was completed in May 1994.

The Monument Valley site is in a sparsely populated area. The nearest town is Dennehotso, about 5.0 mi (8.0 km) south, in Apache County; the county population is 61,591 (DOC, 1990). The climate is arid, with an average annual precipitation of 6.0 inches (15 cm) and an average annual snowfall of 3.3 inches (8.4 cm) (DOE, 1993d). Six cultural resource sites have been identified near the site and are eligible for inclusion on the National Register of Historic Places (DOE, 1989a). The region is characterized by a desert shrub habitat with scattered junipers occurring on higher terrain and rocky areas. There are no known threatened or endangered species at or near the site (DOE, 1989a).

Surface water features at the Monument Valley site consist of Cane Valley Wash and several small ephemeral drainages. These drainages flow northeast into Cane Valley Wash (DOE, 1989a). A series of spring-fed wetlands and ponds occur along Cane Valley Wash, northeast of the tailings site area and extending at least 3.0 mi (4.8 km) north. The Frog Pond is the surface water body closest to the site (2000 ft [600 m] to the east); this pond has not been contaminated. Downstream from the site (2.2 mi [3.5 km]), are additional surface water bodies and wetlands that have not been affected by site-related contaminated ground water.

Ground water occurs in the alluvium and dune sand underneath the Monument Valley site and in the underlying bedrock formations. The depth to ground water in the alluvium is from a few feet in Cane Valley Wash to slightly more than 10 ft (3.0 m) under the site. This ground water is recharged by occasional infiltration from precipitation and upward leakage from the underlying aquifers. The ground water in the alluvium flows north at an estimated velocity range of 90 to 200 ft (27 to 61 m) per year. Below the alluvial aquifer, ground water occurs in the Shinarump Conglomerate and the confined De Chelly Sandstone aquifer. Ground water flows north at an estimated rate of 6.0 to 100 ft (2.0 to 30 m) per year in the Shinarump Conglomerate and 150 ft (46 m) per year in the De Chelly Sandstone.

Background ground water quality in these three aquifers shows no statistical evidence that any hazardous constituent exceeds maximum concentration limits. Contamination in the alluvial ground water beneath the site has exceeded the maximum concentration limits for net gross alpha, nitrate, radium-226 and -228, and uranium twice since 1990. A nitrate plume approximately 3000 ft (900 m) extends north of the site. The estimated amount of contaminated ground water at the Monument Valley site is 1.2 billion gal (4.5 million m^3). Concentrations of nitrate, net gross alpha, and radium-226 and -228 have exceeded the maximum concentration limits in the Shinarump at least twice since 1990. The maximum concentration limits for gross alpha and uranium have been exceeded in the De Chelly at least twice since 1995.

Two domestic wells are completed in the alluvial aquifer just south and upgradient of the site. Other residents near the site use artesian ground water from the De Chelly Sandstone that flows from monitor wells or former production wells. Ground water analyses from all these sources show no sign of contamination (DOE, 1993d).

3.2.2 Tuba City, Arizona

The Tuba City UMTRA Project site is in Coconino County, Arizona, 6.0 air mi (10 km) east of Tuba City (population 7300) (DOC, 1990) on tribal land. The county per capita income is $8683; the population in the vicinity is predominantly Native American (DOC, 1990). The site is on the Kaibito Plateau in the desert shrub vegetation zone. The surrounding terrain is dominated by dissected sandstone formations, mesas, and alluvial terraces. The tailings, windblown and waterborne deposits, demolished mill building, and other contaminated material, which totaled 785,000 yd^3 (600,000 m^3) on 327 ac (132 ha), were stabilized on the site in a 50-ac (20-ha) disposal cell (DOE, 1989b). Surface remediation was completed in May 1990.

The site is arid, with an average annual precipitation of 6 inches (15 cm) and an average annual snowfall of 4.0 inches (10 cm) (DOE, 1986a). There are no known cultural resources or threatened or endangered species at the site (DOE, 1986a). The site is approximately 7000 ft (2100 m) northwest of Moenkopi Wash, an intermittent stream that joins the Little Colorado River to the southwest. No other watercourses exist in the vicinity of the site. A natural spring and seeps appear along the base of an escarpment, approximately

6000 ft (1800 m) east-southeast of the site. The largest of these is used to water livestock. The other seeps have very little flow and are evident most often by the occurrence of riparian plant species and damp areas on the cliff face. Analysis of water and saturated soil samples from one seep south of the site indicates these seeps are not contaminated. The flow in Moenkopi Wash varies from periods of no flow to flows of more than 14,500 cubic feet per second (ft^3/s) (411,000 L per second) (DOE, 1986a). Surface water and sediment sample analysis from Moenkopi Wash indicates this wash is not affected by contaminants from the Tuba City site (DOE, 1986a).

The uppermost aquifer at the Tuba City site is in the Navajo Sandstone. This formation is up to 430 ft (130 m) thick in the site area. The water table ranges from 20 to 150 ft (6.0 to 50 m) deep. Ground water in this aquifer flows southeast toward Moenkopi Wash at an estimated average velocity of 2.0 to 100 ft (0.6 to 30 m) per year. Ground water beneath the site is contaminated, and levels of molybdenum, nitrate, selenium, uranium, and net gross alpha and radium-226 and -228 activity have exceeded the maximum concentration limits at least twice since 1990. The plume of contamination extends approximately 1500 ft (460 m) downgradient from the site. The estimated amount of contaminated ground water at the Tuba City site is 780 million gal (3.0 million m^3). Ground water is not withdrawn from the plume area. Water is taken from springs near Moenkopi Wash and from the wash itself, downgradient of the site. These use areas are all greater than 1.0 mi (1.6 km) from the Tuba City site (DOE, 1989b).

3.2.3 Durango, Colorado

The Durango processing site is in La Plata County, Colorado, just southwest of the city of Durango. The site is on the west side of the Animas River, extending from the floodplain to the base of Smelter Mountain. The site consisted of two areas: the tailings piles in the milling area and the raffinate pond area about 0.5 mi (0.8 km) to the south. Approximately 2,534,000 yd^3 (1,937,000 m^3) of contaminated material were removed from the 127-ac (51-ha) site and associated vicinity properties (DOE, 1985a). The contaminated material was transported to the Bodo Canyon disposal site, approximately 3.5 mi (5.6 km) from the processing site. Surface remedial action was completed at the Durango processing site in May 1990.

The Durango site was revegetated after the completion of remedial action and contains a healthy stand of vegetation. Surface water bodies include the Animas River and Lightner Creek, both of which border the site. Surface water and sediment samples indicate contaminated ground water from the site has not contaminated these water bodies or their sediments. Riparian vegetation along the Animas River consists of cottonwoods and box elders. Threatened or endangered species are known to exist at or near the site (DOE, 1985a). These species include the bald eagle, which winters along the river, and the peregrine falcon, which nests about 1.0 m (1.6 km) from the site.

The Durango area has a semiarid climate, with an average annual precipitation of 19 inches (48 cm). The processing site is near the city of Durango, with an estimated 1990 population of 12,430. La Plata County had an estimated 1990 population of 32,284 (DOC, 1990). The nearest year-round resident is immediately west of the site. The processing site contains no known cultural resources (DOE, 1985a).

The Durango processing site is underlain by approximately 1760 ft (520 m) of Mancos Shale bedrock. The Mancos Shale bedrock is truncated along the Smelter Mountain fault at the south end of the terrace supporting the site. The bedrock is overlain by approximately 5.0 to 20 ft (1 to 6 m) of alluvium and man-made fill. Ground water moves through the alluvium (uppermost aquifer) as a thin (less than 3.0-ft [1.0-m]-thick) layer on top of the almost impermeable shale. The depth to ground water ranges from less than 3.0 ft (1.0 m) along the river to more than 40 ft (12 m) near the mountain. The ground water moves toward Lightner Creek and the Animas River, but the irregular surface of the bedrock makes it impractical to calculate a hydraulic gradient or the rate of ground water movement.

The former raffinate pond area is underlain by alluvium similar to the mill and tailings piles area and overlies relatively permeable sandstone. Ground water moves toward the Animas River through both the alluvium and the bedrock. The rate of ground water movement is estimated to be 800 ft (240 m) per year in the alluvium and 75 ft (22 m) per year in the sandstone. The amount of discharge to the Animas River is probably minimal compared to flow in the river. The minimum seven-day low flow recorded in the Animas River was 100 ft^3/s (3.0 m^3 per second) in December 1917.

Analysis of background water quality of the alluvial aquifer indicates that concentrations of cadmium, chromium, molybdenum, net gross alpha, and selenium have exceeded the maximum concentration limits several times. Seven hazardous constituents have exceeded the EPA maximum concentration limits in the alluvial aquifer beneath both areas of the site at least twice since 1990: cadmium, lead, molybdenum, net gross alpha, radium-226 and -228, selenium, and uranium. The estimated amount of contaminated ground water at the Durango site is 100 million gal (0.38 million m^3).

Water beneath the former processing site is not used for human consumption, and there is no evidence of elevated hazardous constituents in the Animas River as a result of alluvial aquifer discharge into the river. The city of Durango and properties near the site are served by a municipal water supply system. Water for this system is withdrawn from the Animas River upstream of the Durango UMTRA Project site. In addition, the water intake for a planned irrigation project will be in the river in the southern portion of the Durango site.

3.2.4 Grand Junction, Colorado

The Grand Junction site is on state-owned land in the city of Grand Junction, in Mesa County, Colorado, along the north side of the Colorado River. Approximately 4,655,000 yd^3 (3,559,000 m^3) of contaminated material were on 114 ac (46 ha) at the processing site (Sanders, 1993). During surface remedial action, all the contaminated material was moved to the Cheney disposal cell, 18 mi (29 km) southeast of the Grand Junction site (DOE, 1986b). The transportation of this material began in 1991; remedial action was completed in August 1994.

The population of Grand Junction is 29,034 (DOC, 1990). There are no cultural or historic resources at the Grand Junction site (DOE, 1986b). The site was constructed in the floodplain of the Colorado River, and a series of small islands and river side channels occurs between the site and the river. This area supports a dense growth of riparian vegetation and a diverse wildlife species. Other than 8.0 ac (3.0 ha) that were cleaned up during surface remediation, there is little or no site-related contamination in the area (based on analysis of surface water and sediment samples).

The Grand Junction site is arid, with an average annual precipitation of 8.0 inches (20 cm). Snowfall averages 27 inches (69 cm) annually (DOE, 1986b). Threatened or endangered species have been identified near the site (DOE, 1986b). These include the bald eagle, which winters along the river, and the Colorado squawfish, which may occur in the side channels of the Colorado River next to the site.

The Grand Junction processing site is underlain by Colorado River alluvium (uppermost aquifer) that ranges in saturated thickness from less than 10 ft (3.0 m) to more than 20 ft (6.0 m). Alluvial ground water levels beneath the site vary from 2.0 to 5.0 ft (1.0 to 2.0 m) annually, with the lowest levels occurring during the fall and winter. Ground water in the alluvial aquifer flows west and southwest, depending on the stage of the Colorado River, and eventually discharges to the river. The estimated ground water velocity is 73 to 1800 ft (22 to 550 m) per year. The uppermost aquifer is underlain by the Mancos Shale, which functions as an aquitard in the area.

At this time, there is some uncertainty regarding background ground water quality at the Grand Junction site. The background water in the alluvial aquifer has high concentrations of salts such as sulfate. Concentrations of molybdenum, selenium, and uranium and activities of net gross alpha exceeded maximum concentration limits in background ground water at least once. Seeping tailings fluids have contaminated ground water in the alluvium beneath the processing site. This contaminated ground water extends west from the site for approximately 2500 ft (760 m). Concentrations of molybdenum and uranium and activities of net gross alpha have exceeded the maximum concentration limits beneath and downgradient from the site at least twice since 1990. The estimated amount of contaminated ground water at the Grand

Junction site is 330 million gal (1.3 million m^3). The Mancos Shale aquitard prevents contaminated ground water from moving any deeper (DOE, 1991b).

3.2.5 Gunnison, Colorado

The Gunnison processing site is on state-owned land and is adjacent to the city of Gunnison in Gunnison County, Colorado. In 1990 the city of Gunnison had an estimated population of 4636, while Gunnison County had an estimated population of 10,273 (DOC, 1990). The site is on a drainage divide between the Gunnison River and Tomichi Creek in the Gunnison River valley. Approximately 719,000 yd^3 (550,000 m^3) of contaminated material were on 68 ac (28 ha). The contaminated material was moved to the Gunnison disposal site approximately 6.0 mi (10 km) from the processing site. Surface remedial action began in May 1992 and was completed in December 1995.

The processing site is on the floodplain alluvium between the Gunnison River and Tomichi Creek. The site is about 0.4 mi (0.6 km) east of the Gunnison River and 0.4 mi (0.6 km) west of Tomichi Creek. It is bounded on the west by small storm drainage ditches and on the south and west by irrigation ditches. Surface water and sediment samples have been collected from the Gunnison River and Tomichi Creek upstream and downstream from the processing site and from shallow ponds near the site. No site-related contaminants have adversely affected the surface water and sediments in surface water bodies near the site.

An analysis of threatened and endangered species indicates the Gunnison River contains no endangered fish species (DOE, 1992a). Endangered species near the site include the whooping crane, which stops and feeds in the floodplain of Tomichi Creek during migration, and the bald eagle, which occurs along the Gunnison River during the winter. The Gunnison milk vetch, a federal candidate plant species, was growing on the tailings pile. There are no known cultural resources at the site (DOE, 1992a). The site is semiarid, receiving an average annual precipitation of 11 inches (28 cm) and an average annual snowfall of 58 inches (147 cm) (DOE, 1992a).

The uppermost aquifer at the site is in the alluvial deposits of the Gunnison River and Tomichi Creek. These floodplain alluvial deposits extend to at least 110 ft (34 m) beneath the processing site. This aquifer is recharged from rain, snowmelt, the Gunnison River, Tomichi Creek, and seasonal recharge from irrigation ditches around the site. Ground water discharges into the Gunnison River and Tomichi Creek. The average depth to ground water beneath the site is 5.0 ft (2.0 m). This ground water flows southwest at an average of 270 ft (80 m) per year.

Background ground water quality in the alluvial aquifer does not exceed EPA ground water standards. Tailings seepage has contaminated the alluvial ground water beneath the processing site; net gross alpha, radium-226 and -228, and uranium have exceeded the maximum concentration limits at least twice since

1990. The uranium plume extends approximately 7000 ft (2000 m) southwest from the site to the Gunnison River. The estimated amount of contaminated ground water at the Gunnison site is 1.9 billion gal (7 million m^3).

Downgradient of the site, 311 private wells are completed in the alluvial aquifer. Twenty-two of these private wells are known to contain elevated levels of uranium from the processing site plume. A permanent alternate water supply system was constructed for the residents who have wells in and adjacent to the contaminant plume. The municipal water supply for the city of Gunnison is unaffected by the contamination because it comes from wells in the alluvial aquifer upgradient of the processing site (DOE, 1991c).

3.2.6 Maybell, Colorado

The Maybell processing site is in Moffat County, Colorado, 25 mi (40 km) west of the city of Craig and 5.0 mi (8.0 km) northeast of the unincorporated village of Maybell. Approximately 3,500,000 yd^3 (2,700,000 m^3) of contaminated material are at the processing site and in the windblown contaminated areas on 214 ac (87 ha). In addition, 1.9 mi (3.0 km) of Johnson Wash and 1.0 mi (1.6 km) of Lay Creek were contaminated by the inadvertent discharge of 200,000 to 400,000 pounds (90,000 to 180,000 kilograms) of tailings and the routine discharge of tailings pond effluent into these streams in the early 1960s. The surface remedial action will stabilize all contaminated material in place, and is expected to be completed in July 1997.

The Maybell processing site is in a remote area of sagebrush and piñon-juniper habitat. The site is partly on Bureau of Land Management land and partly on private land. The principal land uses are grazing and hunting (for mule deer, pronghorn antelope, and sage grouse). Wetlands occur along Johnson Wash and Lay Creek near the site. Johnson Wash is a dry arroyo that runs near the eastern border of the site. This wash joins Lay Creek about 1.0 m (1.6 km) south of the site. This creek is a tributary of the Yampa River and the confluence is about 5.0 mi (8.0 km) southwest of the site. No site-related contaminated ground water has entered or is expected to enter these bodies of water. The population of Moffat County is 11,357 (DOC, 1990). Although one historic site occurs near the site, it is not considered eligible for inclusion on the National Register of Historic Places (DOE, 1995a).

The Maybell site is semiarid. The average annual precipitation is more than 13 inches (33 cm); snowfall averages more than 80 inches (200 cm) annually (DOE, 1995a). Threatened or endangered species that occur near the site along the Yampa River include wintering bald eagles and the Colorado squawfish (DOE, 1995a).

The processing site is underlain by the Browns Park Formation. The uppermost aquifer is in the upper sandstone unit of this formation. Ground water within this formation ranges in depth from 35 to 300 ft (11 to 90 m) beneath the site. Ground water flows southwest at an average velocity of approximately 40 ft

(12 m) per year. Recharge to the uppermost aquifer is principally from infiltration of precipitation and snowmelt. Ground water from this aquifer discharges into the alluvial aquifer of the Yampa River.

Background ground water quality is affected by natural mineralization related to the uranium ore body; selenium and uranium levels exceed the maximum concentration limits. Contaminants from the processing site have entered the aquifer beneath the site but because of advantageous geochemical conditions, the contamination has not passed the site boundary. Contaminants that have exceeded the maximum concentration limits in the tailings pore fluid and the ground water beneath the site at least twice since 1990 are arsenic, cadmium, molybdenum, nitrate, net gross alpha, radium-226 and -228, selenium, and uranium. The estimated amount of contaminated ground water at the Maybell site is 230 million gal (0.87 million m^3).

The domestic well nearest the site is 3.0 mi (5.0 km) to the southwest in the alluvial aquifer of the Yampa River. Contaminants from the processing site likely will not affect this aquifer because favorable geochemical conditions limit downgradient contaminants migration. In addition, the ground water in the uppermost aquifer is unsuitable for drinking due to widespread ambient contamination that is related to naturally occurring uranium mineralization and to mining activities not related to the uranium milling operations.

3.2.7 Naturita, Colorado

The Naturita processing site is in Montrose County, Colorado, approximately 2.0 mi (3.0 km) northwest of the town of Naturita along the San Miguel River. Much of the site is in the floodplain of the river. Between 1977 and 1979, the tailings were moved to a facility 3.0 mi (5.0 km) south of the processing site for reprocessing. There are 547,000 yd^3 (418,000 m^3) of contaminated material on 247 ac (100 ha) at the site. This total includes 194 ac (79 ha) that were contaminated with windblown and waterborne tailings. Tailings washed down the San Miguel River and contaminated approximately 56 ac (23 ha) of the mostly wooded riparian zone along the river. The contaminated material will be moved out of the floodplain to an off-site disposal cell. Surface remedial action began in April 1995 and is scheduled for completion in September 1997.

The Naturita processing site is in a sparsely populated area on the south side of the San Miguel River. The population of the town of Naturita is 430 (DOC, 1990). The San Miguel River is the only surface water body in the site area. Surface water samples have shown that site-related contaminated ground water is not adversely affecting the water in the river. Cottonwoods and willows dominate a riparian wetland zone along the river. Junipers and piñon pines dominate the surrounding hillsides. The San Miguel River contains no endangered fish species. The endangered southwestern willow flycatcher may occur at the site (DOE, 1994d). Wintering bald eagles also occur along the river in the processing site area.

The site is on private land. The nearest residence is approximately 2000 ft (600 m) north-northwest of the site. The Naturita site is arid, with an estimated average annual precipitation of 9.0 inches (23 cm). The average annual snowfall is approximately 30 inches (80 cm). Three prehistoric sites near the site are eligible for inclusion on the National Register of Historic Places (DOE, 1994d).

Ground water beneath the Naturita site occurs in the alluvial deposits of the San Miguel River floodplain. This aquifer is recharged by the river southeast of the site and discharges into the river northwest of the site. The alluvial aquifer flows approximately parallel to the river at an estimated linear velocity of 22 ft (7.0 m) per year. Background ground water quality in the alluvium near the processing site did not exceed the EPA maximum concentration limits. Uranium concentrations indicate a contaminant plume in the alluvial ground water extending approximately 1500 ft (460 m) downgradient from the processing site. Other site-related contaminants that have exceeded maximum concentration limits in this aquifer at least twice since 1990 are arsenic, molybdenum, selenium, radium-226 and -228, and net gross alpha. The estimated amount of contaminated ground water at the Naturita site is 100 million gal (0.38 million m^3).

Ground water in the Salt Wash aquifer, which is below the alluvial aquifer, is not contaminated by the processing site. Contaminated ground water is likely entering the San Miguel River, but surface water and sediment samples indicate this ground water has not affected the river. There are no known uses of the contaminated ground water beneath or downgradient of the processing site.

3.2.8 <u>Rifle, Colorado (two sites)</u>

The Old and New Rifle UMTRA Project sites are near the city of Rifle, Colorado, in Garfield County. The Old Rifle site is 0.3 mi (0.5 km) southeast of the center of Rifle. The New Rifle site is 2.0 mi (3.0 km) southwest of the center of Rifle. Approximately 661,000 yd^3 (505,000 m^3) of contaminated material were on 88 ac (36 ha) at the Old Rifle site, and approximately 3,474,000 yd^3 (2,656,000 m^3) of contaminated material were on 238 ac (96 ha) at the New Rifle site (DOE, 1990). The contaminated materials from both sites are being transported to the Estes Gulch disposal site, approximately 6.0 mi (10 km) north of the Rifle sites. Remedial action began during the spring of 1992 and is scheduled for completion in October 1996.

The Old and New Rifle sites are in the floodplain of the Colorado River. The base of the Old Rifle site is slightly above the Colorado River during average flow and is separated from the river by the tracks of the Denver & Rio Grande Western Railroad. The Colorado River flows 1000 ft (300 m) east and 600 ft (180 m) south of the New Rifle tailings pile. The mill and ore storage areas were located between the tailings pile and the river to the east.

Before surface remedial action, the Old Rifle site contained a small wetland (0.7 ac [0.3 ha]). In addition, 20 ac (8.0 ha) of wetlands occurred at the New Rifle site, including wetlands in the southeast portion of the site and in the contaminated area west of the site. These wetlands were destroyed during surface remediation and a 44-ac (18-ha) mitigation wetland was constructed near the former New Rifle tailings pile. In addition, sediments and fish in a fishing pond downgradient of the Old Rifle site had elevated uranium levels. Several surface water bodies west of the New Rifle site, including a drainage ditch and a gravel pit pond, also have elevated uranium levels. Sampling in the Colorado River indicated no elevated contaminant levels (DOE, 1992b).

The population of the city of Rifle is approximately 4600, the population in Garfield County is 30,000 (DOC, 1990). The region is semiarid, with an annual average precipitation of 11 inches (28 cm) and an average annual snowfall of 41 inches (104 cm) (DOE, 1990). Threatened or endangered species in the site area include the endangered fish in the Colorado River and the bald eagle (DOE, 1990). Cultural resources were not identified at or near the Old and New Rifle sites.

Both Rifle sites are underlain by Colorado River alluvium. Beneath the alluvium, semiconfined ground water occurs in interlayered sandstone, siltstone, and claystone beds in the Wasatch Formation. In general, ground water in the alluvium and in the Wasatch Formation flows southwest. Seasonal water level fluctuations in the river influence flow in the aquifers. During periods of high flow, the river recharges the alluvium. During periods of low river flow, the alluvial aquifer tends to discharge into the river. The alluvium at the Old Rifle site is approximately 20 ft (6.0 m) thick, with depth to ground water generally ranging from 2.0 to 12 ft (1.0 to 4.0 m). At the New Rifle site, the alluvium is 25 to 30 ft (8.0 to 9.0 m) thick, with depth to ground water generally ranging from 5.0 to 10 ft (2.0 to 3.0 m). The average linear ground water velocity in the alluvial aquifer is 800 ft (250 m) per year at the Old Rifle site and 300 ft (90 m) per year at the New Rifle site. The average linear ground water velocity in the Wasatch Formation is 0.3 ft (0.09 m) per year at the Old Rifle site and 3.0 ft (0.9 m) per year at the New Rifle site (DOE, 1992b).

Background ground water in the alluvial aquifer has exceeded the maximum concentration limits for chromium, molybdenum, selenium, uranium, and net gross alpha at various times since sampling began. The maximum concentration limits have been exceeded for molybdenum, selenium, uranium, and net gross alpha in the Wasatch Formation background ground water. In addition, background ground water for the Wasatch Formation exceeds the maximum concentration limits for barium and activities of radium-226 and -228.

Both the alluvial and Wasatch aquifers are contaminated by seepage from the tailings piles at both sites. Contaminants introduced into the ground water from the tailings at the Old Rifle site that have exceeded the maximum concentration limits at least twice since 1990 are arsenic, molybdenum, selenium, and uranium, and activities of net gross alpha and radium-226 and -228. In addition, levels of fluoride, vanadium, and zinc are elevated above background levels.

Tailings seepage has also contaminated the Wasatch Formation below the Old Rifle site; cadmium and chromium concentrations and activities of net gross alpha and radium-226 and -228 have exceeded the maximum concentration limits at least once since 1990 in monitor wells 623 and 624. Antimony, strontium, vanadium, and zinc are above background levels. The estimated amount of contaminated ground water at the Old Rifle site is 70 million gal (0.26 million m^3). Most of the contaminated ground water at the Old Rifle site discharges into the Colorado River, several hundred feet downriver from the tailings pile (DOE, 1991d).

At the New Rifle site, ground water contamination in the alluvial aquifer extends at least 5000 ft (1500 m) downgradient from the pile. Downgradient contaminant concentrations in the alluvium generally are higher at the New Rifle site than the Old Rifle site. Concentrations of arsenic, cadmium, molybdenum, nitrate, selenium, and uranium, net gross alpha, and radium-226 and -228 activity have exceeded the maximum concentration limits at least twice since 1990. In addition, levels of antimony, fluoride, strontium, vanadium, and zinc exceed background levels in the alluvial aquifer.

The horizontal extent of contamination in the Wasatch Formation at New Rifle extends 3500 ft (1100 m) downgradient from the tailings pile. The estimated amount of contaminated ground water at the New Rifle site is 600 million gal (2.3 million m^3). Concentrations of molybdenum, nitrate, selenium, uranium, and activities of net gross alpha and radium-226 and -228 have exceeded the maximum concentration limits at least once since 1990; levels of antimony, fluoride, strontium, sulfide, vanadium, and zinc are elevated above background levels in the Wasatch Formation (DOE, 1990).

The Colorado River is the primary source of municipal water in the Rifle area. The Colorado River intake is approximately 0.5 mi (0.8 km) upriver from the Old Rifle site. The city obtains about 10 percent of its water from Beaver Creek, southwest of the New Rifle site and south of the Colorado River. The DOE has sampled 16 private wells and springs in the Rifle vicinity. An UMTRA Project position paper discusses potential impact to local private wells and springs near the Rifle sites (DOE, 1995b).

3.2.9 <u>Slick Rock, Colorado (two sites)</u>

Two processing sites are near Slick Rock, Colorado, along the Dolores River in San Miguel County. The population of San Miguel County is approximately 3700 (DOC, 1990). The Union Carbide processing site is approximately 1.0 mi (1.6 km) downriver from the North Continent processing site. Both sites are partially in the floodplain of the Dolores River in a sparsely populated area. There are 488,000 yd^3 (373,000 m^3) of contaminated material on 92 ac (37 ha) at the Union Carbide site and 85,000 yd^3 (65,000 m^3) of contaminated material on 47 ac (19 ha) at the North Continent site. The proposed surface remedial action is to move the contaminated material out of the floodplain to the Burro Canyon disposal cell, 2.0 mi (3.0 km) north of the sites. The current schedule calls for completion of surface remedial action at the two sites in December 1996.

The Union Carbide and North Continent sites are in a steep canyon of the Dolores River, in the floodplain of the river. The Dolores River is the only permanent water body in the area of the sites, although there are dry washes. Surface water and sediment samples indicate contaminated ground water at the site has not adversely affected the water or sediment quality of the river. Willows and other shrubs dominate the riparian wetland zone along the river. A total of 96 ac (39 ha) of the riparian plant communities occurs in the contaminated zone at the Union Carbide and North Continent sites. The riparian zone supports many productive plant communities, which in turn support diverse wildlife. The surrounding canyon contains steep cliff faces or steep slopes dominated by desert shrubs. No endangered fish species are in the river in the area of the sites; endangered species are wintering bald eagles along the river and nesting peregrine falcons within 8.0 mi (13 km) of the sites. The river otter, a federal candidate species, occasionally occurs in the river near the sites.

Cultural resources near the processing and disposal sites have been identified and are being addressed during remedial planning (DOE, 1994e).

Both processing sites are on private land. The major land use in the area is grazing. A gas sweetener plant is adjacent to the Union Carbide site.

The Slick Rock site area is arid. The mean annual precipitation is 7.0 inches (18 cm). The average annual snowfall is approximately 30 inches (76 cm).

Ground water beneath the Slick Rock sites occurs in the alluvial aquifer of the Dolores River and in the underlying Entrada Sandstone and Navajo Sandstone Formations. These three hydrostratigraphic units are believed to be hydraulically interconnected. Ground water in the alluvium generally flows northwest, parallel to the flow of the river. Depth to ground water ranges from 10 to 20 ft (3.0 to 6.0 m) beneath the sites. The average linear ground water velocity in the alluvium ranges from 100 ft (30 m) per year at the North Continent site to 150 ft (50 m) per year at the Union Carbide site. The alluvial aquifer is recharged by seepage from the Dolores River upstream and by precipitation. Ground water discharges from the alluvium into the Dolores River downgradient.

Concentrations of molybdenum and uranium have exceeded the maximum concentration limits in one or more background alluvial monitor wells. These elevated constituent levels may be influenced by nearby mines upriver from the processing sites. Tailings seepage has affected the ground water quality in the alluvium beneath the Union Carbide site. Contaminant plume migration has been limited to within or slightly downgradient of this site. Concentrations of molybdenum, nitrate, selenium, and uranium and activities of net gross alpha and radium-226 and -228 have exceeded the maximum concentration limits at least twice since 1990. The estimated amount of contaminated ground water at the Union Carbide site is 26 million gal (100,000 m^3).

Tailings seepage also has contaminated the alluvial ground water beneath the North Continent site, although the concentrations generally are lower than at the Union Carbide site. Hazardous constituents that have exceeded maximum concentration limits at least twice since 1990 are net gross alpha, radium-226 and -228, and uranium. Contaminant migration appears to be limited to within the site boundary. The estimated amount of contaminated ground water at the North Continent site is 12 million gal (50,000 m^3).

The contaminated ground water in the alluvium at both sites discharges into the Dolores River. Surface water sampling of the river detected none of the contaminants found in the alluvium. Ground water quality of the Entrada Sandstone underlying the alluvium also has been affected by uranium milling activities based on concentrations of selenium and total dissolved solids that are elevated above background levels. Ground water in the underlying Navajo Sandstone aquifer is not contaminated by tailings seepage from either the Union Carbide or North Continent site. Three water supply wells are upgradient or crossgradient from the processing sites. One of these wells is completed in the alluvium and lower formations. The other two are completed in the Navajo Sandstone. There are no known human uses of the contaminated ground water in the alluvium beneath or downgradient of either the Union Carbide or North Continent site.

3.2.10 Lowman, Idaho

The Lowman processing site is in Boise County, Idaho (population 3509), 0.5 mi (0.8 km) northeast of the unincorporated town of Lowman and 70 mi (112 km) north of Boise (DOC, 1990). The site is in the northern Rocky Mountains in heavily wooded terrain within the Boise National Forest. It is surrounded by ponderosa pine forest on the north, south, and east sides. Clear Creek, a perennial trout stream, forms the site's western boundary. Contaminated material from the processing site was deposited in a small portion of the Clear Creek floodplain and associated wetland. The principal land uses in the surrounding forest are logging, recreation, wildlife management, and livestock grazing. The site is characterized by a continental climate with dry, hot summers and cold winters. The average annual precipitation is 27 inches (69 cm); the average annual snowfall is 95 inches (241 cm) (DOE, 1991e). There are no known threatened or endangered species or historic or cultural resources at the site (DOE, 1991e).

A total of 128,000 yd^3 (98,000 m^3) on 30 ac (12 ha) was stabilized on the site in a 8.2-ac (3.3-ha) disposal cell. Surface remedial action was completed in June 1992.

The uppermost aquifer beneath the site consists of ground water in alluvium and weathered granodiorite. Depth to ground water varies from 27 to 78 ft (8.0 to 24 m) at the processing site. Ground water flows west-to-southwest along the alluvium/weathered granodiorite bedrock contact and discharges into Clear Creek. The estimated linear ground water velocity is approximately 55 ft (18 m) per year. Water quality analyses indicate none of the EPA maximum concentration limits are exceeded in the upgradient or downgradient monitor wells or in the tailings pore fluid. Therefore, the ground water beneath the site and the water discharging into Clear Creek does not contain contaminants that are the result of milling operations at the Lowman processing site. Residents in the village of Lowman obtain their water from wells in the deep granodiorite bedrock aquifer or from the South Fork Payette River, which flows through town (DOE, 1991e; 1991f).

3.2.11 Ambrosia Lake, New Mexico

The Ambrosia Lake UMTRA Project site is in McKinley County, New Mexico, approximately 20 mi (32 km) north of Grants. The population of the city of Grants is 8626; the population of McKinley County is 60,686 (DOC, 1990). The site is in the Ambrosia Lake Valley, a broad, elongated valley dominated by desert grassland plant communities with basalt-capped mesas to the north. An estimated 3,759,000 yd^3 (2,874,000 m^3) of contaminated material at the processing site and windblown area covered 612 ac (248 ha). Surface remediation consisted of stabilizing all contaminated material on the site in an 88-ac (36-ha) disposal cell. Remedial action was completed in June 1995.

The Ambrosia Lake site is in a sparsely populated area. Cultural resources have been identified near the site. The site lies within the drainage basin of Arroyo del Puerto, an intermittent stream 1.0 mi (1.6 km) southwest of the site. No permanent surface water bodies, including wetlands, are at or near the site. No threatened or endangered species are known to occur at or near the site. The Ambrosia Lake site is arid, with an average annual precipitation of 9.0 inches (23 cm) (DOE, 1987a).

The uppermost water-bearing unit beneath the Ambrosia Lake site consists of alluvium that grades into weathered Mancos Shale in the eastern portion of the site and into the Tres Hermanos-C Sandstone in the western portion of the site. Ground water in the alluvium and upper weathered bedrock is the result of uranium milling and mining activities in the area. This ground water occurs at depths ranging from 15 to 45 ft (5.0 to 14 m) and flows southwest at an estimated 15 ft (4.0 m) per year. It is unlikely that ground water from the alluvium would be used for drinking water due to its low yield, limited saturated extent, and poor quality.

Background water quality data are not available because the alluvium and upper bedrock did not contain water before the advent of uranium mining and milling in the area. Concentrations of molybdenum, nitrate, selenium, and uranium and activities of radium-226 and -228 have exceeded the maximum concentration limits in the alluvium and upper Mancos Shale ground water beneath the site at least twice since 1990. Ground water in the Tres Hermanos-C Sandstone unit has exceeded the maximum concentration limits of molybdenum, nitrate, selenium, uranium, and the activities of net gross alpha at least twice since 1990. The estimated amount of contaminated ground water at the Ambrosia Lake site is 320 million gal (1.2 million m^3). Ground water in aquifers below the Tres Hermanos-C unit does not appear to have been contaminated by seepage from the contaminated ground water units beneath the Ambrosia Lake site.

No domestic, stock watering, or irrigation wells are completed within the alluvium and upper weathered bedrock in the Ambrosia Lake Valley. This is not expected to change due to the low yield of water from these units.

3.2.12 Shiprock, New Mexico

The Shiprock UMTRA Project site is on Navajo Nation land in San Juan County, New Mexico, on the southeast edge of Shiprock (population, 7687). The county per capita income is $8911 and the population in the site vicinity is predominantly Native American (DOC, 1990). The residents of Shiprock use the public water system, which is supplied by the San Juan River.

Approximately 1,600,000 yd^3 (1,200,000 m^3) of contaminated materials on 130 ac (53 ha) were stabilized in a 72-ac (29-ha) disposal cell in the same location as the former milling operations. Remedial action was completed in September 1986. The site is arid, averaging 6.0 inches (15 cm) of precipitation and 4.1 inches (10.4 cm) of snowfall annually. Threatened and endangered species occur near the site, including wintering bald eagles along the river and the Mesa Verde cactus in the upland desert/shrub plant community. No historic resources occur at or near the site (DOE, 1984a).

The site is along the south side of the San Juan River on an elevated terrace about 50 ft (21 m) above the river. Bob Lee Wash traverses the west side of the site and flows into the floodplain of the San Juan River. This wash is ephemeral, except for the lower 600 ft (200 m) that receives a constant discharge of about 60 gal (200 L) per minute from a potable water artesian well west of the wash. This water has created wetlands within Bob Lee Wash and at the mouth of the wash where it discharges into the floodplain of the river. In addition, two seeps flow from the base of the escarpment below the disposal cell into the floodplain of the river. These seeps flow at an estimated rate of 0.3 to 1.0 gal (1.0 to 4.0 L) per minute. A canal and ditches in the floodplain contain water year-round. Other surface water and small wetland areas are in the San Juan River floodplain below the disposal cell.

Surface water and sediment samples from the San Juan River downgradient of the site and from Bob Lee Wash indicate site-related contaminants have not affected these waters. Water quality data from the two seeps show elevated concentrations of nitrate, sulfate, and uranium (DOE, 1993e).

The Shiprock disposal cell is on unconsolidated alluvial terrace deposits underlain by Mancos Shale. Ground water occurs at the contact between the terrace alluvium and the upper portion of the Mancos Shale, where it has been weathered. There are an insufficient number of water level measuring points to prepare a reliable ground water contour map, but perched ground water on the terrace is believed to follow paleochannels to the southwest and west. The ground water layer in the alluvium above the bedrock is thin (generally less than 3.0 ft [1.0 m]), and the rate of recharge to the monitor wells is slow. Ground water levels in the monitor wells continue to decrease. Ground water also moves through fractures in the Mancos Shale and seeps from the escarpment.

Background ground water quality has not been defined for the terrace alluvium and upper Mancos Shale because all monitor wells installed have intercepted contaminated ground water. Background ground water quality for the floodplain alluvium was defined by ground water quality north of the river. Uranium milling and processing activities have resulted in ground water contamination in the alluvium and upper Mancos Shale on the terrace and in the floodplain alluvium. The contaminated ground water in the river terrace alluvium and upper Mancos Shale beneath the site and in the floodplain alluvium along the river have exceeded the maximum concentration limits for cadmium, net gross alpha, nitrate, radium-226 and -228, selenium, and uranium (DOE, 1993e). In addition, the maximum concentration limits for radium-226 and -228 exceed the maximum concentration limits in the contaminated ground water beneath the site. The volume of contaminated ground water is estimated to be 160 million gal (610,000 m^3).

3.2.13 Belfield, North Dakota

The Belfield, North Dakota, processing site is in Stark County. The Belfield site is 1.0 mi (1.6 km) south of the city of Belfield (population, 881) (DOC, 1990). The estimated amount of contaminated material is 58,000 yd^3 (44,000 m^3) on 31 ac (13 ha) of land. The once proposed remedial action alternative was to transport the contaminated material from the Belfield site 65 mi (104 km) to the Bowman site and stabilize all the material in a 12-ac (5.0-ha) disposal cell at Bowman. However, surface or ground water remedial action at these sites will not be completed at the request of the state.

The Belfield site is in the Northern Great Plains; the climate is semiarid. Annual temperature extremes are common; the recorded maximum and minimum temperatures are 105 degrees Fahrenheit (°F) (35 degrees Celsius [°C]) to -35°F (-19°C). The average annual precipitation is almost 16 inches (41 cm), with an average annual snowfall of 30 inches (80 cm) (DOE, 1993f).

The Belfield site is in a light industrial use area just outside Belfield along the North Branch of the Heart River. Part of the contaminated land is in the floodplain of this river. The Heart River is a wooded draw with steep sides. It is 5.0 to 10 ft (2.0 to 3.0 m) wide with intermittent flow. Contaminated ground water from the site does not discharge into the Heart River in the site area. Cultural resources near the site have been identified and will undergo further study. No federally listed or candidate plant or animal species are known to occur in the site area. U.S. Army Corps of Engineers-designated wetlands occur along the Heart River near the site (DOE, 1993f).

Ground water occurs beneath the Belfield processing site in the fine-grained sediments and lignite layers. Depth to ground water ranges from 15 to 38 ft (5.0 to 12 m). Ground water flow is generally east. The average linear ground water velocity is 26 ft (7.0 m) per year. There is no evidence that contaminated ground water from the Belfield processing site is entering the Heart River, nor has ground water discharged to the land surface at this site. The volume of contaminated ground water at the Belfield site is an estimated 4.7 million gal (18,000 m^3).

Background ground water quality at the Belfield site exceeds the EPA drinking water standards for sulfate and total dissolved solids and the EPA maximum concentration limit for selenium. Contaminants have entered the shallow ground water, and concentrations of chromium, radium-226 and -228, molybdenum, selenium, and uranium exceed the maximum concentration limits. Because of the diffuse nature of the contaminant source, which originated from airborne ash, the development of a contaminant plume in ground water is insignificant. No evidence suggests site-related contaminants have entered deeper aquifers.

Ground water from the shallow aquifer system is used for limited stock watering and some domestic purposes but it is not a drinking water source. Water for most domestic uses is obtained from deep aquifers in the Belfield site area. The water supply for the city of Belfield is obtained from a 1000-ft (300-m) deep aquifer 1000 ft (300 m) upgradient from the Belfield UMTRA Project site (DOE, 1993f).

3.2.14 Bowman, North Dakota

The Bowman, North Dakota, site is in Bowman County, 7 mi (11 km) northwest of the city of Bowman (population, 1713) (DOC, 1990). A total of 128,000 yd^3 (98,000 m^3) of contaminated material on 71 ac (29 ha) will be cleaned up at the Bowman site. This contaminated material, along with contaminated ground water, will not be remediated at the request of the state.

The site is in a rural area surrounded by short-grass prairie and other grasslands used for grazing and dryland farming. One small ephemeral wetland occurs within the zone of contamination. The nearest permanent water bodies are a pond and stream 1200 ft (360 m) west of the site; these water bodies are not affected by the site. Historical structures from early 1900s settlements have been identified at the site and need further study. Two federal candidate species (ferruginous hawk and loggerheaded shrike) have been observed within 1.0 mi (1.6 km) of the site. U.S. Army Corps of Engineers-designated wetlands occur near the site (DOE, 1993f). The annual precipitation is the same as the Belfield site.

Ground water beneath the Bowman processing site occurs in fine-grained sediments and in lignite layers. Depth to ground water ranges from 6.0 to 20 ft (2.0 to 6.0 m), and flow is generally to the east. The average ground water velocity is 2.0 ft (0.7 m) per year at the Bowman site. There is no evidence of ground water discharge to the land surface.

Background ground water quality at the Bowman site exceeds the EPA drinking water standards for sulfate and total dissolved solids, as well as the EPA maximum concentration limits for chromium, selenium, and uranium. Contaminants from the Bowman site have entered the shallow ground water, and concentrations of chromium, radium-226 and -228, molybdenum, selenium, and uranium exceed the maximum concentration limits. The estimated amount of contaminated ground water at the Bowman site is 58 million gal (0.22 million m^3). There is no evidence that site-related contaminants have migrated into deeper aquifers.

Ground water from the uppermost aquifer is not used as a drinking water source but is used for limited stock watering and some domestic purposes. Public water for most uses is obtained from deep aquifers in the Bowman site area.

3.2.15 Lakeview, Oregon

The Lakeview processing site is in Lake County, Oregon, about 1.0 mi (1.6 km) north of the city of Lakeview. About 926,000 yd^3 (708,000 m^3) of contaminated material on 116 ac (47 ha) at the Lakeview processing site were stabilized off the site at the Collins Ranch disposal cell, 7.0 mi (11 km) northwest of Lakeview. Surface remedial action was completed in October 1989.

The Lakeview processing site is nearly surrounded by ranch lands. Two lumber mills to the southeast constitute most of the industrial facilities in the immediate area. The population is approximately 7200 in Lake County and 2500 in the city of Lakeview (DOC, 1990). No historic or prehistoric sites were reported in the vicinity of the processing site (DOE, 1985b).

Surface water bodies at the site include Hunters Creek and associated wetlands along the northern boundary of the site, Warner Creek just west of the site, the East Branch of Thomas Creek along the east and south boundaries, Hammersley Creek on the east side, and a pond near the site of the former mill buildings. Surface water and sediment samples from these water bodies indicate site-related contaminated ground water has not adversely affected the water or sediment quality. The Lakeview site is in a semiarid, high desert climate, with cool temperatures and an average annual precipitation of about 17 inches (43 cm). No threatened or endangered species are known to exist at or near the site; however, migrant species may find suitable habitat near the site (DOE, 1985b).

Ground water beneath the site occurs in an alluvial/lacustrine aquifer. The water table beneath the site generally occurs at a depth of 5.0 to 15 ft (1.5 to 4.6 m). Ground water moves south and southwest at approximately 50 to 160 ft (15 to 49 m) per year. Recharge to the alluvial/lacustrine aquifer is from precipitation and from surface water infiltration from nearby cold water and geothermal water streams. Ground water is withdrawn from agricultural, industrial, municipal, and domestic wells in the site vicinity and discharges into surface water channels that drain into Goose Lake, about 8.0 mi (13 km) south of the site.

Background ground water consists of low-temperature water and hot water from geothermal sources. The background ground water has exceeded maximum concentration limits for molybdenum, and radium-226 and -228 at least once. Arsenic, molybdenum, and net gross alpha have exceeded the maximum concentration limits in the alluvial/lacustrine aquifer beneath the processing site at least twice since 1990. Current information indicates a contaminant plume extends approximately 1500 ft (460 m) southwest from the processing site, as determined from sulfate and total dissolved solids concentrations (DOE, 1992c). The estimated amount of contaminated ground water at the Lakeview site is 1.2 billion gal (4.5 million m^3). Alluvial/lacustrine ground water is used for domestic, livestock watering, and industrial purposes in the processing site area.

3.2.16 Canonsburg, Pennsylvania

The Canonsburg site is in Washington County in western Pennsylvania. This site consists of the former processing site in the borough of Canonsburg, approximately 20 mi (32 km) southwest of downtown Pittsburgh. The Canonsburg disposal cell is surrounded on the north, south, and west by a buffer zone that separates it from nearby residential and commercial properties. The population of the borough of Canonsburg is 9200 (DOC, 1990). Approximately 172,000 yd^3 (132,000 m^3) of contaminated material on 30 ac (12 ha) were stabilized in an on-site disposal cell. Surface remedial action was completed in December 1985.

The Canonsburg site is in the humid continental climate region. The average annual precipitation is 37 inches (94 cm); the average annual snowfall is 45 inches (114 cm).

Chartiers Creek bounds the site on the north, east, and west sides. This creek is bordered by wooded riparian vegetation. The water quality of this creek is poor near the site as a result of sewage and industrial waste. Water samples and limited sediment samples indicate that site-related ground water has not adversely affected the water and sediment quality at Chartiers Creek. There are no known threatened or endangered species at the site. Within a 1.0-mi

(1.6-km) radius of the Canonsburg site are two places that are listed on the National Register of Historic Places (DOE, 1983).

Ground water occurs in unconsolidated fill at a depth of 3.0 to 14 ft (1.0 to 4.0 m) and in the bedrock beneath the Canonsburg site. Ground water in both aquifers flows toward Chartiers Creek. Ground water recharge occurs from precipitation and underflow from upgradient areas. Uranium and net gross alpha have exceeded the maximum concentration limits at least twice since 1990. The estimated amount of contaminated ground water at the Canonsburg site is 5.3 million gal (20,000 m^3). In general, contaminant concentrations in ground water have decreased since post-closure monitoring started. Public water supplies are obtained from protected surface water sources upstream of the site (DOE, 1983).

The Burrell site is a vicinity property disposal cell associated with the Canonsburg site. It is in Indiana County, Pennsylvania, approximately 40 mi (64 km) east of downtown Pittsburgh and 50 mi (80 km) east-northeast of the Canonsburg site. At the Burrell site, 54,000 yd^3 (41,000 m^3) of contaminated material covering 49 ac (20 ha) were stabilized in place in a 6.0-ac (2.4-ha) disposal cell. Surface remedial action was completed in July 1987. Some radioactively contaminated materials were transferred to Burrell from the Canonsburg site from 1956 to 1957. The Burrell site is in a rural setting. Blairsville, the nearest borough, is approximately 0.75 mi (1.2 km) west of the site. The population is 3595 in the borough of Blairsville (DOC, 1990).

The average annual precipitation is 44 inches (112 cm), while the average annual snowfall is 45 inches (114 cm). The Burrell site is within the floodplain of the Conemaugh River. It is surrounded by abandoned fields on the north and east sides and the floodplain of the Conemaugh River on the west and south sides. A spring has created wetlands at the base of the south-facing slope of the disposal cell. This spring drains into the nearby Conemaugh River, which is contaminated by mine drainage, industrial pollution, and municipal wastewater discharge. A small wetland (less than 1.0 ac [0.4 ha]) has developed along the northern boundary of the disposal cell. There are no known threatened or endangered species at the site. Several historical resources are located within a 1.0-mi (1.6-km) radius of the site (DOE, 1983).

Ground water occurs in unconsolidated fill at depths greater than 30 ft (9.0 m) and in the bedrock beneath the site. It flows south toward the Conemaugh River. Surface water samples indicate that constituents associated with the Burrell disposal cell have not entered the Conemaugh River or the wetlands on the south side of the cell. Water samples have not been collected from the wetlands along the north side of the cell. Sediment samples have not been collected from any water bodies near the site. Domestic water supplies for the surrounding population are from protected surface water sources (DOE, 1983).

3.2.17 Falls City, Texas

The Falls City, Texas, site is in Karnes County, 46 mi (74 km) south of San Antonio and 8.0 mi (13 km) southwest of Falls City. During surface remedial action, 593 ac (240 ha) of land and 5,764,000 yd^3 (4,407,000 m^3) of contaminated material are being cleaned up at this site. Contaminated material covered 593 ac (240 ha) of land at this site. The contaminated material was stabilized on the site in a 127-ac (51-ha) disposal cell. Surface remedial action began in 1992 and the disposal cell was completed in June 1994.

The Falls City site is in a rural setting. Grazing is the principal land use for the mesquite-dominated woodlands around the site. The area around the Falls City site is sparsely populated. Falls City, the nearest town, had an estimated population of 497 in 1990 (DOC, 1990). Cultural resource surveys identified prehistoric sites within a 5.0-mi (8.0-km) radius of the site. However, cultural resource surveys were not required at the processing or borrow sites because of previous major disruption to the area (DOE, 1991g).

Surface water bodies that occur on-site or at the site boundary are Tordilla and Scared Dog Creeks, which are intermittent streams, and a pond along the south end of what had been tailings pile number three. Small wetlands occur at these water bodies. Four additional ponds are within 3000 ft (900 m) of the site. Water samples from the surface water bodies indicate site-related contaminated ground water has not adversely impacted water quality. Limited sediment, vegetation, and fish samples from the on-site surface water bodies indicate site-related contaminated ground water likely has not contaminated these media. However, further sampling, including the collection of background samples, is needed to verify this.

The climate at the site is considered subtropical, with hot summers and mild winters. High humidity is typical, and the average annual precipitation is 30 inches (76 cm). No federally listed threatened and/or endangered species occur in the site area. Extensive field surveys determined that none of the state-designated threatened and/or endangered species that may occur in Karnes County occur at the site (DOE, 1991g). However, subsequent observations during remedial action show the Texas horned lizard occurs at the site. In addition, the Texas tortoise and indigo snake may occur in the site area.

Two low-yield aquifers have been identified in the upper 200 ft (60 m) of the clastic sedimentary strata underlying the site. These aquifers are separated by 30 to 50 ft (27 to 46 m) of clay. However, because improperly abandoned exploratory boreholes form a potential hydraulic interconnection between these two aquifers, they are considered together, as the uppermost aquifer. Shallow ground water in the uppermost aquifer occurs at depths of 5.0 to 30 ft (1.5 to 9.0 m) below land surface. The maximum average linear ground water velocity is approximately 130 ft (40 m) per year, and the aquifers yield small amounts of water (1.0 to 2.0 gal per minute) (0.06 to 0.12 L per second). The site is bisected by a drainage divide; the shallow ground water flows primarily northeastward and southwestward, paralleling intermittent drainages. Shallow ground water may discharge into these intermittent drainages from ephemeral seeps. The uppermost aquifer is underlain by a 300-ft (100-m) thick formation of clay and lignite seams that prevents the downward migration of contaminants.

Background water quality is highly variable with depth and location because it occurs within the uranium ore body. The background ground water is classified as limited use, based on high average uranium concentrations and activities of net gross alpha and radium that render the water untreatable by methods reasonably employed by public water systems in the region (DOE, 1992d).

Tailings fluids have migrated into the uppermost aquifer; as a result, concentrations of arsenic, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, and uranium have exceeded the maximum concentration limits at least twice since 1990. However, because the background ground water is of poor quality, this water is of limited use for stock watering and is of no use for any other purpose. The estimated amount of contaminated ground water at the Falls City site is 1.2 billion gal (4.5 million m^3). Because area residents currently do not use the Deweesville/Conquista ground water, human health is not at risk from direct ground water use (DOE, 1994f). Potable water is obtained from one domestic well more than 800 ft (240 m) deep and a water cooperative's well 2000 ft (600 m) deep (DOE, 1991g; 1991h, 1994f).

3.2.18 Green River, Utah

The Green River processing site is in Grand County, Utah, 1.0 mi (1.6 km) southeast of the city of Green River. The site is partially in the floodplain of Brown's Wash, an intermittent tributary of the Green River. The tailings pile covered 8.0 ac (3.0 ha); an additional 40 ac (16 ha) were contaminated with tailings. An estimated 382,000 yd^3 (292,000 m^3) of contaminated material were placed in a 6.0-ac (2.0-ha) disposal cell on the site. Surface remediation was completed in October 1989.

The Green River disposal cell is on a terrace above Brown's Wash. This wash is approximately 800 ft (240 m) north of the cell. The original tailings pile was in the floodplain of Brown's Wash, along the southern border of the wash. The wash flows only during periods of heavy precipitation and is dry for most of the year. However, pools of water that may be created by the discharge of contaminated ground water into Brown's Wash are often present downstream of the site. Sampling over the years has shown that these pools contain elevated concentrations of nitrates, selenium, uranium, and other constituents that have the potential to be harmful to aquatic and terrestrial organisms. The Green River is about 2000 ft (610 m) west of the site and surface water samples from the river indicate that site-related contaminated ground water is not adversely affecting surface water quality.

The site is in a sparsely populated area. The population of the city of Green River is 881; the population in Grand County is 6620 (DOC, 1990). Two cultural resource sites near the processing site are eligible for inclusion on the National Register of Historic Places. The Green River site is arid; the average annual precipitation is 6.0 inches (15 cm), with an average annual snowfall of 10 inches (25 cm). No threatened or endangered species occur at or near the site (DOE, 1988).

Four distinct water-bearing units occur at the Green River site: the alluvium of Brown's Wash and the upper, middle, and lower Cedar Mountain Formation aquifers. The Brown's Wash alluvial aquifer is limited to 300 to 400 ft (90 to 120 m) on each side of the wash and is up to 35 ft (11 m) thick. Depth to ground water ranges from 9.0 to 17 ft (3.0 to 5.0 m) below ground surface. Ground water in this unit flows west, parallel with the wash toward the Green River, at a velocity ranging from 0.6 to 2.0 ft (0.2 to 0.7 m) per day. The alluvial aquifer is recharged from underflow and by infiltration of surface runoff in the channel of Brown's Wash.

Ground water in the upper Cedar Mountain aquifer flows west toward the Green River at a velocity ranging from 4.0 to 260 ft (1.0 to 70 m) per year. Ground water is about 26 ft (8.0 m) deep at the old tailings pile area. Ground water in this unit is recharged by the overlying alluvial aquifer and the underlying middle Cedar Mountain aquifer.

The middle Cedar Mountain aquifer flows west toward the Green River. This aquifer is an estimated 60 ft (20 m) deep beneath the old tailings pile area; however, there is a strong upward gradient between this unit and the overlying aquifers. Due to fracturing, this aquifer likely is connected to the upper Cedar Mountain aquifer. Because of an overlying confining layer and a strong upward hydraulic gradient, the lower Cedar Mountain aquifer is not recharged by the aquifers above it.

In background ground water of the alluvial aquifer, chromium, molybdenum, net gross alpha, nitrate, and selenium have exceeded maximum concentration limits. Concentrations of net gross alpha, nitrate, and selenium in the background ground water in the upper Cedar Mountain aquifer have exceeded the maximum concentration limits. Concentrations of molybdenum, nitrate, selenium, uranium, and net gross alpha have exceeded the maximum concentration limits in background ground water of the middle Cedar Mountain aquifer. Analysis of background ground water in the lower Cedar Mountain aquifer indicates levels of chromium, molybdenum, and selenium exceed the maximum concentration limits. The estimated amount of contaminated ground water at the Green River site is 180 million gal (0.68 million m^3).

Seepage of hazardous constituents from the former tailings pile area has contaminated the alluvial and upper Cedar Mountain aquifers. Net gross alpha and radium-226 and -228 activity and concentrations of molybdenum, nitrate, selenium, and uranium have exceeded the maximum concentration limits beneath and downgradient of the former tailings pile at least twice since 1990. The extent of contamination is confined to these two aquifers by strong upward hydraulic gradients between the upper Cedar Mountain aquifer and the underlying aquifers.

There are no known uses of the ground water at or near the Green River processing site. The city of Green River uses water from the Green River, upriver of the tailings site, for its water supply (DOE, 1988).

3.2.19 Mexican Hat, Utah

The Mexican Hat processing site is in the Navajo Nation in San Juan County, Utah. The village of Halchita is approximately 0.5 mi (0.8 km) from the site, and the estimated population is approximately 500. The per capita income in the county is $5907 and the population is 54 percent Native American (DOC, 1990). The village of Mexican Hat, Utah, is 2.0 mi (2.2 km) from the site, and the estimated population is 43 (DOE, 1987b). This site consisted of two tailings piles totaling 69 ac (28 ha). An estimated 2,810,000 yd^3 (2,150,000 m^3) of contaminated material are contained in these two tailings piles and on an additional 250 ac (101 ha) of adjacent land. The contaminated material at this site and contaminated material from the Monument Valley, Arizona, processing site are being stabilized in a 72-ac (29-ha) disposal cell at the Mexican Hat site. Surface remediation was completed by January 1995.

The climate is arid with an average annual precipitation of 6.0 inches (15 cm). The Mexican Hat site is in a rural setting surrounded by desert shrub habitat. The site is adjacent to an unnamed intermittent arroyo (called the North Arroyo) that is a tributary to Gypsum Creek, a larger ephemeral arroyo that, when flowing, empties into the San Juan River. The site is approximately 1.0 mi (1.6 km) from the San Juan River. There are no known threatened or endangered species or historic resources at or near the processing site (DOE, 1987b). The population of San Juan County is 12,621 (DOC, 1990).

During construction of the Mexican Hat disposal cell, seeps were discovered in the North Arroyo. In Gypsum Creek northeast of the site, naturally occurring seeps are present. The North Arroyo and Gypsum Creek seeps discharge site-related contaminated ground water with concentrations or activities of nitrate, molybdenum, selenium, uranium, net gross alpha, and radium-226 and -228 that have exceeded EPA maximum concentration limits at various times in the past (DOE, 1993d). Surface water samples from the San Juan River indicate that if the site-related contaminated ground water is discharging into the river, it is not adversely affecting water quality.

The tailings site is on top of the Halgaito Shale outcrop. Ground water beneath the Mexican Hat site occurs in the Halgaito Shale and the underlying Honaker Trail Formation. Perched water in the Halgaito Shale occurs only as a result of uranium milling operations. It is only in a localized area of saturation beneath the site at a depth ranging from 35 to 60 ft (11 to 18 m). Perched water in the

Halgaito Shale generally flows northeast, and is controlled by the structural dip and fractures in the Halgaito Shale. The water discharges with very low flow rates (less than 1.0 gal [4.0 L] per minute) into isolated seeps in the North Arroyo. Gypsum Creek seeps flow intermittently.

The Honaker Trail Formation is considered the uppermost aquifer at the site. The Honaker Trail Formation occurs at a depth of 100 to 150 ft (30 to 50 m) beneath the site; ground water in this formation flows at an average velocity of 4.0 ft (1.0 m) per year. This ground water flows generally northeast. Recharge of this unit occurs at higher elevations, and it discharges to seeps in Gypsum Creek or as underflow to the northeast. The occurrence of a thick low-permeability unit and an upward hydraulic gradient has prevented contaminated water from the Halgaito Shale from entering the Honaker Trail Formation aquifer.

Because the ground water in the Halgaito Shale occurs as a result of milling operations, background ground water quality could only be defined from seeps isolated from site-related contamination. Background ground water in the Honaker Trail Formation shows maximum observed concentrations of arsenic, chromium, net gross alpha, radium-226 and -228, selenium, and uranium that have exceeded maximum concentration limits (DOE, 1993d). Ground water in the Halgaito Shale has concentrations of arsenic, chromium, and nitrate that have exceeded the maximum concentration limits at least twice since 1990. The estimated amount of contaminated ground water at the Mexican Hat site is 110 million gal (0.42 million m^3).

There are no records of past or current users of the ground water from these two formations in the Mexican Hat site area. Domestic water for Halchita is supplied by a treatment facility that obtains water from the San Juan River. The Mexican Hat water supply is from a converted oil exploration well and the San Juan River (DOE, 1987b; 1993d).

3.2.20 Salt Lake City, Utah

The Salt Lake City processing site is in Salt Lake County, Utah, 4.0 mi (6.0 km) south-southwest of the center of Salt Lake City. A total of 2,710,000 yd^3 (2,070,000 m^3) of tailings was removed from 128 ac (52 ha) on this site and transported to the South Clive disposal site, 85 mi (136 km) west of Salt Lake City. Surface remedial action was completed in June 1989.

The Salt Lake City processing site is in an urban area, bounded by a sewage treatment plant on the north, a railroad on the east, and city streets on the south and west. The population of Salt Lake County is 725,956; the population of Salt Lake City is 159,936 (DOC, 1990). The site is close to the Jordan River (1500 ft [460 m] west of the site) and Mill Creek, a perennial stream that flows along the site's northern boundary. In addition, an irrigation ditch (South Vitro Ditch) traverses the site and a small wetland is just east of the site. Surface water samples indicate that the site-related contaminated ground water has not adversely affected water quality. Limited sediment sampling indicates that the South Vitro Ditch may have high levels of molybdenum while the remaining samples showed no adverse effects from site-related contamination. The Salt Lake City site has a semiarid climate, receiving an average annual precipitation of 15 inches (38 cm); the average annual snowfall is 59 inches (150 cm) (DOE, 1984b). There are no threatened or endangered species or cultural resources at or near the processing site (DOE, 1984b).

An unconfined aquifer approximately 45 ft (14 m) thick and composed of sand, silt, and clay is the uppermost aquifer under the processing site. The major sources of recharge for this aquifer are infiltration of precipitation and upward leakage from the lower confined aquifer. Water levels of the unconfined aquifer beneath the site range from 5.0 to 15 ft (1.5 to 5.0 m). This aquifer flows primarily toward the northwest and discharges into surface water bodies such as Mill Creek and the Jordan River. The estimated ground water velocity is 170 ft (50 m) per year.

Background water has a total dissolved solids content ranging from 300 to 550 mg/L, and sulfate levels ranging from 2.0 to 6.0 mg/L. Arsenic has exceeded the maximum concentration limit in most background ground water samples. A contaminant plume exists beneath the site, and molybdenum, net gross alpha, and uranium have exceeded the maximum concentration limits in some on-site and downgradient monitor wells at least twice since 1990. The estimated amount of contaminated ground water at the Salt Lake City site is 350 million gal (1.3 million m^3).

There is no evidence that contaminants derived from uranium processing have entered the lower confined aquifer beneath the site, undoubtedly due to the upward gradient between the lower confined and unconfined aquifers. Because of its poor quality and minimal well yield the upper aquifer has very limited potential use for domestic or agricultural purposes (DOE, 1993g). Residents of Salt Lake City obtain water from a municipal supply system that is upgradient of the processing site. However, the city of South Salt Lake is planning to install a water supply well within the site boundary. This well will draw water from an uncontaminated aquifer below the site.

3.2.21 Riverton, Wyoming

The Riverton, Wyoming, site is in a rural setting 2.0 mi (3.0 km) southwest of the city of Riverton in Fremont County. The per capita income in the county is $9806 and the population in the site vicinity is predominantly Native American (DOC, 1990). The site is on private land within the boundary of the Wind River Indian Reservation (Northern Arapaho and Shoshone Indian Tribes). Contaminated material totaling 1,793,000 yd^3 (1,371,000 m^3) was on 140 ac (57 ha) of land at the processing site and at off-site vicinity properties. All the contaminated material was transported 45 mi (72 km) to the Gas Hills uranium district, consolidated into an active uranium tailings pile, and stabilized. Surface remedial action at the Riverton site was completed in November 1989.

The Riverton site is on alluvial deposits between the Wind River, 1.0 mi (1.6 km) to the north, and the Little Wind River, 0.5 mi (0.8 km) southeast of the site. The confluence of these two rivers is 2.5 mi (4.0 km) east of the site. The site is bordered by drainage ditches and irrigation canals on the north, east, and southwest sides. Wetlands are nearby to the east and southwest. Surface water and sediment samples from the drainage ditches and wetlands indicate that the site-related contaminated ground water has not adversely affected these bodies of water. Elevated levels of uranium were detected in a side channel of the Little Wind River, which may represent the discharge of site-related contaminated ground water. The predominant land use in the site vicinity is agricultural; the primary crop is hay grown on irrigated fields. Cultural resources identified at the site are extensive and are considered eligible for listing on the National Register of Historic Places. No known threatened and/or endangered species exist at the site (DOE, 1987c).

A sulfuric acid plant that was used during the former uranium milling is still in operation near the site boundary. Residences exist along the north, south, southeast, and east boundaries of the site. The population of the city of Riverton is 9202, and Fremont County has a population of 33,662 (DOC, 1990). The climate is arid, with an average annual precipitation of almost 8.0 inches (20 cm); the average annual snowfall is almost 36 inches (91 cm) (DOE, 1987c).

Two ground water systems occur in the vicinity of the Riverton processing site. The uppermost aquifer consists of unconfined ground water in the shallow alluvial deposits and the hydrologically connected semiconfined sandstone unit of the Wind River Formation. The second system contains confined ground water in the deeper sandstone layers of the Wind River Formation. Depth to water in the uppermost aquifer is approximately 6.0 ft (2.0 m) below the site; the aquifer has an average saturated thickness of 50 ft (15 m). Ground water flow in the uppermost aquifer is predominantly to the south-southeast toward the Little Wind River. Water from this aquifer discharges into this river approximately 2800 ft (850 m) downgradient of the site and probably to the wetlands east and southwest of the site. The estimated ground water velocity is 160 ft (50 m) per year. Recharge to the uppermost aquifer is from precipitation, snowmelt, and ephemeral and perennial creeks.

Background water quality data from the uppermost aquifer system show that chromium exceeded the maximum concentration limit in one well once. Molybdenum, net gross alpha, selenium, radium-226 and -228, and uranium have exceeded the maximum concentration limits at various times in on-site and downgradient monitor wells in the uppermost aquifer. Molybdenum, net gross alpha, radium-226 and -228, and uranium have exceeded maximum concentration limits in on-site and downgradient ground water at least twice since 1990. Plume movement is in the direction of ground water flow, which is to the south-southeast. The estimated amount of contaminated ground water at the Riverton site is 500 million gal (1.9 million m^3). Surface water samples from the Little Wind River downgradient of the processing site contained detectable concentrations of net gross alpha, radium-226 and -228, and uranium, but these all were below the maximum concentration limits.

The uppermost aquifer is of low quality. Only two wells in the area of the processing site are known to be completed in this unit. One is located about 200 ft (60 m) upgradient of the site and the other is 2000 ft (600 m) downgradient along the boundary of the contaminant plume. Both wells are used for livestock watering. There are no known domestic water supply wells in this aquifer system in the site area. The confined aquifer is of good quality and is used for domestic water supplies in the area (DOE, 1987d).

3.2.22 Spook, Wyoming

The Spook UMTRA Project site is on private ranch land in central Wyoming in Converse County. The site is approximately 48 mi (77 m) northeast of Casper, Wyoming. A total of 315,000 yd^3 (241,000 m^3) of contaminated material was on 21 ac (8.0 ha) at the site. In addition, 1,600,000 yd^3 (1,200,000 m^3) of overburden material from open pit uranium mines on 115 ac (47 ha) were on the site. All the contaminated and overburden material was stabilized in an on-site open pit mine. Surface remedial action was completed in November 1989 (DOE, 1989c).

The Spook site is in rolling sagebrush and grassland terrain and is surrounded by cattle and sheep ranches. Approximately 1.0 mi (1.6 km) south of the Spook site is the Dry Fork of the Cheyenne River, an ephemeral tributary that supports a large stand of mature cottonwood trees and other stream-side vegetation. The nearest residence is a ranch house 1.4 mi (2.3 km) southwest of the site. The population is 11,128 in Converse County (DOC, 1990). The climate is arid, with an average annual precipitation of 11 inches (28 cm). The average annual snowfall is 74 inches (190 cm) (DOE, 1989c).

The Spook site has suitable habitat for three migratory birds of federal interest, and the endangered bald eagle roosts in wooded areas throughout northern Wyoming. The State Historic Preservation Officer does not consider the few cultural resources within a 270 ac (109 ha) radius of the site eligible for the National Register of Historic Places (DOE, 1989c).

Ground water in the uppermost aquifer beneath the Spook site occurs within the Wasatch Formation in a sandstone unit that ranges from 40 to 120 ft (12 to 40 m) deep. There is no evidence of ground water discharge to the surface in the site vicinity. Ground water flows predominantly northeast. The average ground water velocity in the upper aquifer is 150 ft (37 m) per year.

Background ground water quality in this aquifer is affected by naturally occurring mineralization related to the uranium ore body. Concentrations of uranium and selenium in the background ground water exceed the regulatory limits. Contaminants in the ground water beneath the processing site and downgradient that exceed the maximum concentration limits are cadmium, chromium, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, silver, and uranium at least twice since 1990. The contaminant plume extends 2500 ft (1200 m) downgradient from the tailings pile. The estimated amount of contaminated ground water at the Spook site is 1.0 billion gal (3.8 million m^3). Ground water in the underlying lower sandstone aquifer is not contaminated from the milling operations.

The ground water in the uppermost aquifer is considered limited use ground water because it is not a current or potential source of drinking water, and it contains widespread ambient uranium and selenium contamination from natural sources.

The lower sandstone aquifer is used as a drinking water source beyond the site area. This aquifer has not been contaminated by tailings seepage or by naturally occurring contaminants (DOE, 1989c).

4.0 ENVIRONMENTAL IMPACTS

This section analyzes the potential impacts associated with the alternatives for implementing the Ground Water Project. These alternatives, except the no action alternative, implement one or more of three strategies for complying with the EPA ground water standards (Table 4.1).

Table 4.1 Ground water compliance strategies that apply under each alternative

	Alternative			
Strategy	**Proposed action**	**No action[a]**	**Active remediation to background levels**	**Passive remediation**
Active ground water remediation methods	√		√[b]	
Natural flushing [c]	√			√
No ground water remediation				
- Sites that qualify for supplemental standards [d] or alternate concentration limits[e].	√			√
- Sites that meet maximum concentration limits or background levels (no impacts).[f]	√			√

[a]The analysis of the no action alternative is required by the CEQ and DOE.
[b]Active remediation methods would not be used at sites where contamination does not exceed background and likely would not be used at sites that qualify for supplemental standards based on the existence of limited use ground water.
[c]Natural flushing means allowing the natural ground water movement and geochemical processes to decrease contaminant concentrations.
[d]Supplemental standards applicable for certain site conditions, as identified in the EPA standards, that are protective of human health and the environment, and may be applied in lieu of prescriptive levels.
[e]Concentrations of contaminants that may exceed the maximum concentration limits; or, limits for those constituents without maximum concentration limits. If DOE demonstrates, and NRC concurs, that human health and the environment would not be adversely affected, DOE may meet an alternate concentration limit.
[f]"No remediation" at sites that do not exceed maximum concentration limits or background levels is not the same as "no action" because these sites would require activities such as site characterization to show that no remediation is warranted.

These strategies are described below:

- Active ground water remediation—This includes methods such as gradient manipulation, ground water extraction, and *in situ* ground water treatment. Section 2.8 summarizes active ground water remediation methods. This strategy would be used with both the proposed action and active remediation to background levels alternative.

- Passive ground water remediation by natural flushing—Natural flushing is described in Sections 1.4.1 and 2.8.2. This strategy would be used under the proposed action as well as the passive remediation alternative.

- No ground water remediation—In this PEIS, this strategy is considered in two parts: first, "no remediation" sites that do not have ground water contamination above maximum concentration limits and/or background levels, and second, "no remediation" sites that have ground water contamination above maximum concentration limits and/or background levels but qualify for supplemental standards or alternate concentration limits. In the first part of this strategy, site characterization may cause minor environmental impacts, with no impacts expected from implementation. Therefore, this part of the "no remediation" strategy is not considered further in this PEIS. Some minor environmental impacts may result from implementing the second part of this strategy; therefore, these environmental impacts are analyzed in Section 4.2.3 of this PEIS. This strategy would be used for all the alternatives except the no action alternative.

This PEIS differs substantially from a site-specific environmental impact statement because multiple ground water compliance strategies, each with its own set of potential impacts, could be used to implement all the alternatives except the no action alternative. In a traditional environmental impact statement, an impacts analysis leads directly to the defined alternatives. The impacts analysis for implementing alternatives in this PEIS first involves evaluating a ground water compliance strategy or strategies (Figure 4.1), the use of which would result in site-specific impacts. This PEIS impacts analysis assesses only the potential impacts of the various ground water compliance strategies, then relates them to the alternatives to provide a comparison of impacts.

The potential impacts of site characterization are analyzed in Section 4.1. Site characterization is used to help determine the site-specific ground water compliance strategies for the alternatives being evaluated. Impacts analyses for the ground water compliance strategies are presented in Section 4.2, followed by the potential impacts of the no action alternative in Section 4.3. The comparison of alternatives (Section 4.4) and the cumulative impacts analysis (Section 4.5) follow the analysis of the no action alternative.

The following categories were analyzed for potential impacts:

- Human health
- Air quality
- Surface water
- Ground water
- Ecological resources
- Land use
- Cultural/traditional resources
- Background noise

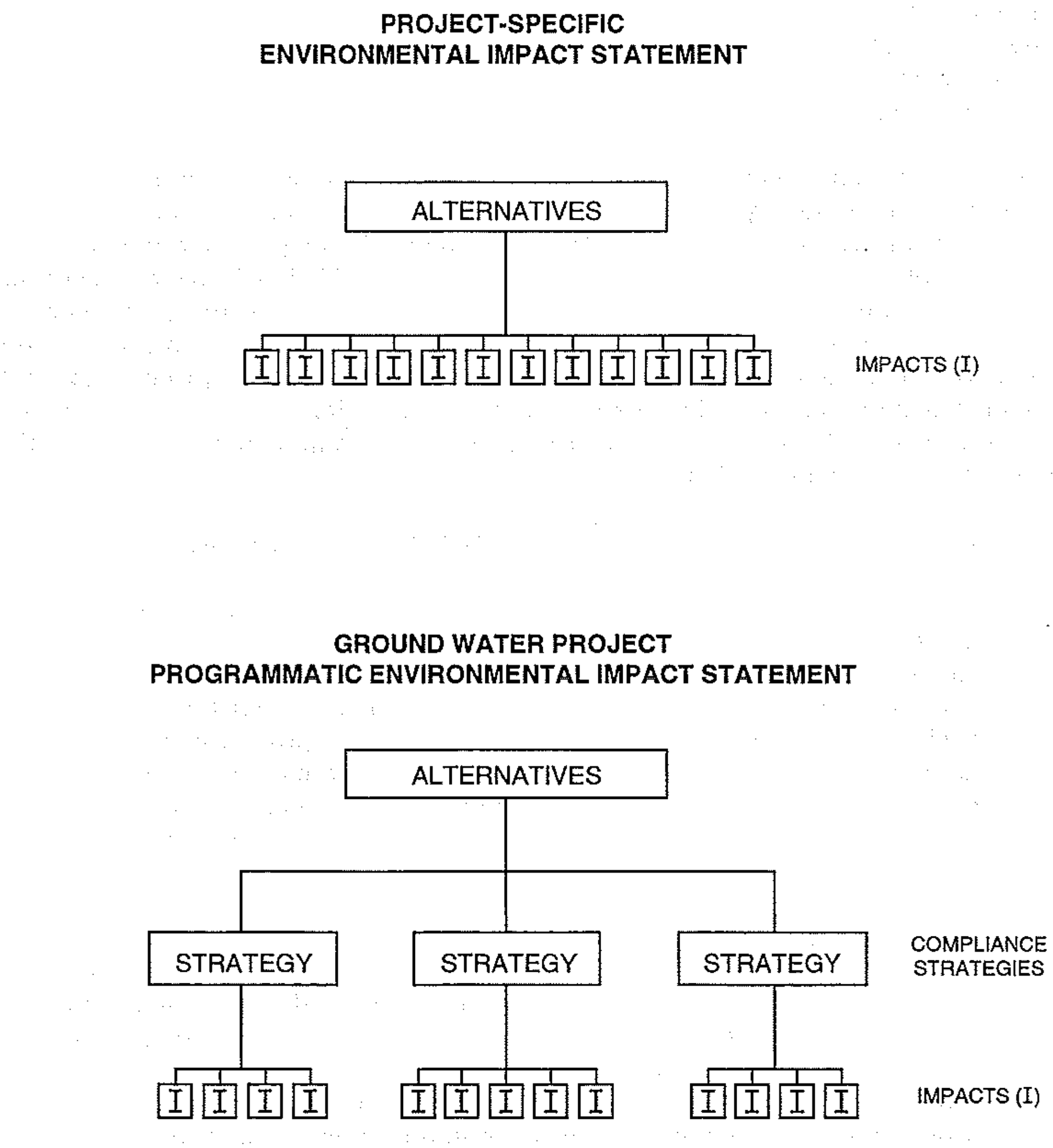

FIGURE 4.1
RELATIONSHIP BETWEEN ALTERNATIVES AND IMPACTS FOR PROJECT-SPECIFIC ENVIRONMENTAL IMPACT STATEMENTS AND THE GROUND WATER PROJECT PEIS

- Visual resources
- Transportation
- Social and economic resources
- Environmental justice
- Utilities and energy resources
- Waste management
- Estimated costs.

Mitigation of the potential impacts analyzed in this section are discussed under each appropriate resource category subheading. Descriptions of the mitigation measures are general. For example, contaminated wastewater produced during ground water remediation would be treated to meet the requirements of a National Pollutant Discharge Elimination System (NPDES) Permit before the water is released into the environment. Other examples are mitigation plans for impacts that may occur to archeological resources or threatened and endangered species. Under all the alternatives except no action, when a site-specific ground water compliance strategy is proposed, its environmental impacts would be assessed in the site-specific environmental documents and specific mitigation measures would be recommended.

4.1 SITE CHARACTERIZATION AND MONITORING IMPACTS ANALYSES

Ground water characterization would be performed to describe the ground water characteristics at the UMTRA Project sites. This characterization would take place under all the alternatives except the no action alternative. Site characterization data would also be used to prepare and/or update the site-specific risk assessments. These risk assessments, ground water characterization, and input from affected tribes, states, and public would be used to determine the appropriate ground water compliance strategy. Monitoring would take place to determine the effectiveness of the ground water compliance strategy and to protect human health.

Field site characterization activities would consist primarily of drilling boreholes and installing monitor wells; sampling ground water, surface water, soil, and other media; and conducting geophysical surveys and aquifer tests. Some of these activities, such as drilling boreholes, would require clearing small amounts of land (e.g., less than 1.0 ac [0.4 ha]) and developing or improving access roads to site areas (if necessary), while other activities such as collecting surface water samples would not result in any environmental disturbance. The potential environmental impacts associated with these types of field activities discussed below are based on the descriptions of site characterization activities in Section 2.8. Table 4.2 summarizes field activities that could affect the environment.

No disproportionally high or adverse human health or environmental effects would occur to minority or low-income populations due to site characterization or monitoring because the impacts of site characterization are minor or nonexistent.

Table 4.2 Hydrogeologic data collection activities and potential environmental effects

Field activity	Objective	Potential environmental effect
Drilling/monitor well installation, core sampling	Ground water sampling, hydraulic parameter data collection, geologic data collection.	Small amount of surface clearing for each location (less than 1.0 ac [0.4 ha]); access road construction; contaminated cuttings and ground water generation requiring proper disposal.
Ground water sampling	Water quality determination.	Contaminated ground water generation requiring proper disposal.
Soil sampling—test pits or soil borings	Unsaturated and saturated zone contamination determination; attenuation determination.	Small amount of surface clearing (less than 1.0 ac [0.4 ha]); contaminated soil requiring proper disposal.
Geophysics	Depth to bedrock, depth to ground water, other hydrogeologic information. Zones of ground water contamination.	Small amount of surface clearing for survey grid; access road construction.
Aquifer testing	Determination of aquifer parameters.	Contaminated ground water generation requiring proper disposal.

Table 4.3 summarizes the potential impacts of site characterization and monitoring activities. Impacts associated with these activities are minor and generally short-term. The construction and use of access roads may generate dust, which may require the use of dust suppressants. Site characterization aquifer tests may pull contaminated ground water into uncontaminated areas; these tests would be conducted in areas where the possibility of such an impact is remote. Potential impacts on ecological or cultural/traditional resources would also be unlikely because site characterization facilities would be located away from sensitive areas such as wetlands or archaeological sites. Potential visual impacts may arise from the long-term use of monitor wells. However, these potential impacts could be reduced by using flush-mounted monitor wells or landscaping. There is the potential for the active remediation to background levels alternative to have a greater chance of affecting resources in the floodplain of rivers due to its reliance on the active ground water remediation strategy. However, these potential impacts could be mitigated by conducting activities outside the floodplain or implementing erosion control measures. The potential for site characterization activities to impact the remaining resources listed in Table 4.3 is also unlikely.

Table 4.3 Potential environmental impacts associated with ground water site characterization and monitoring activities

Resource category	Potential impact
Human health	The potential for unauthorized personnel to enter the site characterization work area would be controlled and workers would be trained in appropriate health and safety procedures. Consequently, human health impacts are not expected.
Air quality	Dust emission would be minor and temporary. In situations when such emissions would be excessive, dust suppressants could be applied.
Surface water	Ground disturbance activities could result in erosion into a surface water body. Facilities would be placed well away from surface water bodies. If this were not possible, erosion control measures such as silt fences or hay bales would be used to control erosion.
Ground water	Aquifer tests could pull contaminated ground water into uncontaminated ground water. This would be avoided by conducting aquifer tests where this situation could not occur.
Ecological resources	Only small amounts of land would be disturbed. Facilities would be situated well away from sensitive ecological areas such as wetlands.
Land use	Installation of monitor wells and temporary land disturbances from soil borings and test pits would have a minor, short-term impact on land and land use.
Cultural/ traditional resources	Cultural resource surveys and contacts with appropriate tribal groups would be conducted before land disturbance activities begin. Cultural/traditional resources would be avoided where possible. If significant resources could not be avoided, a mitigation plan would be prepared in consultation with the State Historic Preservation Officer, tribal officer, or applicable agency.
Background noise	Site characterization may result in a slight and temporary increase in noise.
Visual resources	Site characterization and monitoring may impact visual resources. Flush-mounted monitor wells and landscaping will be used, as necessary, to reduce visual impacts.
Transportation	Site characterization would result in an occasional slight increase in local traffic at the sites. This increase is not expected to affect local traffic use patterns in the site area.
Social and economic	A few temporary jobs associated with drilling wells or digging test pits could be created during site characterization. This may result in a minor temporary benefit to the local economy. No other social or economic impacts would be expected.
Environmental justice	No disproportionally high or adverse effects would be expected because impacts are minor or nonexistent.
Utilities and energy resources	Electricity and fuel would be needed for some site characterization activities. Use of these resources would not be expected to affect local energy resources due to the small scale of activities and short duration of work.
Waste management	Liquid and solid waste could be generated from contaminated well purge water and cuttings. Any contaminated material generated would be managed in accordance with appropriate regulatory requirements.

4.2 GROUND WATER COMPLIANCE STRATEGY IMPACTS

This section addresses the potential impacts associated with the ground water compliance strategies. Some or all of these strategies would be used in three alternatives: the proposed action, the active remediation to background levels alternative, and the passive remediation alternative (Section 2.0). Information collected during the Surface Project pertains to some of the resources analyzed below (e.g., wetlands and cultural/traditional resources). This information is used, where appropriate, to indicate the potential impacts of the Ground Water Project. The actual site-specific impacts of applying these strategies would be addressed in the site-specific NEPA documents.

4.2.1 Active ground water remediation methods impacts

As summarized in Section 2.8.2 and provided in detail in Appendix C, active ground water remediation methods include ground water extraction, gradient manipulation, and *in situ* treatment. Currently, there is insufficient information to predict how many sites would require active ground water remediation under the proposed action, although it is expected that a few sites would. Under the alternative of active remediation to background levels, active ground water remediation would be the major ground water compliance strategy. Active ground water remediation would not be used under the passive remediation alternative.

Active methods would involve ground disturbance activities such as constructing wells and access roads or installing utilities and water treatment facilities. The following sections identify the potential impacts of active ground water remediation methods.

4.2.1.1 Human health

Certain active ground water remediation methods could generate contaminated water or sludge. If the contaminated water were discharged to a surface water body, an NPDES permit or other types of permits may be required to protect human health and the environment. Contaminated sludge would be handled so as to reduce risk of worker exposure and would be disposed of in accordance with applicable regulations. The management of potential waste streams is discussed in more detail in Section 2.9.

A risk assessment would be performed to assess the potential effects to human health of applying nitrogen-rich ground water to agricultural crops. This method involves adding high-nitrate ground water directly on the land or to irrigation water. This water could be treated prior to land application if it contained high levels of undesirable constituents, such as heavy metals or salts. Furthermore, if the risk assessment indicated that land application was not protective of human health, this method would not be used.

The use of active ground water remediation methods could result in injury to workers. This risk would be greatest when workers would be using heavy equipment. The potential for worker injury is minimal because of the short construction period (up to a few months) and the small number of worker-years of labor required (5.0 to 10 worker-years). Following construction, the potential for these types of impacts would exist but be reduced during operation of the active ground water remediation facilities because workers would be trained in health and safety procedures and only a small staff would be needed to operate remediation facilities and equipment.

Active ground water remediation could take many years and a potential exists for the use of contaminated ground water. This potential risk would be minimized because monitoring would likely identify potential risks before they occur and institutional controls could be used to limit access to contaminated ground water.

4.2.1.2 Air quality

Dust could be generated from heavy equipment and earth-moving activities as remediation facilities and access roads are constructed. An air quality permit may be required for some construction activities. An air quality permit would provide information on the potential for generating dust and on mitigation measures to keep dust emissions below air quality standards (such as applying water or other dust suppressants). The potential for dust emissions to exceed the standards is unlikely because the construction activities would be temporary and mitigation measures would be used, if necessary, to reduce fugitive dust.

This impact would be short-term, occurring during construction activities. Dust would be minimal during facility operations because there would be no dirt-moving activities. Some fugitive dust could be generated by workers driving on unimproved access roads. Water or some other dust suppressant would be applied, if necessary, to control dust.

The EPA's priority air pollutants, including sulfur oxides and nitrogen oxides, would be emitted from construction equipment during construction of ground water remediation facilities. Studies for the UMTRA Surface Project show that these emissions form a small portion of the total emissions inventory and that the air quality standards are not exceeded (DOE, 1987b). Therefore, the operation of active ground water remediation facilities is not expected to result in exceedance of the EPA standards for these air pollutants. The potential for extracted contaminants to become airborne from the treatment processes is minimal because the contaminants at the UMTRA Project sites are not volatile, and any solid waste would be disposed of in an approved disposal facility.

4.2.1.3 Surface water

During ground water remediation, potential impacts to surface water could occur but would be reduced or eliminated by implementing best management practices.

Ground water remediation facilities would produce water that may be discharged into a nearby stream or river after the water is treated to remove contaminants. If plans called for this type of discharge, an NPDES permit would be obtained that would stipulate appropriate treatment, monitoring, and reporting requirements. This permit would ensure that the water discharged into a surface water body would have minimal impacts. In addition, a storm water permit may be required.

4.2.1.4 Ground water

Active remediation methods that extract contaminated ground water may cause lateral ground water flow. Lateral flow could mix contaminated ground water with uncontaminated ground water, reducing contaminant concentrations (thus expediting the achievement of remedial goals) but increasing the total volume of contaminated water. Ground water extraction could have a negative impact by depleting an aquifer that is or has the potential to be a ground water resource.

Ground water extracted from contaminated aquifers may be treated, then reinjected into deeper aquifers or in the same aquifer upgradient of the contaminant plume. The quality of the treated ground water would be monitored prior to injection to reduce or eliminate potential adverse affects on the quality of the ground water into which it is injected. At some sites, an NPDES permit would be required to discharge this treated water into an aquifer.

4.2.1.5 Ecological resources

Site-related contaminants in ground water are known to be entering the surface water at some sites. During active ground water remediation, contaminants from this ground water would continue to enter the aquatic and terrestrial ecosystems, negatively impacting the resources. In the long term, active ground water remediation would reduce or eliminate this source of contaminated ground water entering the environment.

Under some active methods, treated ground water could be discharged to the land (e.g., water with high nitrate concentrations). The potential risks of discharging this water into the environment would be determined to ensure there is no unacceptable ecological risk.

Construction of ground water remediation facilities would have a short-term adverse impact, resulting in the clearing of plant communities and wildlife habitat. The amount of habitat that would be cleared at a site typically would be small (up to 20 ac [8.0 ha]), and active cleanup would last from a few months to 10 years or more. Once ground water cleanup activities were complete, most of the facilities and access roads would be revegetated with native species and returned to their approximate pre-remedial action conditions. Revegetation back to a grassland or grassland-shrub plant community would take approximately 2.0 to 5.0 years, depending on the plant community type and climate conditions. As can be seen by the annual precipitation statistics shown in Table 3.2, most UMTRA Project sites are in arid and semiarid climates. Revegetation at sites with these types of climates would likely need mulch and irrigation to be successful.

Construction and operation of ground water remediation facilities could create dust, noise, and human activity, which could indirectly affect habitat adjacent to the direct impact area. However, these impacts would be minor due to the low level of human activity (only a few personnel would be at the site) and the low intensity of operational activities.

Active ground water remediation could negatively impact sensitive habitats such as wetlands, riparian areas, and aquatic habitat. These types of habitats are common at and near the UMTRA Project sites, as documented in Section 3.2; 22 of the sites are near aquatic habitat, while wetlands occur at 18 of the sites (Table 3.2). Placement and construction of facilities could affect these sensitive areas, and pumping ground water may dry up wetlands and lower water levels in other aquatic habitat. Usually, remediation facilities could be placed away from sensitive habitats to reduce potential adverse effects. If sensitive areas such as floodplains or wetlands would be affected, the disturbed area would likely be small and the duration of the impact would be short-term (during construction and remediation). These areas would be returned to preconstruction conditions after ground water remediation is complete. A floodplain/wetlands assessment would be prepared consistent with 10 CFR Part 1022, *Compliance With Floodplains/Wetlands Environmental Review Requirements*, and a U.S. Army Corps of Engineers Section 404 Permit application would be prepared if wetlands under the jurisdiction of the Corps of Engineers were affected. Ground water characterization and data analysis would be used to determine whether ground water extraction would lower the water levels in aquatic habitats. If such an impact were predicted, the active ground water remediation would be altered to avoid this impact. In addition, monitoring during remediation would ensure that drawdowns in sensitive habitats would be detected and corrective action taken.

Threatened and endangered species or other species of concern occur at or near 14 of the UMTRA Project sites (Table 3.2). Active ground water remediation methods could adversely affect these species directly through habitat destruction or indirectly through human activity adjacent to the direct impact zone. In addition, pumping water from aquifers that are hydrologically connected to rivers could adversely affect threatened or endangered fish and/or their critical habitat. The DOE would consult with the Fish and Wildlife Service during the preparation of the site-specific NEPA documents. If impacts to threatened and endangered species were unavoidable, formal consultation with the Fish and Wildlife Service would be initiated and a biological assessment would be prepared.

Construction of ground water restoration facilities, possibly resulting in sediment runoff into surface waters, could adversely affect aquatic resources. Increased sedimentation in surface waters would degrade water clarity, thereby affecting the aquatic food chain. The potential for this type of impact would be slight because erosion protection measures would be implemented, where required, to prevent sediment runoff.

4.2.1.6 Land use

Active ground water remediation methods would require that land be used to construct facilities such as water treatment plants and retention ponds. This would preclude use of the land for other purposes during remediation. This potential negative impact could be short-term (a few months to a year) or long-term (up to 10 years), depending on the ground water remediation objectives and the method used.

In certain cases, the contaminant plume may extend outside the active ground water remediation work zone, and it would be necessary to restrict human access to contaminated ground water during active remediation. These controls could limit the uses of the land to such activities as grazing and prevent other uses such as home construction. In some cases, restriction could preclude any use of the land until compliance with EPA standards is achieved. This impact could be short- or long-term, depending on the goals, methods, and duration of ground water remediation. The potential adverse impacts of institutional controls are discussed in greater detail in Section 4.2.2.6. There is the potential for long-term positive impacts because once the ground water meets the EPA standards, there may be opportunities for more land uses.

4.2.1.7 Cultural/traditional resources

Construction of active ground water remediation facilities could affect cultural resources (for example, archaeological, historic, or Native American traditional areas). The potential for such resources in the area of the UMTRA Project sites is high; during the Surface Project it was determined that there are cultural resources at 11 sites (Table 3.2). The DOE would conduct additional surveys for cultural resources before site-disturbing activities took place in areas that have not been surveyed. Appropriate tribal groups would be contacted regarding the existence of traditional-use areas. Efforts would be made to avoid placing facilities at or near identified cultural/traditional resources. If a site were considered significant (that is, eligible for inclusion on the National Register of Historic Places) and disturbance could not be avoided, the DOE would consult with the State Historic Preservation Officer or tribal officials and other applicable agencies to identify appropriate mitigation.

Water resources, ground water, and seeps have religious significance to many Native Americans. These resources often have ceremonial significance or may be associated with traditional, symbolic plants. The contamination of these resources at the UMTRA Project sites is a negative impact. The remediation of contaminated ground water quality would be a positive benefit.

4.2.1.8 Background noise

Noise from heavy equipment would occur during construction of facilities. If warranted, noise prediction models would be used to determine any increase above background noise. If noise levels were determined to be unacceptable (that is, above EPA hearing protection levels), mitigation measures would be implemented (EPA, 1974). However, potential impacts associated with higher noise levels likely would be minor, given the small scale of the construction operations, and would last only during construction of remediation facilities. Facilities such as ground water extraction wells and water treatment plants would emit noise.

4.2.1.9 Visual resources

Water treatment facilities and retention ponds could be visible from a few months to decades. Impacts on visual resources depend on the extent to which the landscape would be changed by new structures, the scenic value of the landscape, and the potential number of viewers. Facilities constructed in urban areas would be seen by more people; however, urban facilities would be less likely to contrast with the surrounding area. In rural areas, new facilities would be more obtrusive but, in general, fewer people would see the landscape change.

Significant visual resource impacts from remediation facilities are not expected because most facilities would be located on or near a processing site that was already disturbed. Once ground water remediation activities were complete, remediation facilities would likely be removed and the land would be recontoured and revegetated to approximate preoperational conditions.

Monitor wells used during site characterization, ground water remediation, and monitoring may have a visual impact, particularly on residents near the sites. The DOE would work with local landowners, residents, tribes, and states as necessary to reduce potential visual impact, using such measures as flush-mounted monitor wells or landscaping.

4.2.1.10 Transportation

Construction of ground water remediation facilities would involve movement of heavy equipment and increases in traffic from commuting workers. Most of the heavy equipment movement would be on the site and would not increase traffic on local roads. The occasional off-site trip and worker commuting trips would increase traffic levels on local roads. The level of impact would depend on current traffic volumes in the area, load capacity, and the number of additional trips that would result from facility construction. Significant impacts on local traffic patterns are not expected because the construction work force would be small and construction activities would be temporary. Traffic control measures could be implemented if necessary to reduce transportation impacts (for example, traffic lights or turn lanes). During facility operation, the work force would be smaller and potential transportation impacts would be less than during construction.

4.2.1.11 Social and economic resources

Social and economic impacts typically derive from increased employment and circulation of additional monies into local and regional economies as a result of UMTRA Project development. The extent of these impacts depends on the type and level of employment generated by a project. Often these impacts are beneficial, particularly in rural areas with lower employment levels and less diverse economies because Project development offers opportunities for local hiring and an expansion of the local economy. Negative impacts occur when there is a demand for a large work force but few workers are available locally, causing a large, abrupt influx of workers and their families into a community. Social and economic impacts generally occur in four interrelated categories: demographics, employment, economy, and community facilities and services.

Construction and operation of the ground water remediation facilities would minimally increase employment and opportunities for local hiring, particularly during construction. Data from UMTRA Surface Project sites show about 80 percent of the remedial action work force commutes from within 60 mi (100 km). This increased employment would last only during the construction phase. It is expected that fewer, more technically skilled people would be required during facility operation. Workers who relocated during facility operation would be more likely to bring families than construction workers whose employment duration is shorter. The level and extent of impacts on housing, community services, and facilities would depend on the number of workers who relocated with their families and the ability of communities to absorb them. Because operation work force requirements would be small (less than five workers), local communities probably could accommodate their needs for housing, community services, and facilities (for example, schools, fire, and police protection).

Facility construction and operation would temporarily benefit the local and regional economies. This would result from UMTRA Project purchases of goods and services (for example, construction supplies, gasoline, and automotive service contracts); wages paid to employees that are recirculated; and income from employment created by direct and indirect Project-generated monies (that is, as more project money was spent on goods and services, additional employment would be generated to provide these goods and services).

The extent of these economic benefits depends on the number of workers required and the extent to which Project-related materials, supplies, and services are available locally. These beneficial impacts would likely be small given the small work force required for construction and operation of active gound water remediation facilities.

The use of land for active ground water remediation facilities and land use restrictions from institutional controls may reduce the property values of the affected land or limit the types of activities that can take place on the land. These impacts would last for the duration of the active remediation. However, when the ground water is cleaned up, property values that had been devalued due to contamination or construction could be restored and higher or more intense land uses may be possible.

Extracting ground water from aquifers that are a ground water resource has the potential to impinge on the water rights of the users of the aquifer. This could affect uses for agricultural, industrial, and other purposes. During the preparation of the site-specific environmental assessment, the DOE would consult with the tribal water authority or state engineer to determine if such an impact exists.

4.2.1.12 Environmental justice

No disproportionately high or adverse human health or environmental effects to minority or low-income populations would be expected under the active ground water compliance strategy because ground water would likely meet regulatory standards.

4.2.1.13 Utilities and energy resources

It is expected that local utilities would supply electricity, gas, and telephone services during the construction and operation of ground water remediation facilities. In urban areas, water needed during construction likely would come from existing water supply systems; in rural areas, water likely would come from wells or rivers. Because ground water remediation methods are relatively small-scale operations, local utilities probably could meet these short-term Project needs.

Construction equipment would use petroleum products during construction and fuel-powered generators may be used during facility operations. The greatest amount of energy would be used during construction because heavy equipment would be needed to build the facility. Impacts would be minimal, due to the short construction period and the operation's small scale. Energy use during operation would also be minimal due to the low level of activity that would take place.

4.2.1.14 Waste management

The following contaminated materials could be generated during site characterization, operations, and monitoring under the active remediation strategy: well development water, drill cuttings and drilling muds, purge water, sludge and brine, and contaminated ground water and soils. These materials would be analyzed. Based on this analysis, solid material such as mud or soil would be applied to the land or disposed of in a disposal facility such as an existing open UMTRA Project cell capable of accepting these materials. Contaminated water would be treated, if necessary, and applied to the land, reinjected to the ground water, or discharged to surface water, after permits are received. Section 2.9 provides more details on the management of contaminated materials.

Potential adverse impacts on human health or the environment from the generation, treatment, storage, or disposal of contaminated materials are not expected because all such activities would be performed in compliance with applicable regulations and guidelines that were developed to be protective of human health and the environment. However, human error could result in environmental impacts.

4.2.1.15 Estimated costs

As indicated in Section 2.10, activities such as the preparation of baseline risk assessments, site observational work plans, and NEPA documents would be prepared for most UMTRA Project sites, regardless of the proposed ground water compliance strategies. The active remediation compliance strategy also would include site characterization, monitoring, and revisions to site observational work plans; field management, capital equipment, and operations costs associated with implementing an active remediation method; and program support throughout the remediation period.

Estimated costs for active remediation to background levels range from $86 million to $162 million per site (escalated dollars) and include all generic cost elements plus costs associated with field management and operation (Foskey, 1995). These cost elements include utility installation, number of wells required, collection systems, installation of water treatment plants, plant operations, testing, land application of water, closure, demobilization, and site restoration. The plant size and length of operations are generated on a site-specific basis using current assumptions of the technical parameters of the plume, soil, and contaminants.

4.2.2 Natural flushing impacts

Natural flushing in conjunction with institutional controls is a potential strategy for meeting the EPA ground water standards. Sections 1.4.1 and 2.8 summarize the natural flushing process and institutional controls.

Natural flushing would likely be the principal ground water compliance strategy used under the passive remediation alternative. Natural flushing would also be used under the proposed action, either alone or in conjunction with active ground water remediation. This strategy would not be available under the active remediation to background levels alternative because this alternative would rely principally on active ground water remediation.

This impact analysis assumes that the criteria required to implement natural flushing are met. However, under the passive remediation alternative, the use of natural flushing at certain sites may not be protective of human health or the environment; compliance may not be accomplished within 100 years as required by the EPA ground water standards; or required institutional controls may not be viable. In these cases, the standards would not be met and the potential for human health or environmental harm exists. At sites that would not comply with the standards within 100 years, institutional controls and monitoring would be required for more than 100 years; this would not meet the EPA ground water standards and would increase the uncertainty in protecting human health and the environment. In addition, natural flushing may not be protective of beneficial uses of the ground water, such as irrigation or livestock watering. The potential impacts on resources of applying natural flushing under these circumstances are discussed in Section 4.4.

4.2.2.1 Human health

Ground water remediation using natural flushing may result in human exposure to contaminated ground and/or surface water. However, the probability of such an exposure is remote because the following conditions must be met before natural flushing can be used:

- The contaminated aquifer must not be a source for a public drinking water system.
- The concentrations of hazardous constituents must meet the EPA standards within 100 years.
- Any institutional controls relied on to control exposure must be effective and enforceable throughout the natural flushing period.

To ensure continued protection, ground and surface water monitoring, as needed, would take place during the natural flushing period.

4.2.2.2 Air quality

The installation of monitor wells or construction of institutional control structures such as perimeter fences could generate small amounts of dust. This impact would be minor and short-term, lasting only during construction or installation. The potential for air quality impacts from other priority pollutants would be remote, given the limited use of construction equipment needed for establishing and maintaining institutional controls.

4.2.2.3 Surface water

During the natural flushing period, contaminated ground water could discharge into surface water bodies such as springs and wetlands. Before implementing natural flushing, the DOE would evaluate the potential for such a discharge. If it were determined that such a discharge may take place and threaten human health and the environment, natural flushing probably would not be a viable ground water compliance strategy. If it were determined that the potential for such a discharge would be remote, this strategy may be viable. However, because the natural flushing period could last up to 100 years, there would be an increased potential for surface water bodies to be affected within this time period. Monitoring would take place during natural flushing, and if monitoring indicated that surface water bodies were being contaminated, an additional risk assessment may be performed. If the contamination levels were not protective of human health or the environment, active remedial action may be undertaken. Institutional controls would be required to control access to areas where surface waters were contaminated.

4.2.2.4 Ground water

Ground water remediation from natural flushing would most likely be slower than active remediation methods. Hazardous constituent concentrations in the plume that exceed the standards would be reduced to meet background levels, maximum concentration limits, or alternate concentration limits during the natural flushing period. The potential for contaminated ground water to affect uncontaminated areas is site specific. There are three general cases: 1) geochemical attenuation limits plume migration and additional ground water contamination is unlikely or would be minimal, 2) the plume has already reached a discharge point and thus the maximum extent of ground water contamination has already occurred, and 3) the plume is migrating and dispersing through the aquifer system with potential for additional ground water contamination. Ground water monitoring would identify any expansion of the ground water plume. Corrective measures, such as expanding the institutional controls area, may be required.

4.2.2.5 Ecological resources

Natural flushing would have minimal impact on wildlife and aquatic and sensitive habitats. The major activity associated with this strategy is the application of institutional controls. Fencing to supplement other controls could positively impact wildlife and aquatic habitat because activities such as grazing, which can degrade these habitats, may be prevented. However, fencing could negatively impact certain species of wildlife by blocking migration corridors and improperly constructed fences could cause wildlife mortality. These impacts could be minimized by installing fences designed to accommodate wildlife needs.

The low levels of human activity are not likely to result in a negative impact on threatened and endangered species. However, the DOE would consult with the Fish and Wildlife Service during preparation of the site-specific NEPA documents to determine whether threatened and endangered species are known to occur in the area.

The potential for contaminated ground water to be released into the environment during the natural flushing period would be evaluated in an ecological risk assessment to determine whether natural flushing would be protective of the environment. This assessment would consider existing and potential future releases of contaminated ground water into the environment. If there were no risk or there were acceptable risks, natural flushing could be implemented if all other requirements were also met. However, as the length of a natural flushing period increases, so does the potential for contaminated ground water to enter the environment. A ground water and surface water monitoring program would be conducted during the natural flushing period, and any releases of contaminated ground water into the environment would be detected. If contaminated ground water were released into the environment, an ecological risk assessment may be performed. If the risks from such a release were unacceptable, active remedial action may be initiated.

4.2.2.6 Land use

The EPA ground water standards require that institutional controls be implemented to limit access to a contaminated aquifer during natural flushing. These institutional controls would be used to restrict the use of the land above the contaminated aquifer. The types of institutional controls used depend in part on the extent of the ground water contamination and the potential for ground water use. These controls could involve posting information warnings on private land, purchasing an interest in the land, preventing access to the land through fencing, or imposing land or water use restrictions. The potential impacts of institutional controls on land use would be restricted use of land and decreased property values. These impacts would be minimal at the UMTRA Project processing sites, because use of these sites is currently restricted in most cases. Impacts could occur outside processing site boundaries, but as the ground water contamination is reduced over time, the restrictiveness of the institutional controls may be reduced.

4.2.2.7 Cultural/traditional resources

Potential impacts to surface cultural resources would be minor because little if any site-disturbing activity would take place. Installation of fencing or monuments (institutional controls) would likely be the most intensive activity. Cultural resource surveys would be performed prior to site-disturbing activities and appropriate tribal officials would be contacted to identify and evaluate cultural or traditional resources that may be affected. In most cases, fencing and monuments could be located to avoid cultural resource sites.

Water is a traditional resource of significance to many Native Americans. These resources often have ceremonial significance, and surficial expressions such as seeps may be associated with traditional, symbolic plants. Remediation of contaminated ground water by natural flushing would have a positive impact on this resource. Impacts to this Native American traditional resource would be reduced as natural flushing progressed.

4.2.2.8 Background noise

Natural flushing would not affect background noise levels in the site area because no noise-generating activities would occur except for brief periods during the construction of some types of institutional control features.

4.2.2.9 Visual resources

Natural flushing could result in the use of signs, monuments, or fences to control human land use above the contaminated aquifer. These measures typically would be unobtrusive (small and low to the ground), resulting in minor (if any) impact on visual resources. In areas of scenic beauty, structures used to implement institutional controls (such as fences) could negatively impact visual resources.

Monitor wells used during site characterization, ground water remediation, and monitoring may have a visual impact, particularly on residents near the sites. The DOE would work with local landowners, residents, tribes, and states where necessary to reduce this potential visual impact through the use of such measures as flush-mounted monitor wells or landscaping.

4.2.2.10 Transportation

During the operational phase, the only traffic would be for water quality monitoring and monitoring to verify that institutional controls were working as planned. There would be no transportation impacts from these activities.

4.2.2.11 Social and economic resources

No impacts on demography, employment, community services, or facilities would be expected if natural flushing were implemented, because essentially no activities associated with this strategy would require a work force. Institutional controls may require occasional maintenance and monitoring. There could, however, be a slight, short-term beneficial impact to the local economy from local workers or subcontractors who may install land access controls (for example, fencing).

Institutional controls that restrict land use could represent an economic loss to a property owner by precluding a higher use of the land. For example, grazing might be allowed within an area of institutional control, but a more intense (and potentially profitable) use of the land, such as crop production or residential use, may not be allowed. In some cases, the land could be restricted from any use during the period of natural flushing. The extent of the potential adverse economic impact would depend on the type and duration of the land use restrictions and the reasonable alternative uses of the land that could be precluded because of the institutional controls.

4.2.2.12 Environmental justice

Minority or low-income populations would not experience disproportionately high or adverse environmental impacts if criteria for natural flushing are met. However, under the passive remediation alternative, it is possible that the criteria would not be met and that natural flushing would not be protective of human health and the environment at some sites (see Section 4.2.2). For sites that have minority or low-income populations, there would be a potential for disproportionately higher impacts to human health and the environment.

4.2.2.13 Utilities and energy resources

Natural flushing would not affect utilities or energy resources because no activities would occur that would require the use of these resources.

4.2.2.14 Waste management

Contaminated materials that could be generated during site characterization and monitoring under the natural flushing strategy include well development water, drill cuttings and drilling muds, purge water, sludge and brine, and contaminated ground water and soils. These materials would be analyzed. Based on this analysis, solid material such as mud or soil would be applied to the land or disposed of in a disposal facility such as an existing open UMTRA Project cell capable of receiving these materials. Contaminated water would be treated, if necessary, and applied to the land, reinjected to the ground water, or discharged to surface water, after permits are received. Section 2.9 provides more details on the management of contaminated materials.

Potential adverse impacts on human health or the environment are not expected from the generation, treatment, storage, or disposal of contaminated materials because all such activities would be performed in full compliance with applicable regulations and guidelines that were developed to be protective of human health and the environment. However, human error could result in environmental impacts.

4.2.2.15 Estimated costs

Activities associated with natural flushing include all the generic activities, additional site characterization, new wells, and revisions to site observational work plans. Natural flushing would likely require the use of institutional controls. This strategy would likely result in a longer monitoring period than the other two strategies. Estimated costs for the natural flushing compliance strategy range from $14 million to $24 million per site (escalated dollars) and include all generic costs associated with this strategy.

4.2.3 Impacts from applying supplemental standards or alternate concentration limits at no remediation sites

Ground water at some UMTRA Project sites may exceed maximum concentration limits or background levels and yet require no remediation because the sites would qualify for supplemental standards or alternate concentration limits. Supplemental standards or alternate concentration limits could be used in combination with active ground water remediation methods and/or natural flushing to achieve compliance with the EPA ground water standards. For example, active remediation methods may be used to protect beneficial uses at a site that would otherwise qualify for supplemental standards. However, the analysis in this section considers only potential impacts from applying these standards at the no remediation sites; refer to Sections 4.2.1 and 4.2.2 for discussions of potential impacts of active ground water remediation methods and natural flushing.

Supplemental standards and alternate concentration limits are described in Section 1.4.1. Eight criteria are available for applying supplemental standards. The occurrence of limited use ground water is the criterion that likely would be used most frequently to justify the application of supplemental standards for the UMTRA Ground Water Project. However, site-specific uses of ground water from limited use wells, if any, would be carefully evaluated when a supplemental standards application is prepared. Limited use ground water refers to water from units that have poor background quality or low yield (less than 150 gal [570 L] per day). Supplemental standards based on limited use ground water would not involve ground-disturbing activities. Other criteria for applying supplemental standards that may be used on the UMTRA Ground Water Project include 1) protection of the environment from excessive harm, 2) there is no known remedial action, and 3) inability to perform remedial action because it is technically impracticable. The use of supplemental standards may require monitoring or the use of some form of institutional controls to prevent access to contaminated ground water. The DOE UMTRA Ground Water Project would likely not use the remaining criteria listed in Section 1.4.1.

A risk evaluation would be performed to determine whether the use of supplemental standards would be protective of human health and the environment. In all cases, a supplemental standards application would require NRC concurrence, state participation, and consultation with Indian tribes to become effective.

The use of alternate concentration limits would also require an application that would need NRC concurrence, state participation, and consultation with Indian tribes. A risk evaluation would have been performed to demonstrate that an alternate concentration limit would be protective of human health and the environment. This analysis also assumes that potential environmental impacts may be associated with using alternate concentration limits.

The no remediation ground water compliance strategy would likely be used under all the alternatives except the no action alternative. There are two categories of no remediation sites. One category refers to sites where there is no ground water contamination above maximum concentration limits and/or background levels. Under the proposed action and the passive remediation alternative, this no remediation strategy would be appropriate at such sites. Under the active remediation to background levels alternative, this strategy may be appropriate if all the constituents are at background levels; it would not be appropriate for constituents below the maximum concentration limits but above background levels.

The second category under the no remediation ground water compliance strategy refers to sites that have contamination above background levels and/or maximum concentration limits but are eligible for supplemental standards or alternate concentration limits. The sites that would be eligible for this no remediation strategy under the proposed action would also be eligible under the passive remediation alternative. In addition, some of these sites would be eligible for the no remediation strategy under the active remediation to background levels alternative. At some sites, no remediation in the form of supplemental standards based on the existence of limited use ground water could be part of the active remediation to background levels alternative.

The following analysis includes the potential impacts of applying supplemental standards and of applying alternate concentration limits.

4.2.3.1 Human health

For successful application of supplemental standards or alternate concentration limits, a risk evaluation must show that these standards would be protective of human health and the environment. Monitoring or institutional controls may be required if alternate concentration limits or supplemental standards are used. Monitoring may be required to assess the degree and extent of ground water contamination to ensure that supplemental standards and alternate concentration limits remained protective of human health and the environment. Institutional controls may be used if, for example, it were technically impracticable to clean contaminated ground water, but controls were required to prevent its inadvertent use. Consequently, the likelihood of human exposure to contaminated ground water and the surface expression of this water at sites that met supplemental standards or alternate concentration limits would be remote.

4.2.3.2 Air quality

Dust and priority pollutant emissions would not result from the application of supplemental standards or alternate concentration limits because few or no ground-disturbing activities would occur.

4.2.3.3 Surface water

The potential for discharge of contaminated ground water into surface water bodies would be unlikely. As indicated in Section 4.2.3.1, a monitoring program may be required for the use of some supplemental standards and for alternate concentration limits, that may include sampling surface water bodies. If contamination were discovered, further evaluation would be undertaken and remedial action performed if required.

4.2.3.4 Ground water

The application of supplemental standards would have little or no impact on ground water at sites that qualify for supplemental standards based on the presence of limited use ground water. Contaminated ground water at sites that qualify for supplemental standards based on other criteria or alternate concentration limits could contaminate less contaminated or noncontaminated ground water. Ground water monitoring may be required to assess this possibility under these supplemental standard criteria or alternate concentration limits.

4.2.3.5 Ecological resources

If supplemental standards or alternate concentration limits were applied, terrestrial and aquatic ecological habitat disturbance would be minimal because few or no ground-disturbing activities would occur.

As part of the supplemental standards and alternate concentration limits application processes, an ecological risk evaluation may be prepared or updated to determine the potential for contaminated ground water to result in ecological risk. If unacceptable ecological risks could occur, supplemental standards or alternate concentration limits likely would not be proposed. If there were no ecological risks or the risks were acceptable, these standards could be applied if no other factors precluded their use. As indicated in Section 4.2.3.1, a monitoring program may be implemented as part of the supplemental standards and alternate concentration limits applications. If monitoring indicated contaminated ground water from the UMTRA Project site had been released into aquatic habitats such as wetlands and springs, another ecological risk evaluation may be performed. If the results of this evaluation indicated unacceptable risk, remedial action might be required.

4.2.3.6 Land use

Little or no ground-disturbing activity would occur if supplemental standards or alternate concentration limits were applied. The only activity that would potentially affect land use would be the use of institutional controls.

Institutional controls may be implemented if the limited use criterion were used to apply for supplemental standards. These types of controls also may be required if another criterion (such as excessive environmental harm or the technical impracticability of ground water remediation) were used, or if alternate concentration limits were applied. The potential impacts on land use associated with the use of institutional controls are discussed in Section 4.2.2.6.

4.2.3.7 Cultural/traditional resources

There would be no impacts to surface cultural resources because no surface disturbance would take place. Minor surface disturbance would occur if institutional controls were used in conjunction with supplemental standards. The potential impacts of institutional controls on cultural resources are discussed in Section 4.2.2.7.

With the application of supplemental standards or alternate concentration limits, contaminants associated with the UMTRA Project would most likely not be removed. Therefore, traditional resource impacts associated with ground water would not be mitigated. However, at sites where supplemental standards were applied using the limited use criterion, the surrounding background ground water quality is poor; therefore, the impact of leaving the contaminated ground water would be minor.

4.2.3.8 Background noise

The application of supplemental standards or alternate concentration limits would not affect ambient noise because no noise-generating activities would take place.

4.2.3.9 Visual resources

Impacts on visual resources would be limited to those associated with site characterization activities (refer to Section 4.1) or the implementation of institutional controls. These potential impacts would be minor and temporary.

Monitor wells used during site characterization, ground water remediation, and monitoring may have a visual impact, particularly on residents near the sites. The DOE would work with local landowners, residents, tribes, and states where necessary to reduce this potential visual impact through the use of such measures as flush-mounted monitor wells or landscaping.

4.2.3.10 Transportation

There would be no transportation impacts if supplemental standards or alternate concentration limits were instituted.

4.2.3.11 Social and economic resources

Supplemental standards or alternate concentration limits would have little impact on social and economic resources because no ground water remediation activities would take place. Potential minor negative economic impacts could result from the implementation of institutional controls (refer to Section 4.2.2.11).

4.2.3.12 Environmental justice

Disproportionately high or adverse effects to minority or low-income populations would not occur if application of supplemental standards or alternative concentration limits were protective of human health and the environment.

4.2.3.13 Utilities and energy resources

Supplemental standards would not affect utilities or energy resources because no activities would occur that require these resources.

4.2.3.14 Waste management

The following contaminated materials may be generated during site characterization and monitoring under the no remediation strategy: well development water, drill cuttings and drilling muds, purge water, sludge and brine, and contaminated ground water and soils. These materials would be analyzed. Based on this analysis, solid material such as mud or soil would be applied to the land or disposed of in a disposal facility such as an existing open UMTRA Project cell capable of receiving these materials. Contaminated water would be treated, if necessary, and applied to the land, reinjected to the ground water, or discharged to surface water, after permits are received. Section 2.9 describes the management of contaminated materials.

Potential negative impacts are not expected to human health and the environment from the generation, treatment, storage, or disposal of contaminated materials because all such activities would be performed in full compliance with applicable regulations and guidelines that were developed to be protective of human health and the environment. However, human error may result in environmental impacts.

4.2.3.15 Estimated costs

Activities associated with the no remediation compliance strategy include the general activities required for the other two strategies, including site characterization and possible revision of the site observational work plans. This strategy would also require the preparation of supplemental standards and/or alternate concentration limits applications and the concurrence of these applications by the NRC. The estimated cost of the no remediation compliance strategy is $1.0 million to $10.4 million per site, based on 1995 escalated dollars.

4.2.4 Impacts comparison and summary

This summary compares the potential negative impacts of the ground water compliance strategies. The relationship of these potential impacts to the alternatives is presented in Section 4.4. The impacts analysis does not relate to the no action alternative because none of the strategies would be used under this alternative. The potential impacts of the no action alternative are assessed in Section 4.3.

It is anticipated that the impacts that could occur for each strategy (see Table 4.4) would be the impacts analyzed in the site-specific NEPA documents. Based on this analysis, the number of potential negative impacts is highest for the active ground water remediation methods, next highest for natural flushing, and lowest for no remediation sites that meet the standards with supplemental standards or alternate concentration limits (Table 4.4).

4.3 NO ACTION

Under the no action alternative, the UMTRA Project would end with the completion of surface remediation. The DOE would perform no ground water compliance or remediation activities. Evaluation of the no action alternative is required under the NEPA, as it provides a baseline against which impacts of other alternatives can be compared.

4.3.1 Human health

The no action alternative could expose humans to contaminated ground water. Under this alternative, there would be no federally sponsored ground water compliance, remediation, monitoring, or controls over the contaminated aquifers. Although unlikely, exposure could occur in the following ways:

- Using contaminated ground water from water supply wells
- Drilling new water supply wells into contaminant plumes
- Using contaminated surface water for drinking water
- Using contaminated ground water and/or surface water for agricultural purposes, such as irrigation or livestock watering

Table 4.4 Summary of potential impacts of the ground water compliance strategies

Impact	Ground water compliance strategy: Active ground water remediation	Ground water compliance strategy: Natural flushing	Ground water compliance strategy: No remediation[a]
Human health			
Exposure to contaminated water resources	√	√	√
Risks to workers handling contaminated materials	√		
Accidents not involving hazardous constituents	√		
Air quality - Dust emissions	√	√	
Surface water			
Surface water contamination from contaminated ground water	√	√	√
Surface water contamination from wastewater	√		
Ground water			
Expansion of ground water plume into uncontaminated areas	√	√	√
Contaminated wastewater affecting ground water	√		
Ecological resources			
Habitat disturbance	√	√	
Sensitive habitats	√	√	
Threatened and endangered species effects	√	√	√
Contamination of biological systems (ecological risk)	√	√	√
Land use - restrictions	√	√	√
Cultural/traditional resources	√	√	√
Background noise	√		
Visual resources	√	√	√
Transportation	√		
Social and economic			
Economic benefits (employment, goods, services)	√	√	√
Reduction in property values due to remediation activities or implementation of institutional controls	√	√	
Reduction in property values due to contaminated ground water	√	√	√
Water rights	√	√	
Environmental justice[b]		√	√
Utilities and energy resources	√		
Waste management	√	√	√

[a]Refers to no remediation sites where ground water contamination exceeds maximum concentration limits or background levels and that qualify for supplemental standards or alternate concentration limits.
[b]Potential negative impacts may occur only if EPA ground water standards are not met.

√ - an impact could occur.

- Using contaminated surface water for recreational purposes, such as swimming or fishing

- Consuming fish and wildlife exposed to contaminated water.

4.3.2 Air quality

There would be no air quality impacts because no ground-disturbing activities would occur.

4.3.3 Surface water

Under the no action alternative, the discharge of contaminated ground water to surface water bodies (streams, rivers, ponds, wetlands, springs, or arroyos) would continue. In addition, there is the potential for currently uncontaminated surface water bodies to become contaminated. The potential impacts to surface water bodies would be greater in areas of standing water because the hazardous constituents would concentrate in the sediments of ponds or wetlands. The accumulation of contaminants in these aquatic habitats could result in human health and ecological impacts, as discussed in Sections 4.3.1 and 4.3.5.

4.3.4 Ground water

Under the no action alternative, uncontaminated ground water in the same aquifer and other aquifers could become contaminated. This could result in adverse human health and environmental impacts. Under the no action alternative, the continued spread of contaminated ground water and surface water may reduce the beneficial uses of the water, such as drinking, irrigating, or stock watering. These impacts likely would be long-term because there would be no federal program to clean up the ground water; remediation would be accomplished by natural processes that could take decades or longer. The spread of ground water contamination also could result in negative impacts on land use (refer to Section 4.3.6) and to social and economic resources (Section 4.3.11).

4.3.5 Ecological resources

Implementation of the no action alternative would not result in the destruction of wildlife or aquatic habitats because site-disturbing activities would not occur.

Habitats and protected species could be adversely affected if contaminated ground water were discharged to the surface or by plant root uptake of contaminated ground water. Contaminant plumes could surface in sensitive areas such as ponds, lakes, and wetlands that may be hydrologically connected to a contaminated aquifer. Contaminants may accumulate in the sediments and be transported through the food chain and into the terrestrial ecosystems. These contaminants could be taken up by aquatic and/or terrestrial threatened and/or endangered species. Contaminants could also be ingested directly by humans drinking contaminated water or indirectly by consuming fish, wildlife, or livestock that have ingested contaminated material from the affected habitat. Since there would be no Ground Water Project under this alternative, DOE would not monitor the fate and transport of the contaminated ground water and would take no measures to mitigate potential contamination of sensitive habitats, threatened and endangered species, other biological resources, or livestock.

4.3.6 Land use

The no action alternative could affect land uses because of the potential for access to and use of contaminated ground water. Contamination could spread to wells currently used for agricultural purposes, causing farmers or ranchers to seek alternative water supplies. The no action alternative also could affect agricultural land use (e.g., crops and livestock grazing) due to the potential for plant uptake of contaminated water or if ground water discharged to the surface. More intense uses such as industrial, commercial, or residential development also would be affected. This impact would be long-term and could extend over larger land areas if the contaminated ground water plume expands over time.

4.3.7 Cultural/traditional resources

The no action alternative could affect cultural and historic resources because contaminants associated with UMTRA Project sites would not be removed. Therefore, traditional Native American water resources would be adversely affected by the contaminated ground water. Some Native Americans already consider ground water a cultural/traditional resource that is adversely impacted.

4.3.8 Background noise

The no action alternative would not affect background noise levels near the sites because there would be no remediation activities.

4.3.9 Visual resources

There would be no impact on visual resources from the no action alternative because there would be no remediation activities.

4.3.10 Transportation

The no action alternative would not affect traffic or transportation patterns because no traffic-generating activities would occur.

4.3.11 Social and economic resources

The no action alternative could result in the contamination of ground water currently used for domestic purposes (refer to Section 4.3.1). Replacing domestic water sources that become contaminated could require drilling new wells, purchasing bottled water, or funding a domestic water supply line.

The potential contamination of domestic and/or agricultural water supplies could adversely affect property values and sales of agricultural products grown in the area.

4.3.12 Environmental justice

Under no action, there is a potential for significant negative effects on human health and the environment as indicated above. Therefore, a potential exists for high or adverse disproportionate impacts at UMTRA Project sites on minority or low-income populations. For example, low-income or minority populations may not have the financial means to provide an alternate source of drinking water if ground water at the site does not meet compliance.

4.3.13 Utilities and energy resources

The no action alternative would have no effect on utilities and energy resources because there would be no remediation activities.

4.3.14 Waste management

No contaminated materials associated with site characterization, monitoring, or remedial action would be generated under the no action alternative; therefore, there would be no impact.

4.3.15 Estimated costs

Fiscal impacts associated with the no action alternative represent the costs expended on the Ground Water Project to date (such as preparation of this PEIS) and estimated costs to close down current ongoing activities associated with preliminary Ground Water Project activities. Estimated total cost of the no action alternative is $20.1 million.

4.4 COMPARISON OF ALTERNATIVES

The qualitative analysis of potential impacts of the ground water compliance strategies and the no action alternative as presented in Sections 4.2 and 4.3 are used below to compare the alternatives.

This analysis compares one alternative to another alternative. For example, if the no action alternative is said to have a high potential for ecological risk, it is high only in relation to the other alternatives' potential for such an impact. These comparisons do not assess the type and degree of impacts at a given site; this type of assessment would be provided in the site-specific NEPA documents that would tier off the PEIS. Assumptions regarding the severity of potential impacts among alternatives for each impact category are based on the impact analyses in Sections 4.2 and 4.3.

In comparing the potential impacts of the alternatives, technical specialists in each field were consulted. These comparisons are subjective because they are based on estimates of potential impacts, not measurements of actual impacts resulting from on-site remediation. Further, the comparisons treat all impacts equally so that, for example, potential impacts to human health are considered equal to potential impacts on cultural resources. To give more weight to potentially more severe impacts, long-term and short-term impacts were compared separately (Section 4.4.16). Long-term impacts would have the potential to be more severe because they would result from leaving contaminated ground water in place or using institutional controls for a long time. In general, short-term impacts would be potentially less severe because most relate to the effects of construction (such as habitat destruction, noise, and dust emissions) that are relatively minor and/or can be mitigated. While these effects are important, there is greater concern about the potential long-term health and environmental effects of leaving contaminated ground water in place.

4.4.1 Human health

The potential short- and long-term health effects from contaminated ground water would be low for the proposed action and the active remediation to background levels alternative because they would result in compliance with EPA ground water standards at all UMTRA Project sites. In addition, institutional controls may be in place for sites under all alternatives except no action where contaminated ground water has migrated off the site.

The passive remediation alternative would have some potential for adverse health effects because passive strategies and the duration of institutional controls may not protect human health at some sites. However, it would have less impact than the no action alternative because the viability of using the no remediation compliance strategy would be justified at some sites and the public would be protected from contaminated ground water at most of the remaining sites. The no action alternative would have the highest potential to result in adverse health effects from contaminated ground water because no federally sponsored ground water remediation, controls, or monitoring of the contaminated ground water would take place; this impact could be long-term.

4.4.2 Air quality

The potential for the Ground Water Project to affect air quality would be minimal, especially for the no action and passive remediation alternatives. Potential air quality impacts would be low for the proposed action alternative, which relies, at least partially, on passive ground water remediation strategies and methods. The active remediation to background levels alternative would have a short-term potential for minor air quality impacts because of its reliance on active ground water remediation methods; however, mitigation measures could be taken to ensure that no significant impact occurs. There would be no long-term air quality impacts.

4.4.3 Surface water

The proposed action and the active remediation to background levels alternative would have a low potential to result in the contamination of surface water bodies because ground water (the potential source for surface water contamination) would meet EPA ground water standards under these alternatives. Surface water monitoring would take place during ground water remediation activities at the sites and, if necessary, remedial action would be initiated. The passive remediation alternative would have more potential to result in the contamination of surface water bodies because, while passive measures could be adequate at some sites, active methods could be needed at other sites to control plume migration. Under this alternative, there would be no way to clean up contaminated surface water. However, the use of this water could be restricted, thereby reducing the potential impact of using contaminated surface water. The no action alternative would have the greatest potential to result in the contamination of surface water bodies because there would be no federally sponsored remediation. In addition, the use of the contaminated water would not be controlled.

4.4.4 Ground water

The proposed action and the active remediation to background levels alternative would have the least potential to result in contamination of uncontaminated ground water because these alternatives are expected to clean up the quality of contaminated ground water to at least the EPA ground water standards. Ground water monitoring would detect any expansion of the contamination so that appropriate controls could be implemented. Under the passive remediation and no action alternatives, the potential spread of ground water contamination could not be prevented or slowed because active remediation would not be possible. However, the passive remediation alternative would attempt to meet the standards, resulting in less of an impact than no action. The spread of this contaminated ground water would have a greater potential for negative impacts under the no action alternative because access to this water could not be controlled.

4.4.5 Ecological resources

In general, the impacts of surface disturbance activities associated with site characterization and active ground water remediation would be short-term. However, if active remediation took several years, these impacts could become long-term and significant. The potential ecological impacts of leaving contaminated ground water would likely be long-term.

In terms of potential destruction of wildlife and aquatic habitat due to site characterization and the construction of remediation facilities, the no action and passive remediation alternatives would have the least likelihood for adverse impacts because there would be little or no ground-disturbing activities. The proposed action would result in some habitat disturbance because of the site-disturbing activities associated with active remediation. The active remediation to background levels alternative would result in habitat disturbance at most sites because of its reliance on active ground water remediation methods. Every effort would be made to avoid sensitive habitats or species; in most cases, it is likely that ground-disturbing activities would take place in areas away from these resources. If sensitive resources were affected, those effects would be mitigated to minimize environmental impacts.

In terms of contaminated ground water entering the ecosystem and creating a potential ecological risk, the proposed action and the active remediation to background levels alternative would have the lowest potential impact. If a ground water compliance strategy were not protective of the environment, it likely would not be implemented. Under the active remediation to background levels alternative, active ground water remediation methods would be used to remove the potential source of contamination at most UMTRA Project sites regardless of the risks. Under the passive remediation and no action alternatives, there is a greater potential for the release of contaminated ground water into the environment because the use of active remediation methods would not be available with these alternatives. In addition, their implementation would not result in the cleanup of already existing surface water contamination with its potential for an ecological risk. The no action alternative would have the highest potential for ecological risk to occur because no action would be taken to reduce or limit the use of the contaminated water. Under the passive remediation alternative, certain controls such as fencing would be available to limit wildlife use of contaminated water.

4.4.6 Land use

Land uses could be affected if land were acquired to conduct remediation or to impose controls restricting access to or use of land. The no action alternative would not require land acquisition; the proposed action and the passive remediation alternative could result in land acquisition. The active remediation to background levels alternative would likely result in the temporary use of the most land because more land would be needed to conduct active ground water remediation. In most cases, active remediation methods would require the acquisition or total control of land on which these facilities are placed. Land would likely revert to former uses after ground water remediation was completed.

The no action alternative would not limit or restrict land use because no remediation activities would occur. However, where ground water is contaminated and use could be affected. The proposed action and, to a lesser extent, the active remediation to background levels alternative would likely require land use restrictions because these alternatives would require institutional controls at some sites. The passive remediation alternative would likely result in restricted land use at most sites because institutional controls would be the most frequent restriction to access under this alternative. This impact has the potential to be long-term as well as short-term because institutional controls could be in effect for up to 100 years.

Site-related contamination could affect land use by contaminating ground water and surface water used for domestic, agricultural, or industrial purposes. The potential for such an impact is highest under no action because there would be no Ground Water Project. This potential impact would be less under the passive remediation alternative because monitoring and institutional controls, where necessary, would be available to limit use of contaminated ground water. However, this alternative may not be protective of human health and the environment at all sites and the active ground water compliance strategy could not be used. The potential for this impact is lowest under the proposed action and active remediation to background levels alternatives because compliance with the EPA standards would be achieved at all sites. In addition, the active ground water remediation strategy is available for use with these two alternatives. This strategy could be used to clean up areas of contaminated ground water or surface water that may affect beneficial domestic, agricultural, and industrial uses.

4.4.7 Cultural/traditional resources

During construction, the potential effects on cultural resources would be low for both the no action and the passive remediation alternatives because little or no construction would take place. Potential impacts would be possible under the proposed action because it would use both passive and active ground water remediation methods. The potential impacts to cultural/traditional resources would be highest for the active remediation to background levels alternative because of its reliance on active remediation methods. In most cases, it would likely be possible to avoid cultural resources during ground-disturbing activities. If sensitive cultural resources, including tribal traditional areas, were affected, these impacts would be mitigated.

Impacts to Native American traditional resources associated with water would be highest for the no action and passive remediation alternatives because ground water might not meet standards at sites on tribal lands. Under the proposed action and active remediation to background levels alternatives, ground water would meet standards and would provide a beneficial impact to these traditional resources. The active remediation to background levels alternative would have less impact than the proposed action. This is because of its reliance on active ground water remediation methods which presumably would result in compliance with the standards.

4.4.8 Background noise

The potential for adverse noise impacts under any of the alternatives would be minimal, and any impacts would be temporary.

4.4.9 Visual resources

The potential for the Ground Water Project to negatively impact visual resources would be minimal. None of the UMTRA Project sites is located in areas of sensitive scenic resources (e.g., national parks or wilderness areas), and most visual impacts would be temporary (e.g., construction-related only). Potential long-term visual impacts from monitor wells would be possible under all alternatives except no action. As indicated in Section 4.2, these impacts could be mitigated.

4.4.10 Transportation

No significant transportation impacts would be expected under any of the alternatives. Any impacts would be minor and temporary.

4.4.11 Social and economic resources

In comparing the alternatives for potential socioeconomic impacts, the following factors are considered:

- The potential beneficial impacts associated with increased employment and economic expansion
- The potential adverse effects on property values from restrictive land uses or contaminated ground water.

Active remediation to background levels has the highest potential for socioeconomic benefits of increased employment and economic expansion. The proposed action would result in some increased employment, particularly at sites where active remedial actions would be implemented to meet EPA standards.

In terms of impacts on property values due to imposed restrictions on land use, the passive remediation alternative would have the highest potential adverse impact because it would likely result in the use of institutional controls at many sites. The proposed action and active remediation to background levels alternative would have less potential for such an impact. Under the proposed action, land use restrictions would be required as a result of the use of institutional controls at some sites and active remediation methods at other sites. The active remediation to background levels alternative would restrict land use at many sites during the active remediation period. The no action alternative would not entail land use restrictions. Under the no action alternative, contaminated ground water could adversely affect property values.

Property value impacts associated with active ground water remediation are generally short-term, although the impacts of institutional controls are potentially long-term.

In terms of potential impacts on property values due to the existence of contaminated ground water and/or surface water, the proposed action and the active remediation to background levels alternative would have the least impact because implementation of either of these alternatives would result in compliance with the EPA ground water standards. The passive remediation alternative could have an impact because this alternative may not be protective of human health and the environment at some sites. The no action alternative would have the highest potential for long-term property value impacts because the existence of contaminated water resources could preclude the use of land for agricultural purposes or development, require development and use of alternative water supplies, or affect the sale of land or agricultural products.

4.4.12 Environmental justice

The no action alternative would have the potential to result in a high disproportionate impact to minority or low-income groups relative to the other alternatives. This is because the ground water will not comply with EPA standards.

The passive compliance alternative would have a medium potential to have a disproportionately high effect on minorities and low-income populations because it may not result in compliance with the EPA ground water standards at all sites. The natural flushing ground water compliance strategy may result in compliance with the standard.

The proposed action and active remediation to background levels alternatives would have a low potential to have a disproportionately high effect on minority or low-income populations because both of these alternatives would result in compliance with EPA ground water standards.

DOE has attempted in this PEIS, and will continue in subsequent tiered NEPA documents, to identify and to mitigate when so identified, any disproportionately high and adverse human health or environmental effects on minority and low-income populations resulting from decisions based on this PEIS. The activities required to complete the ground water project are highly localized and would not result in cumulative impacts to air quality, noise levels, visual resources, transportation systems, utilities and energy supplies, waste generation, and cultural resources. Further, the proposed action would result in human health, socioeconomic, and environmental impacts that would be beneficial to any surrounding population. Therefore, the DOE does not anticipate any disproportionately high and adverse human health and environmental effects on minority and low-income populations as a result of the implementation of the proposed action. The DOE will reassess potential environmental justice issues in site-specific NEPA documents that will be tiered from this PEIS.

4.4.13 Utilities and energy resources

The potential for the Ground Water Project to have a negative impact on utilities and energy resources would be none to minimal under any of the four alternatives.

4.4.14 Waste management

No liquid or solid waste management issues would arise under the no action alternative. The passive remediation alternative would produce only a small amount of waste during site characterization and monitoring. Therefore, these two alternatives would have little or no impact in terms of the potential for generating liquid and solid waste. The proposed action would have a medium probability of impacts from the production of wastes because it would rely on a combination of ground water strategies ranging from passive methods (generating little or no waste) to active methods (generating more waste). The active remediation to background levels alternative would have the highest potential to produce waste because of its reliance on active methods. All wastes would be managed in accordance with existing regulations (refer to Section 2.9).

4.4.15 Estimated costs

Highest estimated costs are associated with the active remediation to background levels alternative primarily because of the costs associated with equipment, operations, and field management. The no action and passive remediation alternatives are the least costly alternatives. The proposed action, because it combines passive and active strategies, would be less costly than the active remediation to background levels alternatives but more costly than the other two alternatives. The proposed action provides for compliance with ground water standards, and protects public health and safety by using the most appropriate compliance strategy for each UMTRA Project site.

For this PEIS, only qualitative analysis has been done. Quantitative analysis is not possible at the programmatic level because costs for the alternatives are highly variable and could be applied differently depending on site-specific conditions.

4.4.16 Summary of the comparison of alternatives

Table 4.5 compares potential adverse impacts of alternatives. Estimated cost is not included in the table because high and low expenditures are not necessarily negative or positive impacts. The potential impacts of the alternatives are divided into short-term and long-term impacts. Short-term impacts are associated with site characterization and the construction of ground water

Table 4.5 Comparison of potential adverse environmental impacts of the alternatives

Environmental factor	Alternative: Proposed action	No action	Active remediation to background levels	Passive remediation
Human health	Low	High	Low	Medium
Surface water	Low	High	Low	Medium
Ground water	Low	High	Low	Medium
Ecology				
Habitat destruction	Medium	Low	High	Low
Contaminated ground water	Low	High	Low	Medium
Land use				
Land acquisition	Medium	Low	High	Low
Institutional controls	Medium	Low	Medium	High
Contaminated ground water	Low	High	Low	Medium
Cultural/traditional resources				
Surface	Medium	Low	High	Low
Ground water	Medium	High	Low	High
Social and economic				
Institutional controls	Medium	Low	Medium	High
Contaminated ground water	Low	High	Low	Medium
Environmental justice	Low	High	Low	Low
Waste management	Medium	Low	High	Low

Notes: 1. High indicates high potential for negative impact relative to the other alternatives.
2. Medium indicates medium potential for negative impact relative to the other alternatives.
3. Low indicates little to no potential negative impact relative to the other alternatives.
4. The degree of actual negative impact, if any, would be addressed once the site-specific ground water compliance strategies are determined; thus analysis would appear in the site-specific NEPA documents.

remediation facilities. Long-term impacts could occur if no ground water remediation occurred or if ground water remediation took many years.

Short-term potential impacts

The no action alternative would have no short-term impacts associated with site characterization and ground water remediation because such activities would not take place under this alternative. None of the other alternatives are expected to have short-term impacts due to the short duration and small scale of the ground-disturbing activities. Potential negative impacts that could occur under the proposed action and active remediation to background levels alternative include the degradation of air quality (e.g., dust), noise levels, visual resources, transportation systems, and utilities and energy supplies. These resources are not included on Table 4.5 because they are minor and short-term. Site characterization, monitoring, and construction activities have the potential to disturb sensitive habitats, species, and cultural resources. The probability of these impacts occurring would be remote because site characterization and remediation activities can usually take place in areas away from these resources. In addition, if impacts to these resources occur, their effects could be mitigated to minimize impacts. Therefore, the potential for site characterization and construction activities to adversely affect these resources would be considered minor.

Implementation of all the alternatives except no action would have the potential to have a positive short-term effect on minority and low-income populations and other populations if measures such as supplying an alternative source of drinking water are put into effect.

Long-term potential impacts

Based on the analysis below, long-term impacts could arise under the following circumstances:

- If the contaminated ground water did not comply with the EPA standards and use of contaminated ground water was not controlled as under the no action alternative
- If the ground water compliance strategy were not protective of human health and the environment at all sites. This could occur under the passive remediation alternative.
- If institutional controls were in place for many years. This could occur under all the alternatives except the no action alternative.

Significant adverse impacts to human health and the environment could result under the no action alternative. Under this alternative, the public could be exposed to site-related hazardous contaminants by drinking contaminated ground water or surface water from a surface expression of contaminated ground water. Disproportionately high or adverse human health effects to minority or low-income populations could occur because of the lack of means to provide for an alternate water supply.

Adverse impacts to the environment could also potentially occur if contamination enters the food chain (such as livestock or produce) or affects sensitive habitats (such as wetlands) or threatened and endangered species. These potentially significant adverse impacts would likely not occur under the proposed action or the active remediation to background alternative because these alternatives would comply with the EPA standards at all UMTRA Project sites. In addition, surface and ground water monitoring would take place before and during the implementation of the proposed action and the active remediation to background alternatives to ensure that the public is not exposed to existing and potential future surface and ground water contamination.

Implementation of the passive remediation alternative also could potentially result in the exposure of humans and the environment to UMTRA Project site-related contaminants. During the time required to implement the passive remediation alternative, contaminated ground water could reach potential receptors such as domestic wells or surface water features. Both the proposed action and active remediation to background alternatives would use hydrogeologic data and risk assessments to identify the need to implement active ground water remediation strategies quickly or to divert the flow of contamination.

Institutional controls would be required in conjunction with natural flushing. In some cases, institutional controls would be used at active ground water remediation and at no remediation sites. Institutional controls could result in potentially significant long-term land use and socioeconomic impacts. The passive remediation alternative could result in the need for institutional controls for more than 100 years if protection of the public and the environment were necessary. The proposed action and the active remediation to background alternatives would implement strategies to achieve ground water compliance within 100 years. The use of institutional controls could result in long-term land use and social and economic impacts, as discussed in Sections 4.4.6 and 4.4.11.

In summary, the proposed action and the active remediation to background alternative are most effective at protecting human health and the environment from the contaminated ground water at the UMTRA Project sites. When cost is factored in, the proposed action is likely to be the most cost-effective alternative because it would use passive remediation strategies such as natural flushing and no remediation at sites where these strategies are shown to be protective of human health and the environment. Implementation of the active remediation to background levels alternative would be the most costly because of its widespread use of active ground water remediation methods.

4.5 POTENTIAL CUMULATIVE IMPACTS OF THE ALTERNATIVES

Cumulative impacts, as defined in the CEQ regulations (40 CFR §1508.7), are the impacts which result from incremental impacts of the action when added to other past, present, or reasonably foreseeable future action regardless of what agency (federal or nonfederal) or person undertakes such other actions. For example, when the minor impacts of the Ground Water Project on a site-specific resource are combined with similar impacts of other nearby projects, the cumulative impact may become significant. Cumulative impacts in relation to past, present, and future projects at the UMTRA Project sites cannot be fully evaluated at this time because this analysis requires the use of site-specific data that are currently not available. However, the potential cumulative effects of the alternatives, combining the impacts of the Surface Project with potential impacts of the Ground Water Project, were evaluated and are presented below.

Based on the analysis of potential impacts of the ground water compliance strategies in Section 4.2 and the no action alternative in Section 4.3, the potential for the alternatives to result in cumulative impacts to air quality, noise levels, visual resources, transportation systems, utilities and energy supplies, and waste generation is minor. There is potential for cumulative impacts from other resources, as discussed below.

4.5.1 Human health

The UMTRA Surface Project has a positive impact on human health because it results in the cleanup of surface contamination at the designated processing sites. Under the Surface Project, the cleanup of the uranium mill tailings also prevents the misuse of the tailings that, in the past, resulted in the exposure of many people and the contamination of thousands of vicinity properties. Under the proposed action, the UMTRA Ground Water Project would result in a positive cumulative impact on human health by restoring contaminated ground water through active ground water remediation, preventing the use of contaminated ground water during natural flushing, or assuring the public that the contaminated ground water is not a threat to human health through the mechanism of supplemental standards or alternate concentration limits.

When considered with the Surface Project, the active remediation to background levels alternative would also result in a positive cumulative impact to human health because the EPA ground water protection standards would be met. The passive remediation alternative would also have a positive cumulative impact because it would protect the public from exposure to contaminated ground water at sites undergoing natural flushing. It would also demonstrate to the public that some sites are not a threat since they qualify for supplemental standards or alternate concentrations limits. However, the passive remediation alternative may not be protective of human health at some sites and, in comparison to the above alternatives, has the potential for a less positive cumulative impact on human health.

Implementation of the no action alternative under the Ground Water Project would likely have a negative impact because the federal government would not take any steps to monitor, characterize, or clean up contaminated ground water; protect the public from exposure to contaminated ground water; or provide assurances to the public that the contaminated ground water is not a threat. Under this alternative, only positive impacts on human health would result from the Surface Project.

4.5.2 Surface water

Twenty-two of the UMTRA Project sites are located next to or near surface water bodies. The Surface Project has a positive long-term impact on these surface water bodies by removing surface contamination from the floodplains of rivers or from upland areas where the potential for erosion of tailings into a surface water body existed. In addition, the Surface Project eliminates the source of ground water contamination (tailings), which would result in a decrease, over time, of the flow of contaminated ground water into surface water bodies. Also, the disposal cells are designed to greatly limit the infiltration of water through the cell. The Ground Water Project, under the proposed action, and the Surface Project together have a positive cumulative impact on surface water bodies due to the remediation of contaminated surface material and ground water and, in some cases, the cleanup of surface water contamination. In addition, the remediation of contaminated ground water would prevent future contamination of surface water bodies. The implementation of the active remediation to background levels alternative would have a similar positive cumulative impact on surface water.

Under the passive remediation and no action alternatives, no measures would be taken to prevent the spread of contamination into surface water bodies or to clean up those water bodies that currently are contaminated. However, under the passive remediation alternative, measures could be taken to limit or prevent human use of contaminated surface water and, if necessary, use by some wildlife species. Therefore, the passive remediation alternative, in conjunction with the Surface Project, would result in a positive cumulative impact. However, the no action alternative likely would have a negative impact on surface water, and would not result in a positive cumulative impact on surface water from the UMTRA Project as a whole.

The Surface Project resulted in the disturbance of river floodplains at some sites. These impacts have been addressed in site-specific floodplain assessments. When the Ground Water Project is considered in conjunction with Surface Project impacts on floodplains, no cumulative impacts to river floodplains are expected because ground water remediation activities likely would not take place in floodplains due to standard engineering site-selection requirements.

4.5.3 Ground water

Under the Surface Project, the stabilization of the uranium mill tailings and other contaminated material in disposal cells has a positive impact on ground water because the source of ground water contamination (the tailings) is removed from the system. Implementing the proposed action for the Ground Water Project would add to this positive impact by cleaning up contaminated water. The active remediation to background levels alternative would result in a similar positive cumulative impact.

Implementation of the passive remediation or no action alternatives would result in the spread of contaminated ground water. However, the potential impacts of using this contaminated water would be less under the passive remediation alternative because monitoring would identify the extent of contamination and institutional controls would restrict the use of contaminated ground water. In conjunction with the Surface Project, the passive remediation alternative would have a positive cumulative impact on ground water quality. Under the no action alternative, there would be no monitoring or controls to protect the public or the environment from this water. Consequently, this alternative would not result in a positive cumulative impact to ground water.

4.5.4 Ecological resources

The Surface Project has resulted in the disturbance of approximately 3900 ac (1500 ha) of land and associated plant communities and wildlife habitat. Much of the land consisted of upland plant communities or disturbed land associated with the abandoned processing sites. In some cases, riparian and wetland areas were cleared. Impacts to sensitive habitats such as these were mitigated through various processes, including the U.S. Army Corps of Engineers Section 404 Permit. Consultation with the Fish and Wildlife Service eliminated or reduced impacts to sensitive species such as threatened and endangered species. The implementation of the proposed action and the active remediation to background levels alternatives may cumulatively impact plant communities and habitats during the construction and operation of active ground water remediation facilities. This negative cumulative impact is expected to be relatively small because, as indicated in Section 4.2.1.5, the amount of land required for such facilities would likely be small (20 ac [8 ha] or less). The implementation of passive remediation or the no action alternatives would not result in a negative cumulative impact for this resource because little, if any, land would be disturbed.

The Surface Project has a positive impact on ecological resources because it results in stabilization of the surface contamination that at some sites had entered the biological systems via contaminated soil, surface water, or ground water. The cleanup of this material eliminated the soil pathway and the major source of contamination to the surface and ground water. The implementation of the proposed action and the active remediation to background levels alternatives would have a positive cumulative impact because they would further reduce the potential for ecological risk from contaminated ground water. This is because active ground water remediation at some sites would reduce the amount of contaminated ground water available to enter the ecosystem. Active remediation of existing surface water contamination would also likely take place under these two alternatives.

As indicated in Sections 4.5.2 and 4.5.3, the passive remediation and no action alternatives would not result in the active cleanup of contaminated surface and ground water. However, the passive remediation alternative may result in a positive cumulative impact because the extent of contamination would be known and measures may be available to protect some sensitive ecological resources from contaminated surface and/or ground water. Under the no action alternative, no positive cumulative impact is anticipated because no measures would be taken to monitor the extent of contamination or protect resources from contaminated water.

4.5.5 Land use

The Surface Project results in some negative impacts on land use such as the clearing of land that had been used for grazing. Construction of active ground water remediation facilities under the proposed action or the active remediation to background levels alternatives is expected to result in only a minor negative cumulative impact in terms of land disturbance because these facilities use a relatively small amount of land, and it likely was disturbed during the Surface Project. The passive remediation and no action alternatives would not result in a cumulative impact because little or no construction would take place.

Considering both the Surface and Ground Water Projects together, the passive remediation alternative would result in a negative cumulative impact on land use because it would use the natural flushing compliance strategy more extensively than the other alternatives. With this strategy, institutional controls would be required and these controls could affect land use patterns. Under the proposed action, the negative cumulative impact on land use would be less because natural flushing would not be used as extensively. The active remediation to background levels and the no action alternatives would not result in a negative cumulative impact on land use because institutional controls associated with natural flushing would not be used.

The Surface Project has resulted in positive land use and land value impacts, particularly at processing sites where tailings were removed and disposed of off-site. There, land previously precluded from use because of contamination and federal control during cleanup would be available for public purposes such as parks (if ownership remains with a government agency) or for use by private owners following surface remediation. This positive impact would be balanced against the potentially negative land use and economic impacts that could result from institutional controls and from restricted use due to ground water contamination.

4.5.6 Cultural/traditional resources

Cultural resources are known to exist at 11 of the UMTRA Project sites. The Surface Project had very little negative impact on these resources because efforts were made to avoid or protect such resources, or measures were used to document resources. Implementing any of the alternatives for the Ground Water Project is expected to have little or no impact on cultural resources. Therefore, a cumulative impact on cultural resources is not expected.

4.5.7 Social and economic resources

Surface remedial activities employ between 80 and 300 workers per site during the construction season. The number and types of workers depend on the site and the status of remedial activities. For example, employment associated with surface remediation at Grand Junction totaled nearly 300 workers in 1993; in Naturita, employment is expected to average 54 workers and peak at 76 workers. Similarly, fewer workers are required during initial stages of remediation (e.g., building demolition). Research on the UMTRA Surface Project indicates about 80 percent of the work force is local, from within a 60-mi (96-km) commute distance. In addition to direct employment, secondary employment is generated when money spent on remedial action is respent and these expenditures create a demand for new jobs.

Surface remedial activities have a direct positive impact on local economies as well because of wages and salaries paid to workers and expenditures for equipment, materials, supplies, and services. Secondary benefits also result as monies from these wages and salaries are recirculated. Direct and secondary expenditures generate tax revenues that are available for county and state government use.

Similar but lesser impacts could occur with the Ground Water Project. Fewer workers would be required for active ground water remediation than for surface remediation. Consequently, the beneficial cumulative impact of ground water remediation added to the surface activities would be minimal. Higher cumulative beneficial economic impacts (increased employment and economic stimulation) would be expected under the active remediation compliance strategy due to its use of more labor-intensive active remediation methods. No beneficial cumulative impact would occur under the no action alternative.

4.5.8 Environmental justice

The activities required to complete the Ground Water Project under the proposed action and active remediation to background levels alternatives would not result in cumulative negative impacts to air quality, noise levels, visual resources, transportation systems, utilities and energy supplies, waste generation, or cultural/traditional resources. Further, when considered with the Surface Project, these alternatives would result in human health, social, economic, and environmental cumulative positive impacts that would also benefit any surrounding population. Therefore, the DOE does not anticipate any disproportionately high adverse cumulative effects on minority or low-income populations from these alternatives.

Implementation of the passive remediation alternative likely will not be protective of human health and the environment (at some sites) as the proposed action and active remediation to background level alternatives. However, given that the passive compliance alternative would result in characterization and monitoring, and would protect the public from using contaminated ground water (through use of institutional controls), this alternative would have a positive cumulative impact. Therefore, implementation of this alternative is not expected to result in disproportionate negative and adverse cumulative effects to minority and low-income groups.

The no action alternative could result in negative impacts to human health and the environment and when considered with the Surface Project, likely would not have a positive cumulative impact. Further, if the negative impact of no action on human health and the environment is severe enough, there is a potential for the no action alternative to result in a disproportionate adverse cumulative impact on minority and low-income populations.

The DOE will assess potential environmental justice issues in greater detail in site-specific NEPA documents that will be tiered from this programmatic review.

5.0 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

This section discusses unavoidable adverse environmental impacts of the proposed action. The potential impacts identified in Section 4.0 may not occur every time a ground water compliance strategy is employed, but the potential does exist for the identified impacts to occur. Potential impacts would be analyzed in the site-specific NEPA documents. The following potential unavoidable adverse impacts would likely occur under the proposed action.

5.1 ECOLOGICAL RESOURCES

The proposed action would likely result in the clearing of small areas of terrestrial plant communities and wildlife habitat at sites where ground water remediation facilities would be constructed. Most of the land cleared for these facilities would be land that was previously disturbed during the Surface Project, so the plant communities are of marginal quality for wildlife. When ground water remediation is complete, the facilities would be dismantled, and the ground would be recontoured, if necessary, and revegetated.

5.2 LAND USE

Under the proposed action, active ground water remediation methods and natural flushing could affect land use by restricting land and water use during the remediation period. Active ground water remediation methods would require construction of facilities such as water treatment plants and wastewater evaporation ponds. This land for these facilities would not be available for other uses during the ground water remediation activities. Under the proposed action, institutional controls would be used in conjunction with natural flushing and possibly in conjunction with other ground water compliance strategies. Institutional controls could affect land use within the controlled area by restricting certain land uses or even eliminating all uses. This impact could be more significant to land use practices that require ground water withdrawal. These restrictions could last for an extended period because institutional controls for natural flushing could be in effect for up to 100 years.

6.0 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

In accordance with NEPA, this section discusses the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity.

Under the no action alternative, there would be no remediation of the contaminated ground water at the UMTRA Project sites. Therefore, the impacts associated with ground water remediation, such as the disturbance of wildlife habitat and land use restrictions, would not occur. Long-term productivity at some sites would be adversely affected under the no action alternative because the contaminated ground water would not be cleaned up. This could result in the contamination of domestic wells, surface water bodies, and aquatic and wildlife habitat, resulting in potential human and environmental health effects. In addition, the long-term productivity of the sites could be affected because contaminated ground water and surface water bodies could not be used for practices such as agriculture and ranching.

Cleaning up the contaminated ground water at the UMTRA Project sites with active methods or natural flushing would preclude other short-term uses of the land during remediation. The remediation of contaminated ground water however, would enhance long-term productivity of the affected sites because aquifers that are currently contaminated would become available for use.

7.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The no action alternative would not use any resources because the Ground Water Project would not take place under this alternative. The proposed action and the other alternatives would require the use of resources during site characterization, monitoring, and ground water remediation. These resources would be fuel, electricity, construction materials, water, and land. In addition, the proposed action and the active remediation to background alternative would require the use of chemicals and other materials for water treatment. These are irretrievable commitments.

Site-specific NEPA documents would identify the needed amount of resources. The resources that would be irreversibly lost would be fuel; construction materials such as cement, wood, and metal; electricity; and chemicals and other materials used for water treatment. A net depletion of water would be associated with most treatment technologies.

The use of land would not be permanently committed because the land would be returned to its previous condition after the completion of ground water remediation. Land use restrictions due to institutional controls would be lifted once it had been verified that the affected ground water meets the EPA ground water standards. However, land used during the ground water remediation period would be irretrievably committed for that time period.

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42 USC §4321 *et seq., National Environmental Policy Act.*

42 USC §7901 *et seq., Uranium Mill Tailings Radiation Control Act.*

42 USC §7922 *et seq., Uranium Mill Tailings Remedial Action Amendments Act.*

9.0 GLOSSARY

alternate concentration limits	Concentrations of constituents that may exceed the maximum concentration limits; or, limits for those constituents without maximum concentration limits. If DOE demonstrates, and NRC concurs, that human health and the environment would not be adversely affected, DOE may meet an alternate concentration limit.
aquifer	A body of rock that is sufficiently permeable to conduct ground water and to yield economically significant quantities of water to wells and springs.
aquifer hydraulic characteristics	Properties of an aquifer that describe its capability to transport or store ground water.
aquifer pumping test	A test conducted by pumping water from wells and measuring water level changes in the surrounding aquifer. Pumping tests provide information about aquifer hydraulic characteristics.
aquitard	An underground layer of earth or rock that acts as a confining bed and retards ground water flow to or from an adjacent aquifer.
baseline risk assessment	A baseline risk assessment describes the source of contamination, how that contamination reaches people and the environment, the amount of contamination to which people or the ecological environment may be exposed, and the health or ecological effects that could result from that exposure.
bedrock	Rock that commonly occurs below land surface as a solid mass, not loose granules like sand and gravel.
beneficial use	A beneficial use of a ground water resource is any current and reasonably projected use of that ground water. Examples of a ground water beneficial use are for drinking water, stock watering, crop and garden irrigation, and residential use.

bioremediation	The processes of breaking down or immobilizing certain constituents in water through the use of chemical reactions caused by microorganisms.
capture zone	The area of an aquifer that contains ground water that will eventually be removed or captured by the extraction wells.
cleanup	The removal or stabilization of constituents to eliminate or reduce the risk to human health and the environment.
compliance strategy	The method used to meet the EPA ground water standards at an UMTRA Project site.
confined aquifer	An underground layer of earth or porous rock containing water that is separated from the ground water above it by a layer of sediment or rock that retards ground water flow.
constituent	Any substance found in ground water whether or not it is harmful.
contaminant	An undesirable substance from uranium processing activities that may affect human health and the environment.
cooperating agency	A federal, tribal, state, or local agency that participates in the preparation of an environmental impact statement.
cooperative agreement	An agreement between DOE and an affected Indian tribe or state that defines the roles and responsibilities of the parties in implementing the UMTRA Project.
denitrification	A microbial reaction that causes the removal of nitrate from water by converting the nitrate to nitrogen.
downgradient	Ground water located in the same direction as ground water flow from a specified location.
environmental assessment	A document that determines the potential for significant impacts to the environment from an action.
environmental impact statement	A document that describes and evaluates the potential significant impacts on the environment

	from several alternative actions, including no action.
fracture zones	Cracks in bedrock caused by geologic forces. Fractures can conduct ground water flow.
geochemical models	Computer programs used to determine chemical reactions between the aquifer matrix and ground water or chemical reactions in ground water only.
geophysical methods	Methods of investigating the subsurface that involve the analysis of electrical measurements on the land surface or the analysis of subsurface vibrations that are created by an energy source on the land surface.
ground water	Water under the earth's surface that fills spaces between sand, soil, or gravel. When ground water occurs in aquifers, it can be pumped for drinking water, irrigation, and other purposes.
ground water model	A computer program used to estimate ground water flow and contaminant movement rates and directions.
ground water monitoring	The periodic sampling and analysis of ground water to measure water levels and detect the possible presence of chemicals.
ground water plume	A defined area of ground water contamination. In this document, the term "ground water plume" means the contaminated ground water beneath a mill site and surrounding area that DOE determines to contain either soluble radioactive or nonradioactive, hazardous constituents, as a direct or indirect result of the uranium milling process.
ground water recharge area	An area of land surface or a body of surface water that allows water to infiltrate into a shallow aquifer.
ground water remediation	Treatment of ground water to decrease the amount or mobility of constituents.
hydraulic barrier	A natural or constructed restriction of ground water flow.

hydraulic conductivity	A description of an aquifer's capability to transport ground water.
hydraulic diversion	A change in ground water flow direction caused by a higher water table created by injection of water into an aquifer.
hydrogeologic framework	Underground geologic features that control ground water occurrence and movement. Such features include sediment or rock types, their thicknesses, and their orientations.
in situ	Occurring in the original place.
institutional controls	Controls that effectively protect public health and the environment.
maximum concentration limits	EPA's maximum concentration of certain constituents for ground water protection. Constituents with maximum concentration limits that may be present in contaminated ground water at UMTRA Project sites include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, nitrate, radium, selenium, silver, and uranium.
microbial reaction	A chemical reaction caused by microorganisms.
mill site	(see processing site)
mitigation	Includes avoiding an impact altogether by not taking a certain action or parts of an action; minimizing impacts by limiting the degree or magnitude of the action and its implementation; rectifying the impact by repairing, rehabilitating, or restoring the affected environment; reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and compensating for the impact by replacing or providing substitute resources or environments.
natural flushing	Allowing natural ground water movement and geochemical process to decrease contaminant concentrations.
net gross alpha	Net gross alpha is a radiological term for the activity associated with all alpha-emitting radionuclides except uranium.

plume	(see ground water plume)
point of compliance	Anywhere site-related contamination above the EPA standards is found or projected to be found in ground water outside the disposal area and its cover.
processing site	A location where uranium ore was milled to remove the uranium. The term is used interchangeably with uranium mill site.
public drinking water system	A public water system is defined in 40 CFR §125.58 as a "system for the provision to the public of piped water for human consumption, if such system has at least fifteen (15) service connections or regularly serves at least twenty-five (25) individuals. This term includes (1) any collection, treatment, storage and distribution facilities under the control of the operator of the system and used primarily in connection with the system, and (2) any collection of pretreatment storage facilities not under the control of the operator of the system which are used primarily in connection with the system."
record of decision	A document that identifies the alternative selected for a given action described in an environmental impact statement.
remedial action	The action taken to stabilize, control, or clean up contaminants.
residual radioactive materials	Uranium mill tailings DOE determines to be radioactive that have resulted from the processing of uranium ore, and other waste at a processing site which DOE determines to be radioactive and which relates to such processing. EPA has interpreted this to include sludges and captured contaminated water from processing sites.
riparian habitats	Areas located along the banks of streams, rivers, lakes, and other bodies of water.
saturated zone	The zone of soil and rock below the water table.
scoping	An early and open process for determining the scope of issues to be addressed and for

	identifying the significant issues related to a proposed action.
site observational work plan	A document that presents a summary of site hydrogeological data and presents a site conceptual model. It presents an analysis of site environmental and health risks, data gaps in the conceptual model, and identifies appropriate site-specific ground water compliance strategies.
storativity	A description of the volume of water that can be removed from an aquifer in relationship to a decline in water level.
strategy	(see compliance strategy)
supplemental standards	Regulatory standards that are protective of human health and the environment that may be applied when the quantity of certain constituents exceeds the standards.
tailings	(see uranium mill tailings)
tiering	"Tiering" refers to the coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basin-wide program statements or ultimately site-specific statements) incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared (40 CFR §1508.28).
transmissivity	A description of an aquifer's capability to transport ground water in relationship to the aquifer thickness.
unsaturated zone	Soil, sediment, or rock above the water table where the pore spaces are not completely filled with water.
uranium mill tailings	The remaining sand-like portion of the metal-bearing ore after some or all of the uranium has been extracted.
vicinity properties	Properties outside a processing site boundary that have been contaminated by residual

	radioactive materials. These materials could have been dispersed by wind or water erosion, or removed by people.
water displacement tests	Tests conducted by rapidly adding or extracting a volume of water from a well and measuring the water level change.
water table	The boundary between the underground unsaturated zone and the saturated zone, at which the pressure is equal to that of the atmosphere.

10.0 ABBREVIATIONS AND ACRONYMS

Acronym	Definition
ac	acre
CEQ	Council on Environmental Quality
cm	centimeter
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	foot
ft^3/s	cubic feet per second
gal	gallon
ha	hectare
km	kilometer
L	liter
m	meter
m^3	cubic meter
mg/L	milligrams per liter
mi	mile
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
PEIS	programmatic environmental impact statement
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
UPDCC	UMTRA Project Document Control Center
yd^3	cubic yard

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12.0 ORGANIZATIONS CONSULTED DURING PEIS PREPARATION

Federal/Tribal/State	Agency	Location
Federal	U.S. Nuclear Regulatory Commission	Washington, D.C.
	U.S. Environmental Protection Agency	Washington, D.C.
	Department of the Interior	Washington, D.C.
	Bureau of Indian Affairs	Phoenix, Arizona
Tribal	Arapaho Tribe	Fort Washakie, Wyoming
	Wind River Environmental Quality Committee	Fort Washakie, Wyoming
	Hopi Tribal Natural Resources Department	Kykotsmovi, Arizona
	Office of Hopi Land and Water Resources Program	Kykotsmovi, Arizona
	Navajo Nation Division of Natural Resources	Window Rock, Arizona
	Shoshone Tribe	Fort Washakie, Wyoming
State	Colorado Department of Public Health and Environment	Denver, Colorado
	Idaho Department of Health and Welfare	Boise, Idaho
	Idaho Division of Environmental Quality	Boise, Idaho
	New Mexico Hazardous and Radioactive Material Bureau	Santa Fe, New Mexico
	New Mexico Environment Department	Santa Fe, New Mexico
	North Dakota State Department of Health	Bismarck, North Dakota
	Oregon Department of Energy	Salem, Oregon
	Pennsylvania Department of Environmental Resources	Pittsburgh, Pennsylvania
	Texas Bureau of Radiation Control	Austin, Texas
	Utah Department of Environmental Quality	Salt Lake City, Utah
	Wyoming Land Quality Division	Lander, Wyoming

13.0 AGENCIES, ORGANIZATIONS, AND PERSONS RECEIVING COPIES OF THE PEIS

The PEIS has been distributed to the following libraries and federal, tribal, and state agencies and representatives. Copies have also been mailed to members of Congress, governors, and state legislators who represent states where UMTRA Project sites are located. Additional copies have been mailed to private citizens and other interested stakeholders.

Libraries

Arizona

Flagstaff Public Library
Phoenix Public Library
Tuba City Public Library
Navajo Nation Library System
Kykotsmovi Public Library
  Community Development Director

Colorado

Cortez Public Library
Denver Public Library
Rifle Branch Library
Mesa State College Library
Dove Creek School Library
Durango Public Library
Montrose Regional Library
  Naturita Branch
Montrose Public Library
Nucla Public Library
Glenwood Springs Library
Gunnison Public Library

Idaho

Boise Public Library

New Mexico

Navajo Community College Library
  Shiprock Branch
Mother Whiteside Memorial Library
New Mexico State University Library
Octavia Felen Library
National Atomic Museum Library
University of New Mexico Gallup
  Library
University of New Mexico General
  Library
New Mexico Environment Department
  Library

North Dakota

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Oregon

Lake County Library

Pennsylvania

Canonsburg Public Library
People's Library

Texas

Falls City Public Library

Utah

Bluff Public Library
Marriott Library,
  University of Utah
San Juan County Library
Grand County Library
Green River Library

Wyoming

Riverton Branch Library
Wyoming State Library
University of Wyoming Library

Washington, D.C.

DOE Library,
Washington, D.C.

Federal, tribal, and state agencies and representatives

Department of Interior
Office of Environment, Policy, and Compliance

Army Corps of Engineers
Office of Environmental Policy
Office of Chief of Engineers

U.S. Environmental Protection Agency
Regions I-X

U.S. Nuclear Regulatory Commission
Uranium Recovery Branch
Division of Low-Level Waste and Decommissioning

Office of Scientific and Technical Information

National Technical Information Service

Remedial Action Program Information Center

U.S. Geological Survey

Director
Bureau of Land Management
Chief of Staff
State of Arizona

Director
Arizona Radiation Regulatory Agency

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Idaho Office of the Governor

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Remediation Bureau
Community Programs Division

Idaho Division of Environmental Quality

Director
Idaho Department of Health and Welfare

Superfund Project Officer
Community Programs Division
Idaho Department of Health and Welfare

Executive Director
Division of Natural Resources
Navajo Nation

Deputy Director
Division of Natural Resources
Navajo Nation

Director
Navajo Environmental Protection Agency

Director
Navajo UMTRA Program
Division of Resources

Bureau of Indian Affairs
Navajo Area Office

Director
Water and Waste Management Division
New Mexico Environment Department

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Hazardous and Radioactive
Materials Bureau
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General Counsel
Office of General Counsel
New Mexico Environment Department

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Environmental Engineering Division
North Dakota State Department of Health

Acting Director
Oregon Department of Energy

Oregon Radioactive Programs Manager

Lakeview Ranger District
Lakeview, Oregon

Director
Bureau of Radiation Protection
Pennsylvania Department of
Environmental Resources

Program Manager for Radiation
Pennsylvania Department of
Environmental Resources
Bureau of Radiation Protection

Acting Chief of Special Projects
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Pennsylvania Department of
Environmental Resources

Secretary
South Dakota Department of
Environment and Natural Resources

Director
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and Natural Resources

Nuclear Fuel Supply Branch
Tennessee Valley Authority

Director of Environmental Policy
Governor's Policy Council of Texas

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Texas Department of Health

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Texas Department of Health

Director
Division of Licensing, Registration
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Texas Department of Health

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Environmental and Consumer Health

State of Texas
Texas Natural Resources Conservation
Commission

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Utah State Clearinghouse
Office of Planning and Budget

Federal Lands Planning Coordinator
Wyoming State Planning Coordinator's Office

General Manager
Central Valley Water Reclamation Facility
Wyoming State Planning Coordinator's Office

Acting Administrator
Wyoming Land Quality Division

Shoshone Tribal Coordinator

Arapaho Tribal Chairman

Wind River Environmental Quality Committee

Director
Shoshone-Arapaho Tribes

APPENDIX A

HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM AND THORIUM MILL TAILINGS

PROPOSED STANDARDS FOR REMEDIAL ACTIONS AT INACTIVE URANIUM PROCESSING SITES

GROUNDWATER STANDARDS FOR REMEDIAL ACTION AT INACTIVE URANIUM PROCESSING SITES, FINAL RULE

HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM AND THORIUM MILL TAILINGS

40 CFR PART 192

PART 192—HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM AND THORIUM MILL TAILINGS

40 CFR PART 192

Subpart A—Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites

§192.00 Applicability.

This subpart applies to the control of residual radioactive material at designated processing or depository sites under section 108 of the Uranium Mill Tailings Radiation Control Act of 1978 (henceforth designated "the Act"), and to restoration of such sites following any use of subsurface minerals under section 104(h) of the Act.

§192.01 Definitions.

(a) Unless otherwise indicated in this subpart, all terms shall have the same meaning as in Title I of the Act.

(b) *Remedial* action means any action performed under section 108 of the Act.

(c) *Control* means any remedial action intended to stabilize, inhibit future misuse of, or reduce emissions or effluents from residual radioactive materials.

(d) *Disposal site* means the region within the smallest perimeter of residual radioactive material (excluding cover materials) following completion of control activities.

(e) *Depository site* means a disposal site (other than a processing site) selected under section 104(b) or 105(b) of the Act.

(f) *Curie* (Ci) means the amount of radioactive material that produces 37 billion nuclear transformation per second. One picocurie (pCi) = 10^{-12}Ci.

§192.02 Standards.

Control shall be designed[1] to:

(a) Be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,

(b) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:

(1) Exceed an average[2] release rate of 20 picocuries per square meter per second, *or*

(2) Increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter.

Subpart B—Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites

§192.10 Applicability.

This subpart applies to land and buildings that are part of any processing site designated by the Secretary of Energy under section 102 of the Act. section 101 of the Act, states, in part, that "processing site" means—

(a) Any site, including the mill, containing residual radioactive materials at which all or substantially all of the uranium was produced for sale to any Federal agency

[1]Because the standard applies to design, monitoring after disposal is not required to demonstrate compliance.

[2]This average shall apply over the entire surface of the disposal site and over at least a one-year period. Radon will come from both residual radioactive materials and from materials covering them. Radon emissions from the covering materials should be estimated as part of developing a remedial action plan for each site. The standard, however, applies only to emissions from residual radioactive materials to the atmosphere.

prior to January 1, 1971, under a contract with any Federal agency, except in the case of a site at or near Slick Rock, Colorado, unless—

(1) Such site was owned or controlled as of Januray 1, 1978, or is thereafter owned or controlled, by any Federal agency, or

(2) A license (issued by the (Nuclear Regulatory) Commission or its predecessor agency under the Atomic Energy Act of 1954 or by a State as permitted under section 274 of such Act) for the production at site of any uranium or thorium product derived from ores is in effect on January 1, 1978, or is issued or renewed after such date; and

(b) Any other real property or improvement thereon which—

(1) Is in the vicinity of such site, and

(2) Is determined by the Secretary, in consultation with the Commission, to be contaminated with residual radioactive materials derived from such site.

§192.11 Definitions.

(a) Unless otherwise indicated in this subpart, all terms shall have the same meaning as defined in Title I of the Act or in Subpart A.

(b) "Land" means any surface or subsurface land that is not part of a disposal site and is not covered by an occupiable building.

(c) "Working Level" (WL) means any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of alpha particles with a total energy of 130 billion electron volts.

(d) "Soil" means all unconsolidated materials normally found on or near the surface of the earth including, but not limited to, silts, clays, sands, gravel, and small rocks.

§192.12 Standards.

Remedial actions shall be conducted so as to provide reasonable assurance that, *as a result of residual radioactive materials from any designated processing site:*

(a) The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than—

(1) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and

(2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.

(b) In any occupied or habitable building—

(1) The objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL, and

(2) The level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour.

Subpart C—Implementation

§192.20 Guidance for implementation.

Section 108 of the Act requires the Secretary of Energy to select and perform remedial actions with the concurrence of the Nuclear Regulatory Commission and the full participation of any State that pays part of the cost, and in consultation, as appropriate, with affected Indian Tribes and the Secretary of the Interior. These parties, in their respective roles under section 108, are referred to hereafter as "the implementing agencies." The implementing agencies shall establish methods and procedures to provide "reasonable assurance" that the provisions of Subparts A and B are satisfied. This should be done as appropriate through use of analytic models and site-specific analyses, in the case of Subpart A, and for Subpart B through measurements performed within the accuracy of currently available types of field and laboratory instruments in conjunction with reasonable survey and sampling procedures. These methods and procedures may be varied to suit conditions at specific sites. In particular:

(a)(1) The purpose of Subpart A is to provide for long-term stabilization and isolation in order to inhibit misuse and spreading of residual radioactive materials, control releases of radon to air, and protect water. Subpart A may be implemented through analysis of the physical properties of the site and the control system and projection of the effects of natural processes over time. Events and processes that could significantly affect the average radon release rate from the entire disposal site should be considered. Phenomena that are localized or temporary, such as local cracking or burrowing of rodents, need to be taken into account only if their cumulative effect would be significant in determining compliance with the standard. Computational models, theories, and prevalent expert judgment may be used to decide that a control system design will satisfy the standard. The numerical range provided in the standard for the longevity of the effectiveness of the control of residual radioactive materials allows for consideration of the various factors affecting the longevity of control and stabilization methods and their costs. These factors have different levels of predictability and may vary for the different sites.

(2) Protection of water should be considered in the analysis for reasonable assurance of compliance with the provisions of §192.02. Protection of water should be considered on a case-specific basis, drawing on hydrological and geochemical surveys and all other relevant data. The hydrologic and geologic assessment to be conducted at each site should include a monitoring program sufficient to establish background ground water quality through one or more upgradient wells, and identify the presence and movement of plumes associated with the tailings piles.

(3) If contaminants have been released from a tailings pile, an assessment of the location of the contaminants and the rate and direction of movement of contaminated ground water, as well as its relative contamination, should be made. In addition, the assessment should identify the attenuative capacity of the unsaturated and saturated zone to determine the extent of plume movement. Judgments on the possible need for remedial or protective actions for groundwater aquifers should be guided by relevant considerations described in EPA's hazardous waste management system (47 FR 32274, July 26, 1982) and by relevant State and Federal Water Quality Criteria for anticipated or existing uses of water over the term of the stabilization. The decision on whether to institute remedial action, what specific action to take, and to what levels an aquifer should be protected or restored should be made on a case-by-case basis taking into account such factors as technical feasibility of improving the aquifer in its hydrogeologic setting, the cost of applicable restorative or protective programs, the present and future value of the aquifer as a water resource, the availability of alternative water supplies, and the degree to which human exposure is likely to occur.

(b)(1) Compliance with Subpart B, to the extent practical, should be demonstrated through radiation surveys. Such surveys may, if appropriate, be restricted to locations likely to contain residual radioactive materials. These surveys should be designed to provide for compliance averaged over limited areas rather than point-by-point compliance with the standards. In most cases, measurement of gamma radiation exposure rates above and below the land surface can be used to show compliance with §192.12(a). Protocols for making such measurements should be based on realistic radium distributions near the surface rather than extremes rarely encountered.

(2) In §192.12(a), "background level" refers to the native radium concentration in soil. Since this may not be determinable in the presence of contamination by residual radioactive materials, a surrogate "background level" may be established by simple direct or indirect (e.g., gamma radiation) measurements performed nearby but outside of the contaminated location.

(3) Compliance with §192.12(b) may be demonstrated by methods that the Department of Energy has approved for use under Pub. L. 92–314 (10 CFR Part 712), or by other methods that the implementing agencies determine are adequate. Residual radioactive materials should be removed from buildings exceeding 0.03 WL so that future replacement buildings will not pose a hazard [unless removal is not practical—see §192.21(c)]. However, sealants, filtration, and ventilation devices may provide reasonable assurance of reductions from 0.03 WL to below 0.02 WL. In unusual cases, indoor radiation may exceed the levels specified in §192.12(b) due to sources other than residual radioactive materials. Remedial actions are not required in order to comply with the standard when there is reasonable assurance that residual radioactive materials are not the cause of such an excess.

§192.21 Criteria for applying supplemental standards.

The implementing agencies may (and in the case of subsection (f) shall) apply standards under §192.22 in lieu of the standards of Subpart A or B if they determine that any of the following circumstances exists:

(a) Remedial actions required to satisfy Subpart A or B would pose a clear and present risk of injury to workers or to members of the public, notwithstanding reasonable measures to avoid or reduce risk.

(b) Remedial actions to satisfy the cleanup standards for land, §192.12(a), or the acquisition of minimum materials required for control to satisfy §192.02(b), would, notwithstanding reasonable measures to limit damage, directly produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near the site, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

(c) The estimated cost of remedial action to satisfy §192.12(a) at a "vicinity" site (described under section 101(6)(B) of the Act) is unreasonably high relative to the long-term benefits, and the residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a vicinity site should be considered in evaluating this hazard. Remedial action will generally not be necessary where residual radioactive materials have been placed semi-permanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove, or where only minor quantities of residual radioactive materials are involved. Examples are residual radioactive materials under hard surface public roads and sidewalks, around public sewer lines, or in fence post foundations. Supplemental standards should not be applied at such sites, however, if individuals are likely to be exposed for long periods of time to radiation from such materials at levels above those that would prevail under §192.12(a).

(d) The cost of a remedial action for cleanup of a building under §192.12(b) is clearly unreasonably high relative to the benefits. Factors that should be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be affected by the remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of less costly remedial methods than removal of residual radioactive materials.

(e) There is no known remedial action.

(f) Radionuclides other than radium-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials.

§192.22 Supplemental standards.

Federal agencies implementing Subparts A and B may in lieu thereof proceed pursuant to this section with respect to generic or individual situations meeting the eligibility requirements of §192.21.

(a) When one or more of the criteria of §192.21(a) through (e) applies, the implementing agencies shall select and perform remedial actions that come as close to meeting the otherwise applicable standard as is reasonable under the circumstances.

(b) When §192.21(f) applies, remedial actions shall, in addition to satisfying the standards of Subparts A and B, reduce other residual radioactivity to levels that are as low as is reasonably achievable.

(c) The implementing agencies may make general determinations concerning remedial actions under this section that will apply to all locations with specified characteristics, or they may make a determination for a specific location. When remedial actions are proposed under this section for a specific location, the Department of Energy shall inform any private owners and occupants of the affected location and solicit their comments. The Department of Energy shall provide any such comments to the other implementing agencies. The Department of Energy shall also periodically inform the Environmental Protection Agency of both general and individual determinations under the provisions of this section.

§192.23 Effective date.

Subparts A, B, and C shall be effective March 7, 1983.

Subpart D—Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended

§192.30 Applicability.

This subpart applies to the management of uranium byproduct materials under section 84 of the Atomic Energy Act of 1954 (henceforth designated "the Act"), as amended, during and following processing of uranium ores, and to restoration of disposal sites following any use of such sites under section 83(b)(1)(B) of the Act.

§192.31 Definitions and cross-references.

References in this subpart to other parts of the Code of Federal Regulations are to those parts as codified on January 1, 1983.

(a) Unless otherwise indicated in this subpart, all terms shall have the same meaning as in Title II of the Uranium Mill Tailings Rediation Control Act of 1978, Subparts A and B of this part, or Parts 190, 260, 261, and 264 of this chapter. For the purposes of this subpart, the terms "waste," "hazardous waste," and related terms, as used in Parts 260, 261, and 264 of this chapter shall apply to byproduct material.

(b) *Uranium byproduct material* means the tailings or wastes produced by the extraction or concentration of uranium from any ore processed primarily for its source material content. Ore bodies depleted by uranium solution extraction operations and which remain underground do not constitute "byproduct material" for the purpose of this subpart.

(c) *Control* means any action to stabilize, inhibit future misuse of, or reduce emissions or effluents from uranium byproduct materials.

(d) *Licensed site* means the area contained within the boundary of a location under the control of persons generating or storing uranium byproduct materials under a license issued pursuant to section 84 of the Act. For purposes of this subpart, "licensed site" is equivalent to "regulated unit" in Subpart F of Part 264 of this chapter.

(e) *Disposal site* means a site selected pursuant to section 83 of the Act.

(f) *Disposal area* means the region within the perimeter of an impoundment or pile containing uranium by product materials to which the post-closure requirements of §192.32(b)(1) of this subpart apply.

(g) *Regulatory agency* means the U.S. Nuclear Regulatory Commission.

(h) *Closure period* means the period of time beginning with the cessation, with respect to a waste impoundment, of uranium ore processing operations and ending with completion of requirements specified under a closure plan.

(i) *Closure plan* means the plan required under §264.112 of this chapter.

(j) *Existing portion* means that land surface area of an existing surface impoundment on which significant quantities of uranium byproduct materials have been placed prior to promulgation of this standard.

(k) *As expeditiously as practicable considering technological feasibility* means as quickly as possible considering: the physical characteristics of the tailings and the site; the limits of available technology; the need for consistency with mandatory requirements of other regulatory programs; and factors beyond the control of the licensee. The phrase permits consideration of the cost of compliance only to the extent specifically provided for by use of the term "available technology."

(l) *Permanent Radon Barrier* means the final radon barrier constructed to achieve compliance with, including attainment of, the limit on releases of radon-222 in §192.32(b)(1)(ii).

(m) *Available technology* means technologies and methods for emplacing a permanent radon barrier on uranium mill tailings piles or impoundments. This term shall not be construed to include extraordinary measures or techniques that would impose costs that are grossly excessive as measured by practice within the industry or one that is reasonably analogous, (such as, by way of illustration only, unreasonable overtime, staffing or transportation requirements, etc.), provided there is reasonable progess toward emplacement of a permanent radon barrier. To determine grossly excessive costs, the relevant baseline against which cost increases shall be compared is the cost estimate for tailings impoundment closure contained in the licensee's tailings closure plan, but costs beyond such estimates shall not automatically be considered grossly excessive.

(n) *Tailings Closure Plan (Radon)* means the Nuclear Regulatory Commission or Agreement State approved plan detailing activities to accomplish timely emplacement of a permanent radon barrier. A tailings closure plan shall include a schedule for key radon closure milestone activities such as wind blown tailings retrieval and placement on the pile, interim stabilization (including dewatering or the removal of freestanding liquids and recontouring), and emplacement of a permanent radon barrier constructed to achieve compliance with the 20 pCi/m²-s flux standard as expeditiously as practicable considering technological feasibility (including factors beyond the control of the licensee).

(o) *Factors beyond the control of the licensee* means factors proximately causing delay in meeting the schedule in the applicable license for timely emplacement of the permanent radon barrier notwithstanding the good faith efforts of the licensee to achieve compliance. These factors may include, but are not limited to, physical conditions at the site; inclement weather or climatic conditions; an act of God; an act of war; a judicial or administrative order or decision, or change to the statutory, regulatory, or other legal requirements applicable to the licensee's facility that would preclude or delay the performance of activities required for compliance; labor disturbances; any modifications, cessation or delay ordered by state, Federal or local agencies; delays beyond the time reasonably required in obtaining necessary governmental permits, licenses, approvals or consent for activities described in the tailings closure plan (radon) proposed by the licensee that result from agency failure to take final action after the licensee has made a good faith, timely effort to submit legally sufficient applications, responses to requests (including relevant data requested by the agencies), or other information, including approval of the tailings closure plan by NRC or the affected Agreement State; and an act or omission of any third party over whom the licensee has no control.

(p) *Operational* means that a uranium mill tailings pile or impoundment is being used for the continued placement of uranium byproduct material of is in standby status for such placement. A tailings pile or impoundment is operational from the day that uranium byproduct material is first placed in the pile or impoundment until the day final closure begins.

(q) *Milestone* means an enforceable date by which action, or the occurrence of an event, is required for purposes of achieving compliance with the 20 pCi/m²-s flux standard.

[58 FR 60355, Nov. 15, 1993 / Effective Jan. 14, 1994]

§192.32 Standards.

(a) *Standards for application during processing operations and prior to the end of the closure period.* (1) Surface impoundments (except for an existing portion) subject to this subpart must be designed, constructed, and installed in such manner as to conform to the requirements of §264.221 of this chapter, except that at sites where the annual precipitation falling on the impoundment and any drainage area contributing surface runoff to the impoundment is less than the annual evaporation from the impoundment, the requirements of §264.228(a)(2) (iii)(E) referenced in §264.221 do not apply.

(2) Uranium byproduct materials shall be managed so as to conform to the ground water protection standard in §264.92 of this chapter, except that for the purposes of this subpart:

(i) To the list of hazardous constituents referenced in §264.93 of this chapter are added the chemical elements molybdenum and uranium,

(ii) To the concentration limits provided in Table 1 of §264.94 of this chapter are added the radioactivity limits in Table A of this subpart,

(iii) Detection monitoring programs required under §264.98 to establish the standards required under §264.92 shall be completed within one (1) year of promulgation,

(iv) The regulatory agency may establish alternate concentration limits (to be satisfied at the point of compliance specified under §264.95) under the criteria of §264.94(b), provided that, after considering practicable corrective actions, these limits are as low as reasonably achievable, and that, in any case, the standards of §264.94(a) are satisfied at all points at a greater distance than 500 meters from the edge of the disposal area and/or outside the site boundary, and

(v) The functions and responsibilities designated in Part 264 of this chapter as those of the "Regional Administrator" with respect to "facility permits" shall be carried out by the regulatory agency, except that exemptions of hazardous constituents under §264.93 (b) and (c) of this chapter and alternate concentration limits established under §264.94 (b) and (c) of this chapter (except as otherwise provided in §192.32(a)(2)(iv)) shall not be effective until EPA has concurred therein.

(3)(i) Uranium mill tailings piles or impoundments that are nonoperational and subject to a license by the Nuclear Regulatory Commission or an Agreement State shall limit releases of radon-222 by emplacing a permanent radon barrier. This permanent radon barrier shall be constructed as expeditiously as practicable considering technological feasibility (including factors beyond the control of the licensee) after the pile or impoundment ceases to be operational. Such control shall be carried out in accordance with a written tailings closure plan (radon) to be incorporated by the Nuclear Regulatory Commission or Agreement State into individual site licenses.

(ii) The Nuclear Regulatory Commission or Agreement State may approve a licensee's request to extend the time for performance of milestones if, after providing an opportunity for public participation, the Nuclear Regulatory Commission or Agreement State finds that compliance with the 20 pCi/m^2-s flux standard has been demonstrated using a method approved by the NRC, in the manner required in 192.32(a)(4)(i). Only under these circumstances and during the period of the extension must compliance with the 20 pCi/m^2-s flux standard be demonstrated each year.

(iii) The Nuclear Regulatory Commission or Agreement State may extend the final compliance date for emplacement of the permanent radon barrier, or relevant milestone, based upon cost if the new date is established after a finding by the Nuclear Regulatory Commission or Agreement State, after providing an opportunity for public participation, that the licensee is making good faith efforts to emplace a permanent radon barrier; the delay is consistent with the definition of "available technology" in §192.31(m); and the delay will not result in radon releases that are determined to result in significant incremental risk to the public health.

(iv) The Nuclear Regulatory Commission or Agreement State may, in response to a request from a licensee, authorize by license or license amendment a portion of the site to remain accessible during the closure process to accept uranium byproduct material as defined in section 11(e)(2) of the Atomic Energy Act, 42 U.S.C. 2014(e)(2), or to accept materials similar to the physical, chemical and radiological characteristics of the in situ uranium mill tailings and associated wastes, from other sources. No such authorization may be used as a means for delaying or otherwise impeding emplacement of the permanent radon barrier over the remainder of the pile or impoundment in a manner that will achieve compliance with the 20 pCi/m^2-s flux standard, averaged over the entire pile or impoundment.

(v) The Nuclear Regulatory Commission or Agreement State may, in response to a request from a licensee, authorize by license or license amendment a portion of a pile or impoundment to remain accessible after emplacement of a permanent radon barrier to accept uranium byproduct material as defined in section 11(e)(2) of the Atomic Energy Act, 42 U.S.C. 2014(e)(2), if compliance with the 20 pCi/m^2-s flux standard of §192.32(b)(1)(ii) is demonstrated by the licensee's monitoring conducted in a manner consistent with §192.32(a)(4)(i). Such authorization may be provided only if the Nuclear Regulatory Commission or Agreement State makes a finding, constituting final agency action and after providing an opportunity for public participation, that the site will continue to achieve the 20 pCi/m^2-s flux standard when averaged over the entire impoundment.

(4)(i) Upon emplacement of the permanent radon barrier pursuant to 40 CFR 192.32(a)(3), the licensee shall conduct appropriate monitoring and analysis of the radon-222 releases to demonstrate that the design of the permanent radon barrier is effective in limiting releases of radon-222 to a level not exceeding 20 pCi/m^2-s as required by 40 CFR 192.32(b)(1)(ii). This monitoring shall be conducted using the procedures described in 40 CFR part 61, Appendix B, Method 115, or any other measurement method proposed by a licensee that the Nuclear Regulatory Commission or Agreement State approves as being at least as effective as EPA Method 115 in demonstrating the effectiveness of the permanent radon barrier in achieving compliance with the 20 pCi/m^2-s flux standard.

(ii) When phased emplacement of the permanent radon barrier is included in the applicable tailings closure plan (radon), then radon flux monitoring required under §192.32(a)(4)(i) shall be conducted, however the licensee shall be allowed to conduct such monitoring for each portion of the pile or impoundment on which the radon barrier has been emplaced by conducting flux monitoring on the closed portion.

(5) Uranium byproduct materials shall be managed so as to conform to the provisions of:

(i) Part 190 of this chapter, "Environmental Radiation Protection Standards for Nuclear Power Operations" and

(ii) Part 440 of this chapter, "Ore Mining and Dressing Point Source Category: Effluent Limitations Guidelines and New Source Performance Standards, Subpart C, Uranium, Radium, and Vanadium Ores Subcategory."

(6) The regulatory agency, in conformity with Federal Radiation Protection Guidance (FR, May 18, 1960, pgs. 4402–4403), shall make every effort to maintain radiation doses from radon emissions from surface impoundments of uranium byproduct materials as far below the Federal Radiation Protection Guides as is practicable at each licensed site.

(b) *Standards for application after the closure period.* At the end of the closure period:

(1) Disposal areas shall each comply with the closure performance standard in §264.111 of this chapter with respect to nonradiological hazards and shall be designed[1] to provide reasonable assurance of control of radiological hazards to

(i) Be effective for one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,

(ii) Limit releases of radon-222 from uranium byproduct materials to the atmosphere so as to not exceed an average[2] release rate of 20 picocuries per square meter per second (pCi/m^{2}s).

(2) The requirements of §192.32(b)(1) shall not apply to any portion of a licensed and/or disposal site which contains a concentration of radium-226 in land, averaged over areas of 100 square meters, which, as a result of uranium byproduct material, does not exceed the background level by more than:

(i) 5 picocuries per gram (pCi/g), averaged over the first 15 centimeters (cm) below the surface, and

(ii) 15 pCi/g, averaged over 15 cm thick layers more than 15 cm below the surface.

[58 FR 60356, Nov. 15, 1993 / Effective Jan. 14, 1994]

§192.33 Corrective action programs.

If the ground water standards established under provisions of §192.32(a)(2) are exceeded at any licensed site, a corrective action program as specified in §264.100 of this chapter shall be put into operation as soon as is practicable, and in no event later than eighteen (18) months after a finding of exceedance.

§192.34 Effective date.

Subpart D shall be effective December 6, 1983.

TABLE A TO SUBPART D

	pCi/liter
Combined radium-226 and radium-228	5
Gross alpha-particle activity (excluding radon and uranium)	15

Subpart E—Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended

§192.40 Applicability.

This subpart applies to the management of thorium byproduct materials under section 84 of the Atomic Energy Act of 1954, as amended, during and following processing of thorium ores, and to restoration of disposal sites following any use of such sites under section 83(b)(1)(B) of the Act.

[1]The standard applies to design with a monitoring requirement as specified in §192.32(a)(4).

[2]This average shall apply to the entire surface of each disposal area over periods of at least one year, but short compared to 100 years. Radon will come from both uranium byproduct materials and from covering materials. Radon emissions from covering materials should be estimated as part of developing a closure plan for each site. The standard, however, applies only to emissions from uranium byproduct materials to the atmosphere.

§192.41 Provisions.

Except as otherwise noted in §192.41(e), the provisions of subpart D of this part, including §§192.31, 192.32, and 192.33, shall apply to thorium byproduct material and:

(a) Provisions applicable to the element uranium shall also apply to the element thorium;

(b) Provisions applicable to radon-222 shall also apply to radon-220; and

(c) Provisions applicable to radium-226 shall also apply to radium-228.

(d) Operations covered under §192.32(a) shall be conducted in such a manner as to provide reasonable assurance that the annual dose equivalent does not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as a result of exposures to the planned discharge of radioactive materials, radon-220 and its daughters excepted, to the general environment.

(e) The provisions of §192.32(a) (3) and (4) do not apply to the management of thorium byproduct material.

[58 FR 60356, Nov. 15, 1993 / Effective Jan. 14, 1994]

PROPOSED STANDARDS FOR REMEDIAL ACTIONS AT INACTIVE URANIUM PROCESSING SITES

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 192

[FR 3227-5]

Standards for Remedial Actions at Inactive Uranium Processing Sites

AGENCY: U.S. Environmental Protection Agency.

ACTION: Proposed rule.

SUMMARY: The Environmental Protection Agency is proposing health and environmental regulations to correct and prevent contamination of ground water beneath and in the vicinity of inactive uranium processing sites by uranium tailings. EPA issued regulations (40 CFR Part 192 Subparts A, B, and C) for cleanup and disposal of tailings from these sites on January 5, 1983. These new regulations would replace existing provisions at 40 CFR 192.20(a) (2) and (3) that were remanded by the Tenth Circuit Court of Appeals on September 3, 1985. They are proposed pursuant to section 275 of the Atomic Energy Act (42 U.S.C. 2022), as amended by Section 206 of the Uranium Mill Tailings Radiation Control Act of 1978 (Pub. L. 95–604) (UMTRCA).

The regulations would apply to tailings at the 24 locations that qualify for remedial action under Title I of Pub. L. 95–604. They provide that tailings must be stabilized and controlled in a manner that permanently eliminates or minimizes contamination of ground water beneath stabilized tailings, so as to protect human health and the environment. They also provide for cleanup of contamination that existed before the tailings are stabilized.

DATES: *Comments.* Comments on this Notice of Proposed Rulemaking will be accepted until October 26, 1987.

Hearing. A Public Hearing will be held on October 29, 1987 at 9:00 a.m. (see below).

ADDRESSES: *Comments.* Comments should be submitted (in duplicate if possible) to: Central Docket Section (LE–130), U.S. Environmental Protection Agency, Attention: Docket Number R-87–01, Washington, DC 20460. The Docket is available for public inspection between 8:00 a.m. and 3:00 p.m., Monday through Friday, at EPA's Central Docket Section (LE–130), West Tower Lobby, 401 M Street SW., Washington, DC. A reasonable fee may be charged for copying.

Hearing. A Public Hearing will be held at the Strater Hotel, 699 Main Ave., Durango, Colorado 81301. Requests to participate should be made in writing to Floyd L. Galpin, Acting Director, Criteria and Standards Division (ANR-460), U.S. Environmental Protection Agency, Washington, DC 20460. All requests should include an outline of the topics to be addressed and names of the participants. Oral presentations should be limited to a maximum of 30 minutes. Presentations may also be made without prior notice, but may be subjected to time contraints at the discretion of the hearing officer. Written comments made during or in conjunction with the oral presentations will be accepted after the hearing for a period of time to be announced at the hearing.

FOR FURTHER INFORMATION CONTACT: Kurt L. Feldmann, Guides and Criteria Branch (ANR–460), Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, DC 20460; telephone number (202) 475-9620.

SUPPLEMENTARY INFORMATION:

I. Supporting Document

A report ("Draft Background Information Document—Proposed Standard for the Control of Contamination in Ground Water in the Vicinity of Inactive Uranium Mill Sites," EPA 520/1–87–014) has been prepared to support these proposed regulations. Single copies may be obtained from the Program Management Office (ANR-458), Office of Radiation Programs, Environmental Protection Agency, Washington, DC 20460; (202) 475-8386.

The report contains a brief history of the Title I sites, a summary of the types and quantities of ground-water contamination present at sites for which such data are available, where and over what period of time the contamination is projected to disperse in the absence of control, and a description of alternate ground-water contamination control and cleanup technologies and their associated costs. An analysis of information supporting the decisions reflected in this proposed standard completes the report.

II. Scope of this Proposed Rulemaking

On November 8, 1978, Congress enacted the Uranium Mill Tailings Radiation Control Act of 1978, Pub. L. 95–604 (henceforth called "UMTRCA"). In UMTRCA, Congress enunciated its finding that uranium mill tailings ". . . may pose a potential and significant radiation health hazard to the public, and . . . that every reasonable effort should be made to provide for stabilization, disposal, and control in a safe and environmentally sound manner of such tailings in order to prevent minimize radon diffusion into the environment and to prevent or minimize other environmental hazards from such tailings." The Act directs the Administrator of the Environmental Protection Agency (EPA) to set ". . . standards of general application for the protection of the public health, safety, and the environment . . ." to govern this process of stabilization, disposal, and control.

UMTRCA directs the Department of Energy (DOE) to conduct such remedial actions at the inactive uranium processing sites as will insure compliance with the standards established by EPA. This remedial action is to be selected and performed with the concurrence of the Nuclear Regulatory Commission (NRC).

Standards are required for two types of remedial action: disposal and cleanup. Here disposal is used to mean the operation which places tailings in a permanent condition that will minimize risk to people and harm to the environment. Cleanup is the operation which eliminates or reduces to acceptable levels the potential health and environmental consequences of tailings or their constituents that have been dispersed from tailings piles by natural forces or people prior to disposal.

On January 5, 1983, EPA promulgated final standards for the disposal and cleanup of the inactive mill tailings sites under UMTRCA (48 FR 590). These standards were challenged in the Tenth Circuit Court of Appeals by several parties (Case Nos. 83-1014, 83-1041, 83-1206, and 83-1300). On September 3, 1985, the court dismissed all challenges except one: it set aside the ground-water provisions of the regulations at 40 CFR 192.20(a)(2)–(3) and remanded them to EPA ". . . to treat these toxic chemicals that pose a ground-water risk as it did in the active mill site regulations." With this notice, EPA is proposing new regulations to replace those set aside.

III. Summary of Background Information

Beginning in the 1940's, the U.S. Government purchased large quantities of uranium for defense purposes. As a result, large piles of tailings were created by the uranium milling industry. Tailings piles pose a hazard to public health and the environment because they contain radioactive and toxic constituents which emanate radon to the atmosphere and may leach into ground water. Tailings are a sand-like material, and have also been removed from tailings piles in the past for use in construction and for soil conditioning. These uses are inappropriate, because the radioactive and toxic constituents of tailings may elevate indoor radon levels, expose people to gamma radiation, and leach into ground and surface waters.

Most of these mills are now inactive and many are abandoned. Congress designated 22 specific inactive sites in Title I of UMTRCA, and the DOE subsequently added 2 more. Most other uranium tailings sites are regulated by the NRC or States under Title II of UMTRCA (DOE owns one inactive site at Monticello, Utah, that is not included under UMTRCA). The Title I sites are all located in the West, predominantly in arid areas, except for a single site at Canonsburg, Pennsylvania. Tailings piles at the inactive sites range in area from 5 to 150 acres and in height from only a few feet to as much as 230 feet. The amount at each site ranges from residual contamination to 2.7 million tons of tailings. The 24 designated Title I sites combined contain about 26 million tons of tailings covering a total of about 1000 acres.

The disposal of tailings at these sites is currently being carried out by DOE under the provisions of Title I of UMTRCA. In addition, tailings that were dispersed from the piles by natural forces, or that have been removed for use in or around buildings, or on land, are being retrieved and replaced on the tailings piles prior to their disposal.

UMTRCA requires that DOE complete all these remedial actions within 7 years of the effective date of EPA's standards; that is by March 5, 1990. Remedial actions have been completed at the Canonsburg, Pennsylvania, pile, the only site in an area of high precipitation, and at Shiprock, New Mexico. Remedial actions are currently well advanced at two other sites: Salt Lake City, Utah and Lakeview, Oregon. Work is expected to begin at approximately six others during 1987–1988. In view of the rate of progress with remedial work, the DOE is requesting a legislative extension of the completion date until September 1993.

The most important hazardous constituent of uranium mill tailings is radium, which is radioactive. Other potentially hazardous substances in tailings piles include arsenic, molybdenum, selenium, uranium, and usually in lesser amounts, a variety of other toxic substances. The concentrations of these materials vary from pile to pile, ranging from 2 to more than 100 times applicable standards. Although a variety of organics are known to have been used at these sites, none has thus far been detected in tailings.

Exposure to radioactive and toxic substances may cause cancer and other diseases, as well as genetic damage and teratogenic effects. Tailings pose a risk to health because: (1) Radium in tailings decays into radon, a gaseous radioactive element which is easily transported in air, and whose radioactive decay products may lodge in the lungs; (2) individuals may be directly exposed to gamma radiation from the radioactivity in tailings; and (3) radioactive and toxic substances from tailings may leach into water and then be ingested with food or water. It is the last of these hazards that is primarily addressed here. (Although radon from radium in ground water is unlikely to pose a hazard in these locations, these proposed standards would also address that potential hazard.) The other hazards are covered by existing provisions of 40 CFR Part 192.

We have based our analysis on detailed reports for 12 of the 24 inactive uranium mill tailings sites that have been developed to date for the Department of Energy by its contractors. Preliminary data for the balance of the sites have also been examined. These data show that the volumes of contaminated water in the existing aquifers at the 24 sites range from 23 million gallons to 4 billion gallons. In a few instances, mill effluent was apparently the sole source of this ground water. Each of the 12 sites examined in detail have ground-water contamination beneath and/or beyond the site. In some cases, the ground water upgradient of the pile already exceeded EPA drinking water standards for one or more contaminants, thus making it unsuitable for use as drinking water and, in some extreme cases, for any other purpose before it was contaminated by effluent from the mill. Some contaminants from the tailings piles are moving offsite quickly and others are moving slowly. The time for natural flushing of the contaminated portions of these aquifers is estimated to vary from several years to many hundreds of years.

Contaminants that have been identified in the ground water downgradient from a majority of the sites include uranium, sulfate, iron, manganese, nitrate, chloride, molybdenum, selenium, and total dissolved solids. Radium, cobalt, arsenic, fluoride, chromium, cadmium, ammonium, boron, vanadium, lead, thorium, zinc, silver, copper, and magnesium, have also been found in the ground water at one or more sites.

UMTRCA requires that the standards established under Title I provide protection that is consistent, to the maximum extent practicable, with the requirements of the Resource Conservation and Recovery Act (RCRA). In this regard, regulations established by EPA for hazardous waste disposal sites under RCRA provide for the specification of ground-water protection limits for the specific hazardous constituents relevant to each regulated unit in permits. These regulations contain general numerical limits for some constituents in ground water; limits for other constituents are set at their background level in ground water at the regulated unit. Together with a provision for the point of compliance, these limits become the facility's ground-water protection standard, unless alternate concentration limits (ACLs) are approved. ACLs may be requested based upon data which would support a determination that, if the ACL is satisfied, the constituent would not present a current or potential threat to human health or the environment.

IV. The Proposed Standards

The proposed standards consist of two parts; a first part governing the control of any future ground-water contamination that may occur from tailings piles after disposal, and a second part that applies to the cleanup of contamination that occurred before disposal of the tailings piles.

A. The Ground-Water Standard for Disposal

The proposed standard (Subpart A) for control of potential contaminant releases to ground water after disposal is divided into two parts that separately address actions to be carried out during period of time designated as the remedial and post-disposal periods. The remedial and post-disposal periods are defined in a manner analogous to the closure and post-closure periods, respectively, in RCRA regulations. However, there are some differences regarding their duration and the timing of any corrective actions that may become necessary due to failure of disposal to perform as designed. (Because there are no mineral processing activities currently at these inactive sites, standards are not needed for an operational period.) The remedial period, for the purpose of this regulation, is defined as that period of time beginning on the effective date of the original Part 192 (Title I) standard (March 7, 1983) and ending with completion of remedial actions by DOE. The post-disposal period begins with completion of remedial actions and ends after an appropriate period for the monitoring of ground water to confirm the adequacy of the disposal, as determined by NRC for each site. The proposed ground-water standard for the disposal to be carried out during the remedial period adopts relevant paragraphs from Subpart F of Part 264 of this Chapter (§§ 264.92–264.95). The proposed standard for the post-disposal period adopts § 264.111 (a) and (b) of this Chapter, and also incorporates provisions for monitoring and a corrective action program. These provisions are essentially the same as those governing the licensed (Title II) uranium mill tailings sites (40 CFR 192, Subparts D and E; see also the Federal Register notices for these standards published on April 29, 1983 and on October 7, 1983). However, additional constituents are here proposed to be regulated (in addition to the general RCRA list of hazardous constituents and table of applicable limits) that are applicable to these sites only.

These proposed regulations would require installation of monitoring systems upgradient of the point of compliance (i.e., in the uppermost aquifer upgradient of the edge of the tailings disposal site) to determine background levels of any listed constituents that occur naturally at the site. The disposal would then be designed to control, to the extent reasonably achievable for 1000 years and, in any case, for at least 200 years, all listed constituents identified in the tailings at the site to levels for each constituent derived in accordance with § 264.94. Accordingly, the elements of the ground-water protection standard to be specified for each disposal site would include a list of relevant constituents, the concentration limits for each such constituent, and the compliance point.

To obtain an ACL for any constituent, the DOE would have to provide data to support a finding that the presence of the constituent at the proposed ACL in ground water at the site would not pose a substantial present or potential hazard to human health or the environment. ACLs could be granted provided that, after considering practicable corrective actions, a determination can be made that it satisfies the lower of the values given by the standard for setting ACLs in § 264.94(b), and the corrective action that is as low as reasonably achievable (ALARA).

The standards of Title II sites require use of a liner under new tailings piles or lateral extensions of existing piles. These standards for remedial action at the inactive Title I sites do not contain a similar provision. We assume that the inactive piles will not need to be enlarged. Several, however, will be relocated. However, unlike tailings at the Title II sites, which generally may contain large amounts of process water, the inactive tailings contain little or no free water. Such tailings, if properly located and stablized with an adequate cover, are not likely to require a liner in order to protect ground water.

However, a liner may be required to satisfy the proposed ground-water standards in situations where tailings now, or may in the future, contain water above the level of specific retention. For example, tailings to which water is added to facilitate their removal to a new site (i.e., through slurrying) or piles in areas of high precipitation or within the zone of water table fluctuation could discharge contaminants to ground water. Under § 192.20(a)(2) of these proposed standards, it would be necessary for the DOE, with the concurrence of the NRC, to propose and carry out a disposal design in such circumstances which uses a liner or equivalent to assure that ground water would not be contaminated and, at the same time, satisfy the existing requirements of these standards for control of radon emissions. In such circumstances, this may be accomplished by installing a liner beneath the tailings whose permeability is greater than that of the cover material. If the tailings form an acid solution when mixed with water, a neutalizing material mixed with the tailings or added to the liner are additional methods that may need to be considered to fix listed constituents in the immediate vicinity of a pile. In addition, a capillary break may be necessary to prevent migration of water into a pile from below. Currently, however, DOE plans do not include slurrying any tailings to move them to new locations. Further, for all but one site that has already been closed (Canonsburg), the tailings are located in arid areas where annual precipitation is low.

Disposal designs which prevent migration of listed constituents in the ground water for a short period of time would not provide appropriate protection. Such approaches simply defer adverse ground-water effects. Therefore, measures which only modify the gradient in an aquifer or create barriers (e.g., slurry walls) would not of themselves provide an adequate disposal. Where feasible, it may be appropriate to protect ground water by preventing generation of leachate containing listed constituents. A method that appears promising is fixing the constituents *in situ* (in place) so they cannot be leached out. *In situ* treatment of constituents may be considered analogous to removal when it provides long-term protection of human health or the environment. While the Agency recognizes that *in situ* treatment is an emerging technology, applied in only limited circumstances to date, it should be considered where it can provide an effective ground-water protection strategy.

At the end of the remedial period (i.e., when disposal and any cleanup required under Subpart B has been completed), ground waters would be required to be in compliance with the standards established pursuant to these regulations. During the post-disposal period, the regulations would further require that methods used for disposal provide a reasonable expectation that the provisions of § 264.111 (a) and (b) will be met. Paragraph 264.111(a) requires that a site be closed in a manner that minimizes further maintenance. Paragraph 264.111(b) requires control, minimization, or elimination of post-disposal escape of listed constituents to ground or surface water to the extent necessary to prevent threats to human health and the environment. In the context of these regulations, this would mean control pursuant to the standards established under §§ 264.92–264.95. Depending on the properties of the sites, candidate disposal systems, and the effects of natural processes over time, measures required to satisfy the proposed standards would vary from site to site. Actual site data, computational models, and prevalent expert judgment would be used in deciding that proposed measures will satisfy the standards. Under the provisions of section 108(a) of UMTRCA, the adequacy of these judgments would be determined by the NRC.

During the post-disposal period, monitoring of the disposal would be required for a period sufficient to verify the adequacy of the disposal to achieve its design objectives for containment of listed constituents. This period is intended to be comparable to the time period required under § 264.117 for waste sites regulated under RCRA (i.e., a few decades). It is not intended that monitoring be carried out for the 200- to 1000-year period over which the disposal is designed to be effective.

If listed constituents from a disposal site appeared during the post-disposal period in excess of the ground-water standards for disposal, the proposed regulations would require a corrective action program designed to bring the disposal and the ground water back into compliance. Such a corrective action would have to last as long as is necessary to achieve conformance with the ground-water protection standard, and include a modification of the monitoring program sufficient to demonstrate that the corrective measures will be permanently successful.

Additional Regulated Constituents

For the purpose of this regulation only, the Agency proposes to regulate, in addition to the hazardous constituents referenced by § 264.93: molybdenum, nitrate, combined radium-226 and radium-228, and combined uranium-234 and uranium-238. Molybdenum, radium, and uranium were addressed by the Title II standards because these radioactive and/or toxic constituents are found in high concentrations at many mill tailings sites. Nitrate is proposed for addition because it has been identified in concentrations far in excess of drinking water standards in ground water at a number of the inactive sites.

The proposed concentration limit for molybdenum in ground water from uranium tailings is 0.10 milligram per liter. This is the value of the provisional adjusted acceptable daily intake (AADI) for drinking water developed by EPA under the Safe Drinking Water Act (50 FR 46958). The Agency has proposed neither a maximum concentration limit goal (MCLG) nor a maximum concentration limit (MCL) for molybdenum because it occurs only infrequently in water. According to the most recent report of the National Academy of Sciences (*Drinking Water and Health*, 1980, Vol. III), molybdenum from drinking water, except for highly contaminated sources (e.g., molybdenum mining wastewater) is not likely to constitute a significant portion of the total human intake of this element. However, since uranium tailings can be a highly concentrated source of molybdenum, it is appropriate to include a standard for molybdenum in this proposed rule. In addition to the hazard to humans, our analysis of toxic substances in tailings in the Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites (EPA 520/4-82-013-1) found that, for ruminants, molybdenum in concentrations greater than 0.5 ppm in drinking water would lead to chronic toxicity.

The proposed limit for combined uranium-234 and uranium-238 due to contamination from uranium tailings is 30 pCi per liter. At this concentration, the estimated lifetime radiation risk of fatal cancer would be the same as that for the existing ground water standard for combined radium-226 and radium-228 (5 pCi per liter) (51 FR 34836), based on dose assessments for ingestion as determined by the International Commission on Radiological Protection. This proposed limit would apply to remedial actions for uranium tailings under these regulations only; the Agency has not made a proposal for a general standard for isotopes of uranium in water. However, this limit is within the range of values currently under consideration for drinking water.

The proposed concentration limit for nitrate (as nitrogen) is 10 mg per liter. This is the value of the interim drinking water standard for nitrate.

B. The Cleanup Standard

With the exception of the point of compliance provision, the proposed standard (Subpart B) for cleanup of contaminated ground water contains identical basic provisions (§§ 264.92-.94) as the standard for disposal in Subpart A. In addition, it provides for the establishment of supplemental standards under certain conditions and for use of institutional control to permit passive restoration through natural flushing when no community drinking water source is involved.

The standards do not specify a single point of compliance for the cleanup of ground water that has been contaminated by residual radioactive materials from uranium milling before final disposal. Instead, the "point of compliance" is any point where contamination is found in the ground water. The standard requires DOE to establish a monitoring program to determine the extent of contamination (§ 192.12(c)(1)) in ground water around a processing site (§ 192.11(b)). The possible presence of any of the inorganic or organic hazardous constituents identified in tailings or used in the processing operation should be assessed. The remedial action plan referenced under § 192.20(b)(4) would document the extent of contamination, the rate and direction of movement of contaminants, and consider future movement of the plume.

The proposed cleanup standards would normally require restoration of all contaminated ground water to the levels provided for under § 264.94. These levels are either background concentrations, the levels specified in Tables 1 and A, or ACLs. In cases where the ground water is not classified as Class III, any ACL should be determined under the assumption that the ground water may be used for drinking purposes.

In certain circumstances, however, supplemental standards set at levels that assure, at a minimum, protection of human health and the environment, and come as close to meeting the otherwise applicable standards as is reasonably achievable by remedial actions could be granted if:

- The ground water at the site is Class III (See definitions, § 192.11(e)) in the absence of contamination from tailings; or
- Complete restoration would cause more environmental harm than it would prevent; or
- Complete restoration is technically impracticable from an engineering perspective.

The use of supplemental standards for Class III ground water would apply the ground water classification system established in EPA's 1984 Ground Water Protection Strategy. Procedures for classifying ground water are presented in "Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy" released in final draft in December 1986 and due to be finalized during late 1987. Under these draft guidelines, Class I ground waters encompass highly vulnerable resources of particularly high value, e.g. an irreplaceable source of drinking water or ecologically vital ground water. Class II ground water include all non-Class I ground water that is currently used or is potentially adequate for drinking water. Class III encompasses ground waters that are not a current or potential source of drinking water due to widespread, ambient contamination caused by natural or human-induced conditions, or cannot provide enough water to meet the needs of an average household. Human-induced conditions would not include the contribution from the uranium mill tailings. At sites with Class III ground water, the proposed supplemental standards would require only such management of contamination due to tailings as would be required to prevent additional adverse impacts on human health and the environment from that contamination. For example, if the additional contamination from the tailings would cause an adverse effect on Class II ground water that has a significant interconnection with the Class III ground water over which the tailings reside, then the additional contamination from the tailings would have to be abated.

Supplemental standards may also be appropriate in certain other cases similar to those addressed in section 121(d)(4) of the Superfund Amendments and Reauthorization Act of 1986 (SARA). SARA recognizes that cleanup of contamination could sometimes cause environmental harm disproportionate to the health effects it would alleviate. For example, if fragile ecosystems would be impaired by any reasonable restoration process (or by carrying a restoration process to extreme lengths to remove small amounts of residual contamination), then it might be prudent to protect them in lieu of completely restoring ground-water quality. Decisions regarding tradeoffs of environmental damage can only be based on characteristics peculiar to the location. We do not know whether there are such situations in the UMTRCA program, but we believe that DOE should be permitted to propose supplemental standards in such situations, after thorough investigation and consideration of all reasonable restoration alternatives, for concurrence by the NRC.

Based on currently available information, we are not aware that at least substantial restoration of ground-water quality is technically impracticable from an engineering perspective at any of the designated sites. However, our information may be incomplete. We believe DOE should not be required to institute active measures that would completely restore ground water at these sites if such restoration is technically impracticable from an engineering perspective, and if, at a minimum, protection of human health and the environment is assured. Consistent with the provisions of SARA for remediation of waste sites generally, the proposed standards would therefore permit DOE to propose supplemental standards in such situations at levels achievable by site-specific alternate remedial actions that are technically practicable. The concurrence role of the NRC would also apply to such proposals. A finding of technical impracticability from an engineering perspective would require careful and extensive documentation, including an analysis of the degree to which remediation is practicable. It should be noted that the word "practicable" is not identical in meaning to the word "practical." As used here, the former means "able to be put into practice" and the latter means "cost-effective." In addition to documentation of technical matters related to cleanup technology, DOE would also have to include a detailed assessment of such site-specific matters as transmissivity of the geologic formation, contaminant properties (e.g., withdrawal and treatability potential), and the exent of contamination.

Finally, for aquifers where passive restoration can be projected to occur naturally within a period less than 100 years, and where the ground water is not now and is not now projected to be used for a community water supply within this period, we propose to allow extension of the remedial period to that time, provided satisfactory institutional control of public use of ground water and an adequate monitoring program is established and maintained throughout this extended remedial period.

The proposal to allow extension of the remedial period to permit reliance on passive restoration through natural flushing is based on the judgment that no active cleanup is warranted to restore ground-water quality where ground-water concentration limits will be met within a period no greater than 100 years through natural processes and no substantial use of the water exists or is projected, if institutional control is established that will effectively protect public health in the interim. This mechanism may also be a useful supplement for situations where active cleansing to completely achieve the standards is impracticable, environmentally damaging, or excessively costly, if the partially cleansed ground water can achieve the levels required by the standards through natural flushing within an acceptable extended remedial period. Alternate standards would not be required where final cleanup is to be accomplished through natural flushing, since those established under § 264.94 would be met at the end of the remedial period.

The proposed regulations would establish a time limit on such extension of the remedial period to limit reliance on extended use of institutional controls to control public access to contaminated ground water. Following the precedent established by our final rule for high-level radioactive wastes (40 CFR 191.14(a)), it is proposed that use of institutional controls be permitted for this purpose only when they will be needed for periods of less than 100 years. Otherwise, active restoration rather than passive restoration through reliance on natural flushing would be required.

Institutional controls must be effective over the entire period of time that they would be in use. Examples of acceptable measures include legal use restrictions enforceable by permanent government entities, or measures with a high degree of permanence, such as Federal or State ownership of the land containing the contaminated water. In some instances, a combination of institutional controls may have to be used at the same time to provide adequate protection, such as providing an alternate source of drinking water and placing a deed restriction on the property to prevent use of contaminated ground water. Institutional controls that would not be adequate are measures such as health advisories, signs, posts, admonitions, or any other measure that requires the voluntary cooperation of private parties. In all cases in which DOE proposes to use institutional controls, the measures must have a high probability of protecting the human health and the environment and must receive the concurrence of the NRC.

Restoration methods for ground water include removal methods, wherein the contaminated water is removed from the aquifer, treated, and either disposed of, used, or reinjected into the aquifer, and *in situ* methods, such as the addition of chemical or biological agents to fix the contamination in place. Appropriate restoration methods will depend on characteristics of specific sites and may involve use of a combination of methods. Water can be removed from an aquifer by pumping it out through wells or by collecting the water from intercept trenches. Slurry walls can sometimes be put in place to contain contamination and prevent further migration of contaminants, so that the volume of contaminated water that must be treated is reduced. The background information document contains a more extensive discussion of candidate restoration methods.

We have reviewed preliminary information on all 24 sites and detailed information on 12 of the 24 to make a preliminary assessment of the extent of potential applicability of the proposed supplemental standards and use of passive remediation under institutional control. Based on these analyses, none of the pre-existing ground water beneath uranium mill tailings piles falls into Class I. Approximately two-thirds of the sites appear to be over Class II and the balance over Class III ground waters. The rate at which natural flushing is occurring at three or four of the 24 sites would permit consideration of passive remediation under institutional control as the sole remedial method. We are not able to predict the applicability of provisions regarding technical impracticability or excess environmental harm, since this requires detailed analysis of specific sites, but we anticipate that wide application would be unlikely. It is emphasized that the above assessments are not based on final results for the vast majority of these sites, and is, therefore, subject to change.

RCRA regulations provide that, for disposal units regulated by EPA under RCRA, the constituents to be included in the ground water protection standard (§ 264.93) and acceptable concentrations of each (§ 264.94) are decided by the Regional Administrator of EPA. The regulations also provide for ACLs to be issued by the Regional Administrator. The criteria to be considered when issuing ACLs are listed in § 264.94(b). EPA's regulations under Title II of UMTRCA provide that the NRC, which regulates active sites, replace the EPA Regional Administrator for the above functions when any contamination permitted by an ACL will remain on the licensed site. Because section 108(a) of UMTRCA requires the Commission's concurrence with DOE's selection and performance of remedial actions to conform to EPA's standards, we propose that the Nuclear Regulatory Commission administer all such functions for Title I, including concurrence on supplemental standards.

C. Request for Comments

The Agency solicits comment on this entire proposed rule. In addition, we are particularly interested in receiving comments and recommendations on the following issues:

1. Should a liner requirement always be imposed on tailings piles that are moved to a new location? Should a liner be required only if the DOE or the NRC conclude that it is needed to satisfy the ground-water standards for disposal?

2. For designated processing sites from which tailings have been removed, is a specific requirement that DOE clean up the ground water before releasing the land to State or private owners needed to assure that such cleanup will occur?

3. Should institutional controls be relied upon, for a limited time, to prevent access of the public to ground water in order to permit-use of natural flushing of contaminants, as proposed? If so, what types of institutional controls should be allowed? Should these be specified in the rule? Is the proposed time period appropriate?

4. Should the option to make use of natural flushing for cleansing of contaminants be limited to cases where some restoration of the ground water has already been carried out? Should the use of an alternate concentration limit (ACL) be permitted, as proposed, in the case of clean up to be achieved (in whole or part) by natural flushing?

5. Are the proposed bases for supplemental standards for cleanup reasonable and adequate for the protection of public health? Should other bases be provided and, if so, what are they? Should the provisions for natural flushing and supplemental standards for cleanup apply only to existing contamination or should they also apply, as is proposed, to "new" contamination due to failure of the disposal design to perform as intended?

6. Under these proposed standards, alternate concentration limits would be concurred in by the NRC. Should EPA establish generic criteria and/or guidance governing the application of the provisions of § 264.94(b) of this Part to these judgments for these standards?

7. Should EPA publish, as part of this standard, a restricted list of just those radioactive and toxic constituents that are present at these sites, or continue to rely on the entire list (supplemented as proposed) of constituents encompassed by RCRA regulations? Should the proposed list of additional listed constituents be changed?

8. EPA could consider publishing a restricted list of just those radioactive and toxic constituents that are principal contaminants at these sites and specifying a limit for each of these, under the assumption that any minor contaminants would be taken care of in the cleanup of these principal contaminants. With such a restricted set of constituents and corresponding complete set of limits, EPA could then consider dropping the provisions for ACLs and relying solely on the remaining provisions for exceptional cases. Should EPA adopt this approach?

9. Should EPA specify a minimum or the entire period for post-disposal ground-water monitoring in Subpart A, or leave it to the DOE and NRC to determine this period on a site-specific basis, as proposed? If EPA should specify a period, what length would be appropriate to demonstrate conformance to the disposal design standard, and on what basis should this value be chosen?

10. For tailings regulated by NRC under Title II of the Act, section 84(a)(3) requires the NRC to develop regulations to conform to general requirements applicable to the possession, transfer, and disposal of hazardous materials regulated by the Administrator. Should the standards proposed here incorporate such requirements for tailings regulated under Title I?

11. Is it appropriate to base the uranium contaminant limit on radioactivity alone or should the chemical toxicity of uranium result in a more restrictive value?

12. Should the Agency consider revising the Title II regulations to incorporate those portions of the Title I regulations that are different from the Title II regulations, e.g., the additional contaminant limits in Table A?

13. Are the estimated costs of implementing these proposed standards accurate and based on reasonable assumptions?

14. What criteria should be used to judge "technically impracticable from an engineering perspective?" Can and should these criteria be specified in the rule or should they be left to the judgment of the Department of Energy and the Nuclear Regulatory Commission?

15. The criteria proposed here to specify ground water as Class III, and therefore qualified for supplemental standards, are based on draft proposals still under consideration by the Agency. Are these criteria appropriate for this application, or would others be more appropriate for use at these sites?

V. Implementation

UMTRCA requires the Secretary of Energy to select and perform the remedial actions needed to implement these standards, with the full participation of any State that shares the cost. The NRC must concur with these actions and, when appropriate, the Secretary of Energy must also consult with affected Indian tribes and the Secretary of the Interior.

The cost of remedial actions will be borne by the Federal Government and the States as prescribed by UMTRCA. The clean-up of ground water is a large-scale undertaking for which there is relatively little experience. Ground-water conditions at the inactive processing sites vary greatly, and, as noted above, engineering experience with some of the required remedial actions is limited. Although preliminary engineering assessments have been performed, specific engineering requirements and costs to meet the ground-water standards at each site have yet to be determined. We believe that costs averaging about 12 million (1986) dollars for each tailings site at which extensive cleanup is required are most likely.

The benefits from the cleanup of this ground water are difficult to quantify. We expect that, in a few instances, ground water that was unusable due to contamination from tailings piles and needed for use will be restored. In the areas where the tailings were processed, ground water is relatively scarce due to the arid condition of the land. However, most of the contamination at these sites occurs in shallow alluvial aquifers, which have limited current use in these locations because of their generally poor quality and the availability of better water from deeper aquifers.

Implementation of the disposal standard for protection of ground water will require a judgment that the method chosen provides a reasonable expectation that the provisions of the standard will be met, to the extent reasonably achievable, for up to 1000 years and, in any case, for at least 200 years. This judgment will necessarily be based on site-specific analyses of the properties of the sites, candidate disposal systems, and the potential effects of natural processes over time. Therefore, the measures required to satisfy the standard will vary from site to site. We expect that actual site data, computational models, and expert judgment will be the major tools in deciding that a proposed disposal system will satisfy the standard.

The purpose of the proposed ground-water cleanup standard is to provide the maximum reasonable protection of public health and the environment. Costs incurred by remedial actions should be directed toward this purpose. We intend the standards to be implemented using verification procedures whose cost and technical requirements are reasonable. Procedures that provide a reasonable assurance of compliance with the standards will be adequate. Measurements to assess existing contamination and to determine compliance with the cleanup standards should be performed with reasonable survey and sampling procedures designed to minimize the cost of verification.

The explanatory discussions regarding implementation of these regulations in § 192.20 (a)(2) and (a)(3) are revised to remove those provisions that the Court remanded and to reflect these new proposals.

These standards are not expected to affect the disposal work DOE has already performed on tailings. We expect, in general, that a pile that has been properly designed to comply with the disposal standards now in effect for long term stabilization and control of radon emanation from a pile will also comply with these disposal standards for the control of ground-water contamination. DOE will have to determine, with the concurrence of the NRC, if any additional work may be needed to comply with the ground-water cleanup requirements. However, any such cleanup work should not adversely affect the control systems for tailings piles that have already been or are currently being installed.

VI. Regulatory Impact Analysis/Regulatory Flexibility

Under Executive Order 12291, EPA must judge whether a regulation is "Major" and therefore subject to the requirement of a Regulatory Impact Analysis. That order requires such an analysis if the regulations would result in (1) an annual effect on the economy of $100 million or more; (2) a major increase in costs or prices for consumers, individual industries, Federal, State, or local government agencies or geographic regions; or (3) significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of United States-based enterprises to compete with foreign-based enterprises in domestic or export markets.

This proposed regulation is not Major, because we expect the costs of the remedial action program for ground water in any calendar year to be less than $100 million; States bear only 10% of these costs and there are no anticipated major affects on costs or prices for others; and we anticipate no significant adverse effects on domestic or foreign competition, employment, investment, productivity, or innovation. Estimated costs under these proposed regulations are discussed in the Background Information Document.

This proposed regulation was submitted to the Office of Management and Budget (OMB) for review as required by Executive Order 12291.

This rule does not contain any information collection requirements subject to OMB review under the Paperwork Reduction Act of 1980 U.S.C. 3501, et seq.

This proposed regulation will not have a signficant effect on a substantial number of small entities, as specified under section 605 of the Regulatory Flexibility Act, because there are no small entities subject to this regulation.

Dated: September 10, 1987.

Lee M. Thomas,

Administrator.

List of Subjects in 40 CFR Part 192

Environmental protection, Radiation protection, Uranium.

For reasons set forth in the preamble, 40 CFR Chapter I, Part 192, Subparts A, B and C are proposed to be amended as follows:

PART 192—HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM MILL TAILINGS

1. The authority citation for Part 192 continues to read as follows:

Authority: Section 275 of the Atomic Energy Act of 1954, 42 U.S.C. 2022, as added by the Uranium Mill Trailings Radiation Control Act of 1978 as amended, Pub. L. 95-604.

Subpart A—Standards for the Control of Residual Radioactive Materials From Inactive Uranium Processing Sites

* * * * *

2. Section 192.01 is amended by revising paragraph (a) and adding paragraphs (g), (h), (i), and (j) to read as follows:

§ 192.01 Definitions.

(a) Unless otherwise indicated in this subpart, all terms have the same meaning as in Title I of the Act. Reference to Part 264 of the Code of Federal Regulations is to that Part as codified on January 1, 1983. [These references will be replaced by the complete text in the final rule.]

* * * * *

(g) *Remedial period* means the period of time beginning March 7, 1983 and ending with the completion of requirements specified under a remedial action plan.

(h) *Remedial Action Plan* means a written plan for a specific site that incorporates the results of site characterization studies, environmental assessments or impact statements, and engineering assessments into a plan for disposal and cleanup which satisfies the requirements of Subparts A and B.

(i) *Post-disposal period* means the period of time beginning immediately after the completion of the requirements of Subpart A and ending at completion of the monitoring requirements established under § 192.02(b).

(j) *Ground water* is subsurface water within a zone in which substantially all the voids are filled with water under pressure equal to or greater than that of the atmosphere.

3. Section 192.02 is amended by redesignating and revising the introductory text as paragraph (a); paragraph (a) is redesignated as paragraph (a)(1); paragraph (b) introductory text is redesignated as paragraph (a)(2); paragraph (b)(1) is redesignated as paragraph (a)(2)(i); paragraph (b)(2) is redesignated as paragraph (a)(2)(ii); and paragraphs (a)(3), (a)(4), (b) and (c) are added to read as follows:

§ 192.02 Standards.

(a) Control of residual radioactive materials and their listed constituents shall be designed [1] to:

* * * * *

(3) Conform to the ground-water protection provisions of §§ 264.92–264.95 of Part 264 of this chapter, except that, for the purposes of this subpart:

(i) To the list of constituents referenced in § 264.93 of this chapter are added molybdenum, radium, uranium, and nitrate,

[1] Because the standard applies to design, monitoring after disposal is not required to demonstrate compliance. This footnote applies only to § 192.02(a) (1) and (2).

(ii) To the concentration limits provided in Table 1 of § 264.94 of this chapter are added the constituent limits in Table A of this subpart.

TABLE A.

Constituent	Limit
Combined radium-226 and radium-228.	5 pCi/liter.
Combined uranium-234 and uranium-238.	30 pCi/liter.
Gross alpha-particle activity (excluding radon and uranium)..	15 pCi/liter.
Nitrate (as N)	10 mg/liter.
Molybdenum	0.1 mg/liter.

(iii) The Secretary shall determine what listed constituents are present in the tailings at a disposal site.

(iv) A monitoring program shall be established upgradient of the disposal site adequate to determine background levels of listed constituents.

(v) The Secretary may propose and, with the Commission's concurrence, apply alternate concentration limits, provided that, after considering practicable corrective actions, the Commission determines that these are as low as reasonably achievable, and that, in any case, § 264.94(b) is satisfied, and

(vi) The functions and responsibilities designated in referenced paragraphs of Part 264 of this chapter as those of the "Regional Administrator" with respect to "facility permits" shall be carried out by the Commission.

(4) Comply with the performance standard in § 264.111 (a) and (b) of this chapter.

(b) The Secretary shall propose and, following concurrence by the Commission, implement a monitoring plan, to be carried out over a period of time which shall constitute the post-disposal period, which is adequate to demonstrate that initial performance of the disposal is in accordance with the design requirements of § 192.02(a).

(c) If the ground-water standards established under provisions of § 192.02(a) are found or projected to be exceeded, as a result of the monitoring program established for the post-disposal period under § 192.02(b), a corrective action program to restore the disposal to the design requirements of § 192.02(a) and, as necessary, to clean up ground water in conformance with Subpart B shall be put into operation as soon as is practicable, and in no event later than eighteen (18) months after a finding of exceedance.

Subpart B—Standards for Cleanup of Land and Buildings Contaminated With Residual Radioactive Materials From Inactive Uranium Processing Sites

* * * * *

4. Section 192.11 is amended by revising paragraph (b) and adding paragraph (e) to read as follows:

§ 192.11 Definitions.

* * * * *

(b) *Land* means (1) any surface or subsurface land that is not part of a disposal site and is not covered by an occupiable building, and (2) subsurface land that contains ground water contaminated by listed constituents from residual radioactive material from the processing site.

* * * * *

(e) *Class III ground water*[3] means ground water that is not a current or potential source of drinking water because (1) the concentration of total dissolved solids is in excess of 10,000 mg/1, (2) widespread, ambient contamination not due to activities involving residual radioactive materials from a designated processing site exists that cannot be cleaned up using treatment methods reasonably employed in public water-supply systems, or (3) the quantity of water available is less than 150 gallons per day.

5. In § 192.12, the introductory text is republished and paragraph (c) is added to read as follows:

§ 192.12 Standards.

Remedial actions shall be conducted so as to provide reasonable assurance that, *as a result of residual radioactive materials from any designated processing site:*

* * * * *

(c) The concentration of any listed constituent in ground water as a result of releases from residual radioactive material at any designated processing site shall not exceed the provisions of §§ 264.92–264.94 of this chapter as modified by § 192.02(a)(3) (i) and (ii), except that for the purposes of this subpart:

(1) The Secretary shall carry out a monitoring program adequate to define the extent of ground-water contamination by listed constituents from residual radioactive materials and to monitor compliance with this Subpart.

(2) The Secretary may propose and, with the Commission's concurrence, apply alternate concentration limits, provided that, after considering practicable corrective actions, the Commission determines that these are as low as reasonably achievable, and § 264.94(b) is satisfied.

(3) The functions and responsibilities designated in referenced paragraphs of Part 264 of this chapter as those of the "Regional Administrator" with respect to "facility permits" shall be carried out by the Commission.

(4) The remedial period established under Subpart A may be extended by an amount not to exceed 100 years if:

(i) The concentration limits established under this Subpart are not projected to be exceeded at the end of this extended remedial period,

(ii) Institutional control, which will effectively protect public health and satisfy beneficial uses of ground water during the extended remedial period, is instituted, as part of the remedial action, at the processing site and wherever contamination by listed constituents from residual radioactive materials is found in ground water, or is projected to be found,

(iii) The ground water is not currently and is not now projected to become a source of supply for public drinking water subject to provisions of the Safe Drinking Water Act during the extended remedial period, and

(iv) The requirements of Subpart A are satisfied within the time frame established under section 112(a) of the Act, or as extended by Act of Congress.

Subpart C—Implementation

6. In § 192.20, paragraphs (a)(2), and (a)(3) and (b)(1) are revised and paragraph (b)(4) is added to read as follows:

§ 192.20 Guidance for implementation.

* * * * *

(a) * * *

(2) Protection of water should be considered on a case-specific basis, drawing on hydrological and geochemical surveys and all other relevant data. The hydrologic and geologic assessment to be conducted at each site shall include a monitoring program sufficient to establish background ground water quality through one or more upgradient wells. New disposal sites for tailings that still contain water at greater than the level of "specific retention" or tailings that are slurried to the new location shall use

[3] Class III ground waters are further defined in *Ground-Water Protection Strategy*, Office of Ground-Water Protection, USEPA, Washington, DC 20460, August 1984, and the Final Draft of *Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy*, Office of Ground-Water Protection, USEPA, Washington, DC 20460, December 1986.

a liner or equivalent to prevent contamination of ground water.

(3) The remedial action plan, following approval by the Commission, will specify how applicable requirements of Subpart A are to be satisfied. The plan shall include the schedule and steps necessary to complete disposal operations at the site. It shall include an estimate of the inventory of wastes to be disposed of in the pile and their listed constituents and address (i) any need to eliminate free liquids; (ii) stabilization of the wastes to a bearing capacity sufficient to support the final cover; and (iii) the design and construction of a cover to manage the migration of liquids through the stabilized pile, function with minimum maintenance, promote drainage and minimize erosion or abrasion of the cover, and accommodate settling and subsidence so that the cover's integrity is maintained.

(b)(1) Compliance with § 192.12 (a) and (b) of Subpart B, to the extent practical, should be demonstrated through radiation surveys. Such surveys may, if appropriate, be restricted to locations likely to contain residual radioactive materials. These surveys should be designed to provide for compliance averaged over limited areas rather than point-by-point compliance with the standards. In most cases, measurement of gamma radiation exposure rates above and below the land surface can be used to show compliance with § 192.12(a). Protocols for making such measurements should be based on assuming realistic radium distributions near the surface rather than extremes rarely encountered.

* * * * *

(4) The remedial action plan, following approval by the Commission, will specify how applicable requirements of Subpart B would be satisfied. The plan should include the schedule and steps necessary to complete the cleanup of ground water at the site. It should document the extent of contamination due to releases prior to final disposal, including the identification and location of listed constituents and the rate and direction of movement of contaminated ground water. In addition, the assessment should consider future plume movement, including an evaluation of such processes as attenuation and dilution. In cases where § 192.12(c)(4) is invoked, the plan should include a monitoring program to verify projections of plume movement and attenuation throughout the remedial period. Finally, the plan should specify details of the method to be used for cleanup of ground water.

7. In § 192.21, the introductory text and paragraph (b) are revised, paragraph (f) is redesignated as paragraph (h), and new paragraphs (f) and (g) are added to read as follows:

§ 192.21 Criteria for applying supplemental standards.

Unless otherwise indicated in this subpart, all terms shall have the same meaning as defined in Title I of the Act or in Subparts A and B. The implementing agencies may (and in the case of subsection (h) shall) apply standards under § 192.22 in lieu of the standards of Subparts A or B if they determine that any of the following circumstances exists:

* * * * *

(b) Remedial actions to satisfy the cleanup standards for land, § 192.12 (a) and (c), or the acquisition of minimum materials required for control to satisfy § 192.02(a) (2) and (3), would, notwithstanding reasonable measures to limit damage, directly produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near the site, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

* * * * *

(f) The restoration of ground water quality at any designated processing site under § 192.12(c) is technically impracticable from an engineering perspective.

(g) The ground water is Class III.

* * * * *

8. In § 192.22, paragraphs (a) and (b) are revised and paragraph (d) is added to read as follows:

§ 192.22 Supplemental standards.

* * * * *

(a) When one or more of the criteria of § 192.21 (a) through (g) applies, the implementing agencies shall select and perform remedial actions that come as close to meeting the otherwise applicable standard as is reasonable under the circumstances.

(b) When § 192.21(h) applies, remedial actions shall, in addition to satisfying the standards of Subparts A and B, reduce other residual radioactivity to levels that are as low as is reasonably achievable.

* * * * *

(d) When § 192.21 (f) or (g) applies, implementing agencies must apply any remedial actions for the restoration of contaminated ground water that is required to assure, at a minimum, protection of human health and the environment.

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GROUNDWATER STANDARDS FOR
REMEDIAL ACTION AT INACTIVE
URANIUM PROCESSING SITES
FINAL RULE

federal register

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January 11, 1995

Part IV

Environmental Protection Agency

40 CFR Part 192

Groundwater Standards for Remedial Actions at Inactive Uranium Processing Sites; Final Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 192

[FRL-3510-1]

RIN 2060-AC03

Groundwater Standards for Remedial Actions at Inactive Uranium Processing Sites

AGENCY: Environmental Protection Agency.

ACTION: Final rule.

SUMMARY: The Environmental Protection Agency is issuing final regulations to correct and prevent contamination of groundwater beneath and in the vicinity of inactive uranium processing sites by uranium tailings. EPA issued regulations (40 CFR part 192, subparts A, B, and C) for cleanup and disposal of tailings from these sites on January 5, 1983. These new regulations replace existing provisions at 40 CFR 192.20(a)(2) and (3) that were remanded by the U.S. Court of Appeals for the Tenth Circuit on September 3, 1985. They are promulgated pursuant to Section 275 of the Atomic Energy Act, as amended by Section 206 of the Uranium Mill Tailings Radiation Control Act of 1978 (Public Law 95-604).

The regulations apply to tailings at the 24 locations that qualify for remedial action under Title I of Public Law 95-604. They provide that tailings must be stabilized and controlled in a manner that permanently eliminates or minimizes contamination of groundwater beneath stabilized tailings, so as to protect human health and the environment. They also provide for cleanup of contamination that occurred before the tailings are stabilized.

EFFECTIVE DATE: February 10, 1995.

ADDRESSES: *Background Documents.* A report ("Groundwater Protection Standards for Inactive Uranium Tailings Sites, Background Information for Final Rule," EPA 520/1-88-023) has been prepared in support of these regulations. Another report ("Groundwater Protection Standards for Inactive Uranium Tailings Sites, Response to Comments," EPA 520/1-88-055) contains the detailed responses of the Environmental Protection Agency to comments on the standard by the reviewing public. Single copies of these documents may be obtained from the Program Management Office (6601J), Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, DC 20460; (202) 233-9354.

Docket. Docket Number R-87-01 contains the rulemaking record. The docket is available for public inspection between 8 a.m.-4 p.m., weekdays, at EPA's Central Docket Section (LE-131), Room M-1500, 401 M Street SW., Washington, DC 20460. A reasonable fee may be charged for copying.

FOR FURTHER INFORMATION CONTACT: Allan C.B. Richardson, Criteria and Standards Division (6602J), Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, DC 20460; telephone (202) 233-9213.

SUPPLEMENTARY INFORMATION:

I. Introduction

On November 8, 1978, Congress enacted the Uranium Mill Tailings Radiation Control Act of 1978 (henceforth called "UMTRCA"). In UMTRCA, Congress found that uranium mill tailings "* * * may pose a potential and significant radiation health hazard to the public, and * * * that every reasonable effort should be made to provide for stabilization, disposal, and control in a safe and environmentally sound manner of such tailings in order to prevent or minimize radon diffusion into the environment and to prevent or minimize other environmental hazards from such tailings." The Act directs the Administrator of the Environmental Protection Agency (EPA) to set "* * * standards of general application for the protection of the public health, safety, and the environment * * *" to govern this process of stabilization, disposal, and control.

UMTRCA directs the Department of Energy (DOE) to conduct such remedial actions at the inactive uranium processing sites as will insure compliance with the standards established by EPA. This remedial action is to be selected and performed with the concurrence of the Nuclear Regulatory Commission (NRC). Upon completion of the remedial action program, the depository sites will remain in the custody of the Federal government under an NRC license.

The standards apply to residual radioactive material at the 24 processing sites designated, as provided in the Act, by DOE. Residual radioactive material is defined as any wastes which DOE determine to be radioactive, either in the form of tailings resulting from the processing of ores for the extraction of uranium and other valuable constituents of the ores, or in other forms which relate to such processing, such as sludges and captured contaminated water from these sites. (Additional wastes that do not meet this definition may be subject to regulation as hazardous waste under the Solid Waste Disposal Act (SWDA) as amended by the Resource Conservation and Recovery Act of 1976 (RCRA).)

Standards are required for two types of remedial actions: disposal and cleanup of residual radioactive material. Disposal is here used to mean the operation that places tailings in a permanent condition which will minimize risk of harmful effects to the health of people and harm to the environment. Cleanup is the operation that eliminates, or reduces to acceptable levels, the potential health and environmental consequences of tailings or their constituents that have been dispersed from tailings piles or disposal areas by natural forces or by human activity, through removal of residual radioactive materials from land, buildings, and groundwater.

On January 5, 1983, EPA promulgated final standards for the disposal and cleanup of the inactive mill tailings sites under UMTRCA (48 FR 590). These standards were challenged in the Tenth Circuit Court of Appeals by several parties (Case Nos. 83-1014, 83-1041, 83-1206, and 83-1300). On September 3, 1985, the court dismissed all challenges except one: it set aside the groundwater provisions of the regulations at 40 CFR 192.20(a)(2) and (3) and remanded them to EPA "* * * to treat these toxic chemicals that pose a groundwater risk as it did in the active mill site regulations." On September 24, 1987, EPA proposed new standards to replace those remanded. A public hearing was held in Durango, Colorado, on October 29, 1987. In response to requests from several commenters at the public hearing and a later request by the American Mining Congress, the public record for comments on the proposed standard was not closed until January 29, 1988. With this notice, EPA is establishing final standards to replace those set aside.

II. Summary of Background Information

Beginning in the 1940's, the U.S. Government purchased large quantities of uranium for defense purposes. As a result, large piles of tailings were created by the uranium milling industry. Tailings piles pose a hazard to public health and the environment because they contain radioactive and toxic constituents which emanate radon to the atmosphere and may leach into groundwater. Tailings, which are a sand-like material, have also been removed from tailings piles in the past for use in construction and for soil conditioning. These uses are inappropriate, because the radioactive and toxic constituents of tailings may elevate indoor radon levels, expose people to gamma radiation, and leach into ground and surface waters.

Most of the mills are now inactive and many of the sites were abandoned. These abandoned sites are being remediated under Title I of UMTRCA. Congress designated 22 specific inactive sites in Title I of UMTRCA, and the DOE subsequently added two more. Most remaining uranium mill tailings sites are regulated by the NRC or States and will be reclamated under Title II of UMTRCA. (DOE also owns one inactive site at Monticello, Utah, that is not included under UMTRCA). The Title I sites are located in the West, predominantly in arid areas, except for a single site at Canonsburg, Pennsylvania. Before disposal operations began, tailings piles at the inactive sites ranged in area from 5 to 150 acres and in height from only a few feet to as much as 230 feet. The amount at each site ranges from residual contamination to 2.7 million tons of tailings. The 24 designated Title I sites combined contain about 26 million tons of tailings covering a total of about 1000 acres.

Under the provisions of Title I of UMTRCA, the DOE is responsible for the disposal of tailings at these sites, which will then be licensed to DOE by NRC for long term surveillance and maintenance, following NRC approval of the remediation. In addition, tailings that were dispersed from the piles by natural forces or that have been removed for use in or around buildings or on land are being retrieved and replaced on the tailings piles prior to their disposal.

UMTRCA, as originally enacted, required that DOE complete all these remedial actions within 7 years of the effective date of EPA's standards, that is, by March 5, 1990. At the end of 1993 disposal actions had been completed at ten sites: Canonsburg, Pennsylvania, one of two sites in areas of high precipitation (Falls City, Texas is the other); Shiprock, New Mexico; Salt Lake City, Utah; Lakeview, Oregon; Green River, Utah; Spook and Riverton, Wyoming; Lowman, Idaho; Tuba City, Arizona; and Durango, Colorado. Disposal actions were well advanced at eight other sites: Rifle (two piles), Grand Junction, and Gunnison, Colorado; Monument Valley, Arizona; Mexican Hat, Utah; Falls City, Texas; and Ambrosia Lake, New Mexico. The remaining sites are in the advanced stages of planning and should be under construction within the next two years.

In view of the rate of progress with remedial work, Congress in 1988 extended the completion date for disposal and most cleanup activities until September 30, 1994, and provided further "* * * that the authority of the Secretary to perform groundwater restoration activities under this title is without limitation." (Uranium Mill Tailings Remedial Action Amendments Act of 1988, P.L. 100–616, November 5, 1988; 42 U.S.C. 7916). Section 1031 of the Energy Policy Act of 1992 further extended the completion date for UMTRCA surface stabilization (disposal) activities to September 30, 1996.

The most important hazardous constituent of uranium mill tailings is radium, which is radioactive. Other potentially hazardous substances in tailings piles include arsenic, molybdenum, selenium, uranium, and, usually in lesser amounts, a variety of other toxic substances. The concentrations of these materials in tailings vary from pile to pile, ranging from 2 to more than 100 times local background soil concentrations. A variety of organics is also known to have been used at these sites.

Exposure to radioactive and toxic substances may cause cancer and other diseases, as well as genetic damage and teratogenic effects. Tailings pose a risk to health because: (1) Radium in tailings decays into radon, a gaseous radioactive element which is easily transported in air and the radioactive decay products of which may lodge in the lungs; (2) individuals may be directly exposed to gamma radiation from the radioactivity in tailings; and (3) radioactive and toxic substances from tailings may leach into water and then be ingested with food or water, or inhaled following aeration. It is the last of these hazards that is primarily addressed here. (Although radon from radium in groundwater is unlikely to pose a substantial hazard at these locations, these standards also address that potential hazard.) The other hazards are covered by existing provisions of 40 CFR part 192.

EPA's technical analysis was based on detailed reports for 14 of the 24 inactive uranium mill tailings sites that had been developed by late 1988 for the Department of Energy by its contractors. Preliminary data for the balance of the sites were also examined. Those data showed that the volumes of contaminated water in aquifers at the 24 sites range from a few tens of millions of gallons to 4 billion gallons. In a few instances mill effluent was apparently the sole source of this groundwater. Each of the 14 sites examined in detail had at least some groundwater contamination beneath and/or beyond the site. In some cases the groundwater upgradient of the pile already exceeded EPA drinking water standards for one or more contaminants due to mineralization sources or due to anthropogenic sources other than the uranium milling activities, thus making it unsuitable for use as drinking water without treatment and, in some extreme cases, for most other purposes before it was contaminated by effluent from the mill. Some contaminants from the tailings piles are moving offsite quickly and others are moving slowly. The time for natural flushing of the contaminated portions of these aquifers was estimated to vary from a couple of years to many hundreds of years. Active restoration was estimated to take from less than 5 years at most sites to approximately 50 years at one site.

DOE currently estimates that there is approximately 4.7 billion gallons of contaminated water, but this estimate does not include all sites. One site, Lowman, Idaho, shows no sign of contamination related to the processing activities, while the site with the largest amount of contamination, Monument Valley, Arizona, has an estimated 0.75 billion gallons of contaminated water. The DOE estimate does not include those sites where current assessments indicate that supplemental standards should be applied, because contamination at these sites has been hard to quantify.

Contaminants that have been identified in the groundwater downgradient from a majority of the sites include uranium, sulfate, iron, manganese, nitrate, chloride, molybdenum, selenium, and total dissolved solids. Radium, arsenic, fluoride, sulfide, chromium, cadmium, vanadium, lead, and copper have also been found in the groundwater at one or more sites.

UMTRCA requires that the standards established under Title I provide protection that is consistent, to the maximum extent practicable, with the requirements of RCRA. In this regard, regulations established by EPA for hazardous waste disposal sites under RCRA provide for the specification of a groundwater protection standard for each waste management area in the facility permit (see 40 CFR part 264, subpart F). The groundwater protection standard includes a list of specific hazardous constituents relevant to each waste management area, a concentration limit for each hazardous constituent, the point of compliance, and the compliance period. The subpart F regulations specify that the concentration limits may be set at general numerical limits (maximum concentration limits (MCLs)) for some hazardous constituents or at their background level in groundwater unless alternate concentration limits (ACLs) are requested and approved. ACLs may be requested based upon data which would support a determination that, if the ACL is satisfied, the constituent would not present a current or potential threat to human health and the environment. This standard incorporates many of these provisions into the regulations for the Title I sites.

III. Changes and Clarifications in Response to Comments

These final standards modify and clarify some of the provisions of the proposed standards as a result of information and views submitted during the comment period and at the public hearing. EPA received many comments on the proposed standards. Twenty-three letters were received and eight individuals testified at the public hearing. Comments were submitted from private citizens, public interest groups, members of the scientific community, and representatives of industry and of State and Federal agencies. EPA has carefully reviewed and considered these comments in preparing its detailed Response to Comments and the final Background Information Document and in developing the final standards. EPA's responses to major comments are summarized below.

Uranium Concentration Limit

Several commenters pointed out that the Agency used inappropriate dose conversion values (nonstochastic) for uranium and radium (instead of the more appropriate stochastic values) in developing the proposed concentration limit for uranium. These comments were correct. We have reevaluated the risks associated with ingestion of uranium, using current risk factors for radiocarcinogenicity of uranium, and have also considered the chemical toxicity of uranium. We have concluded that the level proposed, 30 pCi/liter, provides an adequate margin of safety against both carcinogenic and toxic effects of uranium, and that the level should be expressed in terms of the concentration of radioactivity, because it is related to the principal health risk, and can accommodate different levels of radioactive disequilibrium between uranium-234 and uranium-238

EPA's Office of Groundwater and Drinking Water has also examined these factors, and, on July 18, 1991, proposed the MCL for uranium in drinking water be set at a chemical concentration comparable to the limit on radioactivity promulgated in this regulation. Should the MCL for drinking water, as finally promulgated, provide a level of health protection different from that provided by the limit in this regulation, EPA will reconsider the limit at that time. On the basis of the above considerations, the limit for uranium has been established at 30 pCi/liter for this regulation.

Molybdenum Concentration Limit

Several reviewers objected to the proposed inclusion of a limit on molybdenum. They pointed out that EPA has not established a drinking water standard for this element. While this is true, the drinking water regulations also make provision for health advisories in the case of contaminants that are problems only in special situations. Molybdenum in the vicinity of uranium mill tailings is such a special case. Uranium mill tailings often contain high concentrations of molybdenum that can leach into groundwater in concentrations that may cause toxic effects in humans and cattle. This rule therefore continues to contain a limit on the concentration of molybdenum in groundwater. The value chosen remains the same as that proposed, as discussed in Section IV below.

Other Groundwater Limits

These groundwater limits incorporate MCLs issued under the Safe Drinking Water Act (SDWA) (42 USC 300f, et seq.) and in effect for sites regulated under RCRA from the time these limits were proposed on September 24, 1987, to the present. However, on January 30, 1991, EPA issued new MCLs for some of the inorganic constituents included in the present limits, and proposed new drinking water standards for radioactive constituents were published on July 18, 1991 (56 FR 3526 and 33050). Following publication of final drinking water standards for radioactive constituents, EPA will consider whether the benefits and costs implied by differences between these limits and the new drinking water standards warrant proposing to incorporate the new values into both the Title I and the Title II limits for groundwater

Application of These Regulations to Vicinity Properties

Several commenters questioned the wisdom of applying these regulations to vicinity properties. (Vicinity properties are real properties or improvements in the vicinity of a tailings pile that are determined by DOE, in consultation with the NRC, to be contaminated with residual radioactive materials.) They indicated that if the portion of the proposed rule requiring detailed assessment and monitoring were applied to all vicinity properties, it would greatly expand the cost of the program without providing additional benefits. Since only a few vicinity properties contain sufficient tailings to constitute a significant threat of groundwater contamination, we have concluded that detailed assessment and monitoring, followed by identification of listed constituents and groundwater standards, is *not* required at all vicinity properties. It is necessary only at those vicinity properties with a significant potential for groundwater contamination, as determined by the DOE (with the concurrence of NRC) using factors such as those in EPA's RCRA Facility Assessment Guidance document. It should be noted that this modification applies to the requirement for detailed assessment and monitoring only; the standards for cleanup of groundwater contamination are not changed. In addition, we note that the minimal quantities of residual radioactive materials left behind at vicinity properties after compliance with subpart B do not constitute disposal sites under subpart A.

Application of State Regulations to These Sites

Some commenters expressed the view that these regulations should require consistency with State laws and regulations. EPA's regulations for licensed mill tailings sites under Title II of this Act do not contain such a provision. (Although NRC Agreement States may, under the Atomic Energy Act, adopt standards which "* * * are equivalent to the extent practicable or more stringent * * *," they have not done so under UMTRCA.) We have decided that decisions regarding consistency with State laws and regulations should be made by DOE in consultation with the States, as provided by Section 103 of the Act In making these decisions in cases where an approved Wellhead Protection Area, under the Safe Drinking Water Act, is associated with the site, however, DOE must comply with the provisions of that program, unless an exemption is granted by the President of the United States. In addition, contamination on the site that is not covered by UMTRCA (because it is not related to the processing operation) may be covered by Federal or State RCRA programs.

Application of Institutional Controls During an Extended Remedial Period

Several comments were received concerning the effectiveness, reliability.

and enforceability of institutional controls to be applied during a remedial period that has been extended to take advantage of natural flushing. EPA recognizes that some institutional controls, such as advisories or signs, although desirable as secondary measures, are not appropriate as primary measures for preventing human exposure to contaminated water. For this reason, the regulations permit institutional controls to be used in place of remediation only when DOE is able to ensure their effectiveness will be maintained during their use. The standards require that institutional controls "* * * effectively protect public health and the environment and satisfy beneficial uses of groundwater * * *" during their period of application. In this regard, we note that tribal, state, and local governments can also play a key role in assuring the effectiveness of institutional controls. In some cases this may be effected through changes in tribal, state, or local laws to ensure the enforceability of institutional controls by the administrative or judicial branches of government entities. One State indicated that some institutional controls, such as deed restrictions, should not be viewed as restrictions since they do not empower any agency to prohibit access to contaminated water. However, judicial enforcement of deed restrictions can be as effective as administrative enforcement of other institutional controls by a government agency. Therefore, deed restrictions are an acceptable institutional control if they are enforceable by a court with jurisdiction over the site at which they are used, and if the implementing agency will take appropriate steps to assure their effective application.

Some commenters expressed the view that, if institutional controls are used, this use must be restricted to the 7-year period for remediation authorized in Section 112(a) of UMTRCA. EPA believes that it is not possible to achieve cleanup of groundwater at all of the sites within 7 years, no matter what reclamation scheme is employed. It is therefore necessary to consider time frames other than that originally contemplated in UMTRCA for completion of remedial actions. Congress, in granting an extension of the authorization in Section 112(a) of UMTRCA for disposal and cleanup actions from March 5, 1990 to September 30, 1994, provided further "* * * that the authority of the Secretary to perform groundwater restoration activities under this title is without limitation." (Uranium Mill Tailings Remedial Action Amendments Act of 1988 (42 U.S.C. 7916)). In addition, under Section 104(f)(2) of the Act (42 U.S.C. 7919(f)(2)), the NRC may require maintenance of corrective and institutional measures that are already in place at the time authorization under Section 112(a) expires, without time limitation.

The provisions for use of natural flushing when appropriate institutional controls are in place are consistent with existing regulations under Title II, although they are not explicit in those regulations. In cases where groundwater contamination is detected, the Title II regulations specify when corrective actions must begin, but do not specify a time when corrective actions must be completed. These provisions under Title I provide additional guidance on the length of time over which institutional control may reasonably be relied upon, and further guidance on the kinds of institutional provisions that would be appropriate at any uranium tailings site. In addition, use of institutional controls is not limited to extended remedial periods. Interim institutional controls may also be used to protect public health or the environment, when DOE finds them necessary and appropriate, prior to commencing active remedial action, during active remedial action, or during implementation of other compliance strategies.

Other comments addressed a variety of matters, including the monitoring of institutional controls, the relationship between long-term maintenance responsibilities and the 100-year limit on use of institutional controls, types of institutional controls, longer or shorter extended remedial periods, and the legality of institutional controls under UMTRCA. These matters are addressed in the Response to Comments, published separately as a background document.

Point of Compliance

Several commenters objected to the definition of the point of compliance in the disposal standards (subpart A), and suggested that it be defined at some finite distance from the edge of the remediated tailings instead of at the downgradient edge of the pile, as in regulations established under RCRA. They indicated that the remediated tailings may seep a minor amount of contamination, which may cause the standards to be exceeded at the proposed point of compliance, under conditions where there would be no detriment to human health or the environment at small distances away This difficulty can be solved, as proposed, by moving the point of compliance or, alternatively, by granting an ACL if it can be shown that such levels of contamination will not impair human health or damage the environment. We have concluded the latter is more in keeping with the regulations established under RCRA. The standards provide that DOE may request an ACL under such circumstances and NRC may approve such a request if contamination of groundwater will not endanger human health or degrade the environment. It is our view that this requirement would usually be satisfied at any site where the minor seepage noted above is not projected to extend beyond a few hundred meters from the waste management area and will not extend outside the site boundary. This could occur under a variety of circumstances where important roles are played by attenuation, dilution, or by vapor transport in unsaturated zones.

Under the cleanup standard (subpart B), the DOE is required to characterize the extent of contamination from the site and clean it up wherever it exceeds the standards. This characterization and confirmation of cleanup will be carried out through the monitoring program established under § 192.12(c)(3). Although the DOE is not required to clean up preexisting contamination that is located beneath a remediated tailings pile, they are required to consider this contamination when developing their plan(s) for remedial action and will have to clean up any contamination that will migrate from beneath the pile and exceed the concentration limits established in accordance with § 192.02(c)(3).

Alternate Concentration Limits

Several reviewers commented that EPA should not, for a variety of reasons, delegate the responsibility for approving ACLs to the NRC. Others stated that the standards were so strict that ACLs would be needed at every site. EPA considered a number of approaches to the provision for granting ACLs. These included deleting the ACL provision, establishing (by regulation) generic criteria for ACLs to be implemented by NRC, providing for some form of EPA review or oversight of ACL implementation, and (as in the proposed regulation) providing for no EPA role in setting ACLs at individual sites.

EPA has decided not to delete the ACL provision because it is clearly needed, if for no other reason than to deal with the possibilities of unavoidable minor projected seepage over the extremely long-term design life (1000 years) of the disposal required, in most cases, by these standards, and of cleanup situations involving pollutants for which no MCLs exist. Establishment of a complete set of regulations specifying generic criteria for granting ACLs presents difficulties for rulemaking, since ACL determinations often involve complex judgments that are not amenable to being reduced to simple regulatory requirements. In this regard we note that such regulations do not yet exist in final form for sites directly regulated under RCRA. However, the Agency has issued interim final Alternate Concentration Limit Guidance (OSWER Directive 9481.00; EPA/SW–87–017), and has proposed several relevant rules, e.g., under 40 CFR parts 264, 265, 270, and 271, for Corrective Action for Solid Waste Management Units at Hazardous Waste Management Facilities (55 FR 30798; July 27, 1990). In addition, the NRC proposed a draft Technical Position on Alternate Concentration Limits for Uranium Mills at Title II sites on March 21, 1994 (59 FR 13345). EPA has reviewed the NRC draft Technical position, and we find that it is consistent, in general, with EPA's own guidance and proposed rules. The NRC draft position does not, however, specify an upper limit on risks to humans from carcinogens. We have reconsidered the issue of EPA review or oversight of ACLs at Title I sites in light of this review, and concluded that, in the interests of assuring that public health is adequately protected while at the same time minimizing the regulatory burden on DOE, the best course of action is to specify that upper limit in this regulation and assign the responsibility for making determinations for ACLs at individual sites to NRC. Accordingly, in this rule, in the implementing guidance contained in subpart C, § 192.20(a)(2), we now specify that the criterion for known or suspected carcinogens contained in the above-referenced RCRA documents should be applied in granting ACLs. That criterion specifies that ACLs should be established at levels which represent an excess lifetime risk, at a point of exposure, no greater than 10^{-4} to 10^{-6} to an average individual.

EPA is required by UMTRCA (Section 206) to be consistent, to the maximum extent practicable, with RCRA. For this reason, relevant portions of the RCRA regulations have been incorporated. For example, these regulations provide for the use of ACLs when it can be shown that the criteria specified in § 192.02(c)(3)(ii) are satisfied. It remains the view of the Agency that, as at the Title II sites, an ACL is appropriate if the NRC has determined that these criteria are satisfied when the otherwise applicable standard will be met within the site boundary (or at a distance of 500 meters, if this is closer). It is clear that ACLs will usually be appropriate to accommodate the controlled minor seepage anticipated from properly designed tailings disposal within such distances, when public use is not possible.

Cost

Greater consideration of cost and cost-benefit analysis was requested by several commenters. In 1983, Congress amended UMTRCA to provide that when establishing standards the Administrator should consider, among other factors, the economic costs of compliance We have considered these costs in two ways. First, we compared them to the benefit, expressed in terms of the value of the product—processed uranium ore—which has led to contamination of groundwater at these sites. We estimate the present value of the processed uranium ore from these sites as approximately 3 9 billion dollars (1989 dollars). The estimated cost of compliance is approximately 5.5% of this value, and we judge this to be a not unreasonable incremental cost for the remediation of contamination from the operations which produced this uranium. As a second way of considering the economic costs of compliance, we examined the cost of alternative ways to supply the resources for future use represented by these groundwaters. As noted earlier, water is a scarce resource in the Western States where this cleanup would occur. When other resources have been exhausted, the only remaining alternative to cleaning up groundwater in the vicinity of these sites is to replace this water by transporting water from the nearest alternative source. Our analysis of the costs of doing this indicates that it is significantly more costly to supply water from alternative sources than it would be to clean up the groundwater at these sites. We have concluded, therefore, that this final rule involves a reasonable relationship between the overall costs and benefits of compliance.

The RCRA subpart F regulations do not include cost as a consideration for the degree of cleanup of groundwater, and these regulations also do not provide for site-specific standards based on site-specific costs. Nonetheless, it is clearly desirable and appropriate to apply the most cost-effective remedies available to meet these standards at each site, and we anticipate that DOE will make such choices in choosing the remedies it applies to satisfy these standards. Further, once the basic criteria for establishing ACLs set forth in § 192.02(c)(3)(ii)(B) have been satisfied, if a higher level of protection is reasonably achievable, this should be carried out. However, we do not believe it is appropriate to apply detailed cost/benefit balancing judgments to justify lesser levels of protection for ground water The benefits of cleaning up groundwater are often not quantifiable and may not become known for many years; therefore, site-specific cost-benefit analyses are difficult to apply in such situations. Moreover, Congress provided no authority that protection of ground water at each site should be limited by cost/benefit considerations, even after reconsidering the question in the 1984 amendments

Some reviewers raised the issue of additional costs arising from use of these standards in other applications, such as CERCLA cleanups. We recognize that there may be costs associated with using these standards as precedents for other waste cleanup projects. However, the reasonableness of incurring such costs should be assessed when it is possible to do so with complete information, that is, at the time of application of these standards as precedents for situations other than the one for which they were developed.

Natural Restoration

The use of natural restoration of an aquifer was discussed by several reviewers. Some felt that it was a viable and desirable alternative, because it is easy and inexpensive to apply, for groundwaters that are not expected to be used for drinking or other purposes during the cleanup period. Others felt that it should be prohibited because it required a reliance on institutional controls and would circumvent active cleanup of groundwater. EPA believes that the use of natural restoration can be a viable alternative in situations where water use and ecological considerations are not affected, and cleanup will occur within a reasonable time. We have concluded that institutional controls, when enforced by government entities, or that otherwise have a high degree of permanence, can be relied on for periods of time up to 100 years, and that adequate safeguards are provided through NRC oversight of the implementation of these standards to prevent this alternative from being used to circumvent active cleanup of water that will be used by nearby populations.

Commenters suggested that natural restoration was not adequate to restore water quality at these sites. DOE has indicated that they expect that natural restoration may be all that is necessary at up to eight sites and could be used in conjunction with active remedial measures at several other sites. Natural restoration is most valuable when the contaminated aquifer discharges into a surface water body that will not be adversely affected by the contamination.

Pile and Liner Design

The design of the remediated pile and the use of a liner was of concern to several commenters, and recommendations were given for suitable designs. These commenters feared that water would continually infiltrate the remediated piles and contaminate groundwater

These EPA standards would not be satisfied by designs which allow contamination that would adversely affect human health or the environment. Further, current engineering designs for covers incorporate a number of features that control infiltration to extremely low levels. These may include an erosion barrier (with vegetation, where feasible) to transpire moisture and reduce infiltration; rock filters and drains to drain and laterally disperse any episodic infiltration; very low permeability infiltration barriers to intercept residual infiltration; and finally, the thick radon barrier, which further inhibits infiltration. The combined effect of these features is to reduce the overall hydrological transmission of covers to levels on the order of one part in a billion, with a resulting high probability that there will be no saturated zone of leachate in or below the tailings. EPA expects DOE to use such state-of-the-art designs wherever it is appropriate to do so because of the proximity of groundwater.

Under the provisions of UMTRCA, the detailed design of the pile and its cover is the responsibility of DOE, and confirmation of the viability of the design to satisfy EPA's standards is the responsibility of NRC. EPA's responsibility is to promulgate the standards to which the disposal must conform. It would be inconsistent with the division of responsibilities set forth in UMTRCA to specify actual designs for the piles in these regulations. In this connection, the requirement to provide a liner when tailings are moved to a new location in a wet state is properly seen as a generic management requirement. Any liner for this purpose would only serve a useful purpose for the relatively short time over which the moisture content of the pile adjusts to its long-term equilibrium value, after which the cover design would determine the groundwater protection capability of the disposal.

Restricted List of Constituents

Commenters were overwhelmingly opposed to a restricted list of radioactive or toxic constituents and recommended that the entire list of constituents be relied upon. It is the Agency's experience that, under RCRA, no changes in this list have been requested based on the criteria provided in § 264.93(b). These criteria allow for hazardous constituents to be excluded based on a determination that the constituent does not pose a substantial present or potential hazard to human health or the environment. Therefore, that portion of the RCRA standards which specify conditions for the exclusion of constituents from the RCRA list of hazardous constituents has been excluded as unnecessary.

However, a short list of compounds has been developed by EPA for use in monitoring groundwater under RCRA. This rule incorporates that list of constituents (Appendix IX of part 264) in place of the complete list in Appendix I for the monitoring programs required at §§ 192.02(c)(1), 192.03, and 192.12(c)(1). However, the rule still requires that all hazardous constituents listed in Appendix I be considered when corrective action is necessary

IV. Summary of the Final Standard

These final standards consist of three parts: a first part governing protection against future groundwater contamination from tailings piles after disposal; a second part that applies to the cleanup of contamination that occurred before disposal of the tailings piles; and a third part that provides guidance on implementation and specifies conditions under which supplemental standards may be applied.

A. The Groundwater Standard for Disposal

The standard for protection of groundwater after disposal (subpart A) is divided into two parts that separately address actions to be carried out during periods of time designated as the disposal and post-disposal periods. The disposal and post-disposal periods are defined in a manner analogous to the closure and post-closure periods, respectively, in RCRA regulations. However, there are some differences regarding their duration and the timing of any corrective actions that may become necessary due to failure of disposal systems to perform as designed. (Because there are no mineral processing activities currently at these inactive sites, standards are not needed for an operational period.) The disposal period, for the purpose of this regulation, is defined as that period of time beginning on the effective date of the original Title I part 192 standard for the inactive sites (March 7, 1983) and ending with completion of all actions related to disposal except post-disposal monitoring and any corrective actions that might become needed as a result of failure of completed disposal. The post-disposal period begins with completion of disposal actions and ends after an appropriate period for the monitoring of groundwater to confirm the adequacy of the disposal. The groundwater standard governing the actions to be carried out during the disposal period incorporates relevant requirements from subpart F of part 264 of this chapter (§§ 264.92–264.95). The standard for the post-disposal period reflects relevant requirements of § 264.111 of this Chapter. The disposal standard also includes provisions for monitoring and any necessary corrective action during both disposal and post-disposal periods These provisions are essentially the same as those governing the licensed (Title II) uranium mill tailings sites (40 CFR 192, subparts D and E; see also the **Federal Register** notices for those standards published on April 29, 1983 and on October 7, 1983). Several additional constituents are regulated, however, in these final Title I regulations.

These regulations do not change existing requirements at Title I sites for the period of time disposal must be designed to comply with the standards, and therefore remain identical to the requirements for licensed (Title II) sites in this respect. The Agency also recently promulgated final regulations for spent nuclear fuel, and high level and transuranic radioactive wastes (40 CFR part 191; 58 FR 66398, December 20, 1993). Those standards specify a different design period for compliance (10,000 years versus 1000 years) for two principle reasons: (1) The level of radioactivity, and therefore the level of health risk, in the wastes addressed under 40 CFR part 191 is many orders of magnitude greater than those addressed here. (The radioactivity of tailings is typically 0.4 to 1.0 nCi/g, 40 CFR part 191 wastes are always greater than 100 nCi/g, and are typically far higher.) (2) The volume of uranium mill tailings is far greater than the waste volumes addressed under 40 CFR part 191. The containment that would be required to meet a 10,000 year requirement is simply not feasible for the volumes of tailings involved (the option of underground disposal was addressed and rejected in the original rulemakings for the Title I and Title II sites).

These regulations require installation of monitoring systems upgradient of the point of compliance (i.e., in the uppermost aquifer upgradient of the edge of the tailings disposal site) or at some other point adequate to determine background levels of any listed constituents that occur naturally at the site. The disposal should be designed to control, to the extent reasonably achievable for 1000 years and, in any case, for at least 200 years, all listed constituents identified in residual radioactive materials at the site to levels for each constituent derived in accordance with § 192.02(c)(3). Accordingly, the elements of the groundwater protection standard to be specified for each disposal site include a list of relevant constituents, the concentration limits for each such constituent, and the compliance point.

These standards provide for consideration of ACLs if the disposal cannot reasonably be designed to assure conformance to background levels (or those in Table 1) over the required term. ACLs can be granted provided that, after considering practicable corrective actions, a determination can be made that it satisfies the values given by implementing the conditions for ACLs under § 192.02(c)(3)(ii).

The standards for Title II sites require use of a liner under new tailings piles or lateral extensions of existing piles. These standards for remedial action at the inactive Title I sites do not contain a similar provision. EPA assumes that the inactive piles will not need to be enlarged. Several, however, will be relocated. However, unlike tailings at the Title II sites, which generally may contain large amounts of process water, the inactive tailings contain little or no free water. Such tailings, if properly located and stabilized with a cover adequate to ensure an unsaturated zone, are not likely to require a liner in order to protect groundwater.

However, a liner would be needed for an initial drying-out period to meet these groundwater standards if a situation arose where the tailings initially contained water above the level of specific retention. For example, tailings to which water was added to facilitate their removal to a new site (i.e., through slurrying), or for compaction during disposal. (It is anticipated that piles will never be moved to areas of high precipitation or situated within a zone of water table fluctuation.) Section 192.20(a)(3) requires the remedial plan to address how any such excess water in tailings would be dealt with. In such circumstances it will normally be necessary to use a liner or equivalent to assure that groundwater will not be contaminated while the moisture level in the tailings adjusts to its long-term equilibrium value. Currently, however, DOE plans do not include slurrying any tailings to move them to new locations. Further, for all but two sites, of which one has already been closed (Canonsburg) and at the other (Falls City) disposal actions are well advanced, the tailings are located in arid areas where annual precipitation is low

Disposal designs which prevent migration of listed constituents in the groundwater for only a short period of time would not provide appropriate protection. Such approaches simply defer adverse groundwater effects. Therefore, measures which only modify the gradient in an aquifer or create barriers (e.g., slurry walls) would not of themselves provide an adequate disposal.

Section 192.02(d) requires that a site be closed in a manner that minimizes further maintenance. Depending on the physical properties of the sites, candidate disposal systems, and the effects of natural processes over time, measures required to satisfy these standards will vary from site to site. Actual site data, computational models, and prevalent expert judgment may be used in deciding that proposed measures will satisfy the standards. Under the provisions of Section 108(a) of UMTRCA, the adequacy of these judgments is determined by the NRC.

For the post-disposal period, a groundwater monitoring plan is required to be developed and implemented. The plan will require monitoring for a period of time deemed sufficient to verify, with reasonable assurance, the adequacy of the disposal to achieve its design objectives for containment of listed constituents. EPA expects this period of time to be comparable, in most cases, to that required under § 264.117 of Title 40 for waste sites regulated under RCRA (i.e., a few decades). However, there may be situations where longer or shorter periods are appropriate. Installation and commencement of the monitoring required under § 192.03 will satisfy this EPA standard, for the purposes of licensing of the site by the NRC.

With regard to this monitoring, UMTRCA provides that, after remediation is completed and custody is transferred to a Federal agency, NRC may require that the Federal agency having custody of each remediated tailings site "* * * undertake such monitoring, maintenance, and emergency measures * * * and other actions as [NRC] deems necessary to comply with [EPA's standards]" (UMTRCA, Section 104(f)(2)). Although it is not intended that routine monitoring be carried out as a requirement for conformance to these standards for the 200- to 1000-year period over which the disposal is designed to be effective, NRC may require more extensive monitoring to comply with EPA's standards, as NRC deems necessary under § 104(f)(2) of the Act.

During the post-disposal period, if listed constituents from a disposal site are detected in excess of the groundwater standards, these regulations require a corrective action program designed to bring the disposal and the groundwater into compliance with the provisions of § 192.02(c)(3) and subpart B, respectively. In designing such a corrective action program, the implementing agencies may consider all of the provisions available under subparts A, B, and C. A modification of the monitoring program sufficient to demonstrate that the corrective measures will be successful is also required. In designing future corrective action programs, the implementing agencies may also wish to consider the guidance provided by new regulations now being developed for the RCRA program that will be proposed as subpart S to Title 40. However, the requirements of Part 192 will still govern regulatory determinations of acceptability.

Additional Regulated Constituents

For the purpose of this regulation only, the Agency is regulating, in addition to the hazardous constituents referenced by § 264.93, molybdenum, nitrate, combined radium-226 and radium-228, and combined uranium-234 and uranium-238. Molybdenum, radium, and uranium were addressed by the Title II standards because these radioactive and/or toxic constituents are found in high concentrations at many mill tailings sites. These regulations add numerical limits for these constituents. Nitrate was added because it had been identified in concentrations far in excess of drinking water standards in groundwater at a number of the inactive sites.

The concentration limit for molybdenum in groundwater from uranium tailings is set at 0.1 milligram per liter. This is the value of the provisional Adjusted Acceptable Daily Intake (AADI) for drinking water developed by EPA under the Safe Drinking Water Act (50 FR 46958). The Agency has established neither a maximum concentration limit goal

(MCLG) nor a maximum concentration limit (MCL) for molybdenum because it occurs only infrequently in water. According to the most recent relevant report of the National Academy of Sciences (*Drinking Water and Health*, 1980, Vol. III), molybdenum from drinking water, except for highly contaminated sources, is not likely to constitute a significant portion of the total human intake of this element. However, as noted above, uranium tailings are often a highly concentrated source of molybdenum, and it is therefore appropriate to include a standard for molybdenum in this rule. In addition to the hazard to humans, our analysis of toxic substances in tailings in the Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites (EPA 520/4-82-013-1) found that, for ruminants, molybdenum in concentrations greater than 0.05 ppm in drinking water would lead to chronic toxicity. This concentration included a safety factor of 10; the standard provides for a safety factor of 5, which we consider adequately protective for ruminants.

The standard for combined uranium-234 and uranium-238 due to contamination from uranium tailings is 30 pCi per liter. The level of health risk associated with this standard is equivalent to the level proposed as the MCL for uranium in drinking water by EPA (56 FR 33050, July 18, 1991). The standard promulgated here applies to remedial actions for uranium tailings only. When the Agency has established a final MCL for isotopes of uranium in drinking water, we will consider whether this standard needs to be reviewed.

The limit for nitrate (as nitrogen) is 10 mg per liter. This is the value of the drinking water standard for nitrate.

B. The Cleanup Standard

With the exception of the point of compliance provision, the standard (subpart B) for cleanup of contaminated groundwater contains the same basic provisions as the standard for disposal in subpart A. In addition, it provides for the establishment of supplemental standards under certain conditions, and for use of institutional control to permit passive restoration through natural flushing when no public water system is involved.

Although the standards specify a single point of compliance for conformance to the groundwater standards for disposal, this does not suffice for the cleanup of groundwater that has been contaminated before final disposal. Instead, in this case compliance must be achieved anywhere contamination above the levels established by these standards is found or is projected to be found in groundwater outside the disposal area and its cover. The standards require DOE to establish a monitoring program adequate to determine the extent of contamination (§ 192.12(c)(1)) in groundwater around each processing site. The possible presence of any of the inorganic or organic hazardous constituents identified in tailings or used in the processing operation should be assessed. The plan for remedial action referenced under § 192.20(b)(4) should document the extent of contamination, the rate and direction of movement of contaminants, and consider future movement of the plume. The cleanup standards normally require restoration of all contaminated groundwater to the levels provided for under § 192.02(c)(3). These levels are either background concentrations, the levels specified in Table 1 in the rule, or ACLs. In cases where the groundwater is not classified as of limited use, any ACL should be determined under the assumption that the groundwater may be used for drinking purposes. In certain circumstances, however, supplemental standards set at levels that would be achieved by remedial actions that come as close to meeting the otherwise applicable standards as is reasonably achievable under the circumstances may be appropriate. Such supplemental standards and ACLs are distinct regulatory provisions and may be considered independently. The regulations provide that supplemental standards may be granted if:

- Groundwater at the site is of limited use (§ 192.11(e)) in the absence of contamination from residual radioactive materials; or
- Complete restoration would cause more environmental harm than it would prevent; or
- Complete restoration is technically impracticable from an engineering perspective.

The use of supplemental standards for limited use groundwater applies the groundwater classification system proposed in EPA's 1984 Groundwater Protection Strategy. As proposed for use in these standards (52 FR 36003, September 24, 1987), Class III encompasses groundwaters that are not a current or potential source of drinking water because of widespread, ambient contamination caused by natural or human-induced conditions, or cannot provide enough water to meet the needs of an average household. These standards adopt the proposed definition of limited use groundwater. However, for the purpose of qualifying for supplemental standards, human-induced conditions exclude contributions from residual radioactive materials.

Water which meets the definition of limited use groundwater may, nevertheless, reasonably be or be projected to be useful for domestic, agricultural, or industrial purposes. For example, in some locations higher quality water may be scarce or absent. Therefore, § 192.22(d) requires the implementing agencies to remove any additional contamination that has been contributed by residual radioactive materials to the extent that is necessary to preserve existing or reasonably projected beneficial uses in areas of limited water supplies. At a minimum, at sites with limited use groundwater, the supplemental standards require such management of contamination due to tailings as is required to assure protection of human health and the environment from that contamination. For example, if the additional contamination from the tailings would cause an adverse effect on drinkable groundwater that has a significant interconnection with limited use groundwater over which the tailings reside, then the additional contamination from the tailings will have to be abated.

Supplemental standards are also appropriate in certain other cases similar to those addressed in Section 121(d)(4) of the Superfund Amendments and Reauthorization Act of 1986 (SARA). SARA recognizes that cleanup of contamination could sometimes cause environmental harm disproportionate to the effects it would alleviate. For example, if fragile ecosystems would be impaired by any reasonable restoration process (or by carrying a restoration process to extreme lengths to remove small amounts of residual contamination), then it might be prudent not to completely restore groundwater quality. Such a situation might occur, for example, if the quantity of water that would be lost during remediation is a significant fraction of that available in an aquifer that recharges very slowly. Decisions regarding tradeoffs of environmental damage can only be based on characteristics peculiar to the specific location of the site. We do not yet know whether such situations exist in the UMTRCA program, but EPA believes that use of supplemental standards should be possible in such situations, after thorough investigation and consideration of all reasonable restoration alternatives.

Based on currently available information, we are not aware that at least substantial restoration of groundwater quality is technically impracticable from an engineering perspective at any of the designated sites. However, our information is incomplete. For example, there may not be enough water available in a very small aquifer to carry out remediation and retain the groundwater resource, or, in other cases, some contaminants may not be removable without destroying the aquifer. EPA believes that DOE should not be required to institute active measures that would completely restore groundwater at these sites if such restoration is technically impracticable from an engineering perspective, and if, at a minimum, protection of human health and the environment is assured. Consistent with the provisions of SARA for remediation of waste sites generally, the standards therefore permit supplemental standards in such situations at levels achievable by site-specific alternate remedial actions. A finding of technical impracticability from an engineering perspective requires careful and extensive documentation, including an analysis of the degree to which remediation is practicable. It should be noted that the phrase "technically impracticable from an engineering perspective" means that the remedial action cannot reasonably be put into practice; it does not mean a conclusion derived from the balancing of costs and benefits. In addition to documentation of technical matters related to cleanup technology, DOE should also include a detailed assessment of such site-specific matters as transmissivity of the geologic formation, aquifer recharge and storage, contaminant properties (e.g., withdrawal and treatability potential), and the extent of contamination.

Finally, for aquifers where compliance with the groundwater standards can be projected to occur naturally within a period of less than 100 years, and where the groundwater is not now used for a public water system and is not now projected to be so used within this period, this rule permits extension of the remedial period to that time, provided institutional control and an adequate verification plan which assures satisfaction of beneficial uses is established and maintained throughout this extended remedial period.

Active restoration should be carefully considered when evaluating the use of such passive restoration. The provision to permit reliance on natural restoration is based on the judgment that sole reliance on active cleanup may not always be warranted under these standards promulgated pursuant to UMTRCA. This may be the case for situations where active cleansing to completely achieve the standards is impracticable, environmentally damaging, or excessively costly, if groundwater can reach the levels required by the standards through natural flushing within an acceptable period of time. This mechanism may be considered where groundwater concentration limits can be met through partial (or complete) reliance on natural processes and no use of the water as a source for a public water system exists or is projected. Any institutional control that may be required to effectively protect public health and the environment and assure that beneficial uses that the water could have satisfied are provided for in the interim must be verified for effectiveness and modified as necessary. Alternate standards are not required where final cleanup is to be accomplished through natural flushing, since those established under § 192.02(c)(3) must be met at the end of the remedial period.

The regulations establish a time limit on such extension of the remedial period to limit reliance on extended use of institutional controls to manage public access to contaminated groundwater. Following the precedent established by our rule for high-level radioactive wastes (40 CFR 191.14(a)), use of institutional controls is permitted for this purpose only when they will be needed for periods of less than 100 years.

The effectiveness of institutional controls must be verified and maintained over the entire period of time that they are in use. Examples of acceptable measures include use restrictions enforceable by the administrative or judicial branches of government entities, and measures with a high degree of permanence, such as Federal or State ownership of the land containing the contaminated water. In some instances, a combination of institutional controls may be needed to provide adequate protection, such as providing an alternate source of water for drinking or other beneficial uses and restricting inappropriate use of contaminated groundwater. However, institutional control provisions are not intended to require DOE to provide water for uses that the groundwater would not have been available or suitable for in the absence of contamination from residual radioactive materials. Institutional controls that are not adequate by themselves include such measures as health advisories, signs, posts, admonitions, or any other measure that requires the voluntary cooperation of private parties. However, such measures may be used to complement other enforceable institutional controls.

Restoration of groundwater may be carried out by removal, wherein the contaminated water is removed from the aquifer, treated, and either disposed of, used, or re-injected into the aquifer, and *in situ*, through the addition of chemical or biological agents to fix, reduce, or eliminate the contamination in place. Appropriate restoration will depend on characteristics of specific sites and may involve use of a combination of methods. Water can be removed from an aquifer by pumping it out through wells or by collecting the water from intercept trenches. Slurry walls can sometimes be put in place to contain contamination and prevent further migration of contaminants, so that the volume of contaminated water that must be treated is reduced. The background information document contains a more extensive discussion of candidate restoration methods.

Previously EPA reviewed preliminary information for all 24 sites and detailed information for 14 to make a preliminary assessment of the extent of the potential applicability of supplemental standards and the use of passive remediation. Approximately two-thirds of the sites appear to be located over potable (or otherwise useful) groundwater and the balance over limited use groundwaters. DOE, based on more recent information, feels that up to ten sites are candidates for supplemental standards, and that the rate at which natural flushing is occurring at up to eight of the sites permits consideration of passive remediation under institutional control as the sole remedial method. Some sites exhibit conditions that could be amenable to a combination of strategies. Further, EPA is not able to predict the applicability of provisions regarding technical impracticability or excess environmental harm, since this requires detailed analysis of specific sites, but anticipates that wide application is unlikely. It is emphasized that the above assessment is not based on final results for the vast majority of these sites, and is, therefore, subject to change.

RCRA regulations, for hazardous waste disposal units regulated by EPA, provide that acceptable concentrations of constituents in groundwater (including ACLs) are determined by the Regional Administrator (or an authorized State). EPA's regulations under Title II of UMTRCA provide that the NRC, which regulates active sites, replace the EPA Regional Administrator for the above functions when any contamination permitted by an ACL will remain on the licensed site or within 500 meters of the disposal area, whichever is closer. Because Section 108(a) of UMTRCA requires the Commission's concurrence with DOE's selection and performance of remedial actions to conform to EPA's standards, this rule makes the same provision for administration by the NRC of those functions for Title I as it did in the case of the Title II standards, and also provides for NRC concurrence on supplemental standards.

V. Implementation

UMTRCA requires the Secretary of Energy to select and perform the remedial actions needed to implement these standards, with the full participation of any State that shares the cost. The NRC must concur with these actions and, when appropriate, the Secretary of Energy must also consult with affected Indian tribes and the Secretary of the Interior.

The cost of remedial actions is being borne by the Federal Government and the States as prescribed by UMTRCA. The clean-up of groundwater is a large-scale undertaking for which there is relatively little long-term experience. Groundwater conditions at the inactive processing sites vary greatly, and, as noted above, engineering experience with some of the required remedial actions is limited. Although preliminary engineering assessments have been performed, specific engineering requirements and detailed costs to meet the groundwater standards at each site have yet to be determined. We believe that costs averaging about 10–15 million (1993) dollars for each of the approximately fourteen tailings sites at which remedial action may be required are most likely.

The benefits from the cleanup of this groundwater are difficult to quantify. In some instances, groundwater that is contaminated by tailings is now in use and will be restored. Future uses that will be preserved by cleanup are difficult to project. In the areas where the tailings were processed, groundwater is an important resource due to the arid condition of the land. However, much of the contamination at these sites occurs in shallow alluvial aquifers. At some of these sites such aquifers have limited use because of their generally poor quality and the availability of better quality water from deeper aquifers.

Implementation of the disposal standard for protection of groundwater will require a judgment that the method chosen provides a reasonable expectation that the provisions of the standard will be met, to the extent reasonably achievable, for up to 1000 years and, in any case, for at least 200 years. This judgment will necessarily be based on site-specific analyses of the properties of the sites, candidate disposal systems, and the potential effects of natural processes over time. Therefore, the measures required to satisfy the standard will vary from site to site. Actual site data, computational models, and expert judgment will be the major tools in deciding that a proposed disposal system will satisfy the standard.

The purpose of the groundwater cleanup standard is to provide the maximum reasonable protection of public health and the environment. Costs incurred by remedial actions should be directed toward this purpose. We intend the standards to be implemented using verification procedures whose cost and technical requirements are reasonable. Procedures that provide a reasonable assurance of compliance with the standards will be adequate. Measurements to assess existing contamination and to determine compliance with the cleanup standards should be performed with 1 reasonable survey and sampling procedures designed to minimize the cost of verification.

The explanations regarding implementation of these regulations in §§ 192.20(a)(2) and (3) have been revised to remove those provisions that the Court remanded and to reflect these new requirements.

These standards are not expected to affect the disposal work DOE has already performed on tailings. On the basis of consultations with DOE and NRC, we expect, in general, that a pile designed to comply with the disposal standards proposed on September 24, 1987, will also comply with these disposal standards for the control of groundwater contamination. DOE will have to determine, with the concurrence of the NRC, what additional work may be needed to comply with the groundwater cleanup requirements. However, any such cleanup work should not adversely affect the control systems for tailings piles that have already been or are currently being installed.

However, at three sites (Canonsburg, PA; Shiprock, NM; and Salt Lake City, UT) the disposal design was based on standards remanded in part on September 3, 1985. We have considered these sites separately, based on information supplied by DOE, and reached the tentative conclusion that modification of the existing disposal cells is not warranted at any of them. Final determinations will be made by DOE, with the concurrence of NRC.

The disposal site at Canonsburg, PA, is located above the banks of Chartiers Creek. Contamination that might seep from the encapsulated tailings will reach the surface within the site boundary, and is then diluted by water in the creek to insignificant levels. Under these circumstances, this site qualifies for an ACL under § 192.02(c)(3)(ii), and modification of the existing disposal cell is not warranted.

The site at Shiprock, NM, which is located above the floodplain of the San Juan River, is over an aquifer that may not be useful as a source of water for drinking or other beneficial purpose because of its quality, areal extent, and yield. Most of the groundwater in this aquifer appears to have originated from seepage of tailings liquor from mill impoundments and not to be contributing to contamination of any currently or potentially useful aquifer Additionally, the quality of this water may be degraded by uncontrolled disposal of municipal refuse north and south of the site. DOE is currently in the process of completing its characterization of this groundwater, and may or may not recommend use of a supplemental standard under § 192.21(g). In any case, however, it appears unlikely that modification of the existing disposal cell will be necessary.

The site containing the tailings from the Salt Lake City mill is located at Clive, Utah, over groundwater that contains dissolved solids in excess of 10,000 mg/l and is not contributing to contamination of any currently or potentially useful aquifer. Under these circumstances, this site also qualifies for a supplemental standard under § 192.21(g), and modification of the existing disposal cell is not warranted.

VI. Relationship to Other Policy and Requirements

In July 1991 EPA completed development of a strategy to guide future EPA and State activities in groundwater protection and cleanup. A key element of this strategy is a statement of 'EPA Groundwater Protection Principles' [1] that has as its overall goals the prevention of adverse effects on human health and the environment and protection of the environmental integrity of the nation's groundwater resources. To achieve these

[1] *Protecting the Nation's Groundwater: EPA's Strategy for the 1990s*, The Final Report of the EPA Groundwater Task Force, U.S. Environmental Protection Agency, Washington, (Report 21Z–1020), July 1991

goals, EPA developed principles regarding prevention; remediation; and Federal, State, and local responsibilities. These principles are set forth and their implementation by this rule summarized below.

(1) With respect to prevention: groundwater should be protected to ensure that the nation's currently used and reasonably expected drinking water supplies, both public and private, do not present adverse health risks and are preserved for present and future generations. Groundwater should also be protected to ensure that groundwater that is closely hydrologically connected to surface waters does not interfere with the attainment of surface water quality standards, which is necessary to protect the integrity of associated ecosystems. Groundwater protection can be achieved through a variety of means including: pollution prevention programs; source controls; siting controls; the designation of wellhead protection areas and future public water supply areas; and the protection of aquifer recharge areas. Efforts to protect groundwater must also consider the use, value, and vulnerability of the resource, as well as social and economic values.

This rule for uranium mill tailings protects groundwater by requiring that disposal piles be designed to avoid any new contamination of groundwater that would threaten human health or the environment in the future. Water is scarce in the Western States where these disposal sites occur. Currently almost half of the water consumed in Arizona and New Mexico and 20 to 30 percent of the water consumed in Utah, Colorado, Idaho, and Texas is groundwater. The population in the Mountain States is expected to increase more than that of any other region between now and the year 2010. In particular, the population in Colorado, New Mexico, Arizona, and Utah is expected to increase dramatically. Thus, in order to ensure that all currently used and reasonably expected drinking water supplies near these sites, both public and private, are adequately protected for use by present and future generations, these rules apply drinking water standards to all potable groundwater The rule also requires that hydrologically-connected aquifers and surface waters, including designated wellhead protection areas and future public water supply areas, be identified and protected, and that other beneficial uses of groundwater besides drinking be identified and protected, including the integrity of associated ecosystems. In this regard we note that DOE has not identified any critical aquatic habitats that have been or could be adversely affected by contamination from these sites.

(2) With respect to remediation: groundwater remediation activities must be prioritized to limit the risk of adverse effects to human health risks first and then to restore currently used and reasonably expected sources of drinking water and groundwater closely hydrologically connected to surface waters, whenever such restorations are practicable and attainable.

Pursuant to our responsibilities under Section 102(b) of UMTRCA, EPA advised DOE in 1979 concerning the criteria which should govern the order in which these sites should be cleaned up. Those criteria specified, in essence, that sites capable of affecting the health of human populations the most should be remediated first. As a result DOE has divided the 24 sites into three levels of priority, based on the populations affected. In order to facilitate implementation of these principles, we have, in this rule, provided DOE with flexibility to prioritize their cleanup activities so as to first minimize human exposure, then restore reasonably expected drinking water sources, and finally to clean up groundwater only when restoration is practicable and attainable. This has been done by relaxing the requirements for cleanup of water:

(a) If it is not a current or potential source of drinking water (i.e., it meets the definition of limited use),

(b) Where natural processes will achieve the standards and there is no current or planned use,

(c) Where adverse environmental impact will occur, and (d) where cleanup is technologically impracticable.

(3) With respect to Federal, State, and local responsibilities: the primary responsibility for coordinating and implementing groundwater protection programs has always been and should continue to be vested with the States. An effective groundwater protection program should link Federal, State, and local activities into a coherent and coordinated plan of action. EPA should continue to improve coordination of groundwater protection efforts within the Agency and with other Federal agencies with groundwater responsibilities.

In the case of the sites covered by these regulations, UMTRCA specifies a primary role for Federal rather than State agencies. However, since these regulations are modeled after existing RCRA regulations, this will serve to insure coherence and coordination with similar prevention and remediation actions by EPA, the States, and other Federal agencies. For example, the concentration limits in groundwater for listed constituents at the sites covered by this rule are the same as those specified for cleanup and disposal at RCRA sites by EPA and the States and at uranium mill sites licensed by NRC.

Executive Order 12866

Under Executive Order 12866 (58 FR 51735; October 4, 1993), EPA must determine whether a rule is "significant" and therefore subject to review by the Office of Management and Budget (OMB) and the requirements of the Executive Order. The Order defines "significant regulatory action" as one that is likely to result in a rule that may:

(1) Have an annual effect on the economy of $100 million or more or adversely effect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local or tribal governments or communities;

(2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

(3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of the recipients thereof; or

(4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

Pursuant to the terms of Executive Order 12866, it has been determined that this rule is may be a "significant regulatory action," because it may qualify under criterion #4 above on the basis of comments submitted to EPA by letter on January 15, 1993, as a result of OMB review under the previous Executive Order 12291. This action was therefore resubmitted to OMB for review. Comments from OMB to EPA for their review under the previous Executive Order and EPA's response to those comments are included in the docket. Any changes made in response to OMB suggestions or recommendations as a result of the current review will be documented in the public record.

Paperwork Reduction Act

Under the Paperwork Reduction Act of 1986, the Agency is required to state the information collection requirements of any standard published on or after July 1, 1988. In response to this requirement, this standard contains no information collection requirements and imposes no reporting burden on the public.

List of Subjects in 40 CFR Part 192

Environmental protection, Groundwater, Radiation protection, Uranium.

Dated: December 14, 1994.

Carol M. Browner,

Administrator, Environmental Protection Agency.

For the reasons set forth in the preamble, 40 CFR part 192 is amended as follows:

PART 192—HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM AND THORIUM MILL TAILINGS

1. The authority citation for part 192 continues to read as follows:

Authority: Section 275 of the Atomic Energy Act of 1954, 42 U.S.C. 2022, as added by the Uranium Mill Tailings Radiation Control Act of 1978, Pub. L. 95–604, as amended.

Subpart A—Standards for the Control of Residual Radioactive Materials From Inactive Uranium Processing Sites

2. Section 192.01 is amended by revising paragraphs (a) and (e) and adding paragraphs (g) through (r) to read as follows:

§ 192.01 Definitions.

(a) *Residual radioactive material* means:

(1) Waste (which the Secretary determines to be radioactive) in the form of tailings resulting from the processing of ores for the extraction of uranium and other valuable constituents of the ores; and

(2) Other wastes (which the Secretary determines to be radioactive) at a processing site which relate to such processing, including any residual stock of unprocessed ores or low-grade materials.

* * * * *

(e) *Depository site* means a site (other than a processing site) selected under Section 104(b) or 105(b) of the Act.

* * * * *

(g) *Act* means the Uranium Mill Tailings Radiation Control Act of 1978, as amended.

(h) *Administrator* means the Administrator of the Environmental Protection Agency.

(i) *Secretary* means the Secretary of Energy.

(j) *Commission* means the Nuclear Regulatory Commission.

(k) *Indian tribe* means any tribe, band, clan, group, pueblo, or community of Indians recognized as eligible for services provided by the Secretary of the Interior to Indians.

(l) *Processing site* means:

(1) Any site, including the mill, designated by the Secretary under Section 102(a)(1) of the Act; and

(2) Any other real property or improvement thereon which is in the vicinity of such site, and is determined by the Secretary, in consultation with the Commission, to be contaminated with residual radioactive materials derived from such site.

(m) *Tailings* means the remaining portion of a metal-bearing ore after some or all of such metal, such as uranium, has been extracted.

(n) *Disposal period* means the period of time beginning March 7, 1983 and ending with the completion of all subpart A requirements specified under a plan for remedial action except those specified in § 192.03 and § 192.04.

(o) *Plan for remedial action* means a written plan (or plans) for disposal and cleanup of residual radioactive materials associated with a processing site that incorporates the results of site characterization studies, environmental assessments or impact statements, and engineering assessments so as to satisfy the requirements of subparts A and B of this part. The plan(s) shall be developed in accordance with the provisions of Section 108(a) of the Act with the concurrence of the Commission and in consultation, as appropriate, with the Indian Tribe and the Secretary of Interior.

(p) *Post-disposal period* means the period of time beginning immediately after the disposal period and ending at termination of the monitoring period established under § 192.03.

(q) *Groundwater* means water below the ground surface in a zone of saturation.

(r) *Underground source of drinking water* means an aquifer or its portion:

(1)(i) Which supplies any public water system as defined in § 141.2 of this chapter; or

(ii) Which contains a sufficient quantity of groundwater to supply a public water system; and

(A) Currently supplies drinking water for human consumption; or

(B) Contains fewer than 10,000 mg/l total dissolved solids; and

(2) Which is not an exempted aquifer as defined in § 144.7 of this chapter.

3. Section 192.02 is revised to read as follows:

§ 192.02 Standards.

Control of residual radioactive materials and their listed constituents shall be designed [1] to:

(a) Be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,

(b) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:

(1) Exceed an average [2] release rate of 20 picocuries per square meter per second, or

(2) Increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter.

(c) Provide reasonable assurance of conformance with the following groundwater protection provisions:

(1) The Secretary shall, on a site-specific basis, determine which of the constituents listed in Appendix I to Part 192 are present in or reasonably derived from residual radioactive materials and shall establish a monitoring program adequate to determine background levels of each such constituent in groundwater at each disposal site.

(2) The Secretary shall comply with conditions specified in a plan for remedial action which includes engineering specifications for a system of disposal designed to ensure that constituents identified under paragraph (c)(1) of this section entering the groundwater from a depository site (or a processing site, if residual radioactive materials are retained on the site) will not exceed the concentration limits established under paragraph (c)(3) of this section (or the supplemental standards established under § 192.22) in the uppermost aquifer underlying the site beyond the point of compliance established under paragraph (c)(4) of this section.

(3) Concentration limits:

(i) Concentration limits shall be determined in the groundwater for listed constituents identified under paragraph (c)(1) of this section. The concentration of a listed constituent in groundwater must not exceed:

(A) The background level of that constituent in the groundwater; or

(B) For any of the constituents listed in Table 1 to subpart A, the respective value given in that Table if the background level of the constituent is below the value given in the Table; or

(C) An alternate concentration limit established pursuant to paragraph (c)(3)(ii) of this section.

(ii)(A) The Secretary may apply an alternate concentration limit if, after

[1] Because the standard applies to design, monitoring after disposal is not required to demonstrate compliance with respect to § 192.02(a) and (b).

[2] This average shall apply over the entire surface of the disposal site and over at least a one-year period. Radon will come from both residual radioactive materials and from materials covering them. Radon emissions from the covering materials should be estimated as part of developing a remedial action plan for each site. The standard, however, applies only to emissions from residual radioactive materials to the atmosphere.

considering remedial or corrective actions to achieve the levels specified in paragraphs (c)(3)(i)(A) and (B) of this section, he has determined that the constituent will not pose a substantial present or potential hazard to human health and the environment as long as the alternate concentration limit is not exceeded, and the Commission has concurred.

(B) In considering the present or potential hazard to human health and the environment of alternate concentration limits, the following factors shall be considered:

(*1*) Potential adverse effects on groundwater quality, considering:

(*i*) The physical and chemical characteristics of constituents in the residual radioactive material at the site, including their potential for migration:

(*ii*) The hydrogeological characteristics of the site and surrounding land;

(*iii*) The quantity of groundwater and the direction of groundwater flow;

(*iv*) The proximity and withdrawal rates of groundwater users;

(*v*) The current and future uses of groundwater in the region surrounding the site;

(*vi*) The existing quality of groundwater, including other sources of contamination and their cumulative impact on the groundwater quality;

(*vii*) The potential for health risks caused by human exposure to constituents;

(*viii*) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to constituents;

(*ix*) The persistence and permanence of the potential adverse effects;

(*x*) The presence of underground sources of drinking water and exempted aquifers identified under § 144.7 of this chapter; and

(*2*) Potential adverse effects on hydraulically-connected surface-water quality, considering:

(*i*) The volume and physical and chemical characteristics of the residual radioactive material at the site;

(*ii*) The hydrogeological characteristics of the site and surrounding land;

(*iii*) The quantity and quality of groundwater, and the direction of groundwater flow;

(*iv*) The patterns of rainfall in the region;

(*v*) The proximity of the site to surface waters;

(*vi*) The current and future uses of surface waters in the region surrounding the site and any water quality standards established for those surface waters;

(*vii*) The existing quality of surface water, including other sources of contamination and their cumulative impact on surface water quality;

(*viii*) The potential for health risks caused by human exposure to constituents;

(*ix*) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to constituents; and

(*x*) The persistence and permanence of the potential adverse effects.

(4) Point of compliance: The point of compliance is the location at which the groundwater concentration limits of paragraph (c)(3) of this section apply. The point of compliance is the intersection of a vertical plane with the uppermost aquifer underlying the site, located at the hydraulically downgradient limit of the disposal area plus the area taken up by any liner, dike, or other barrier designed to contain the residual radioactive material.

(d) Each site on which disposal occurs shall be designed and stabilized in a manner that minimizes the need for future maintenance.

4. Section 192.03 is added to read as follows:

§ 192.03 Monitoring.

A groundwater monitoring plan shall be implemented, to be carried out over a period of time commencing upon completion of remedial actions taken to comply with the standards in § 192.02, and of a duration which is adequate to demonstrate that future performance of the system of disposal can reasonably be expected to be in accordance with the design requirements of § 192.02(c). This plan and the length of the monitoring period shall be modified to incorporate any corrective actions required under § 192.04 or § 192.12(c).

5. Section 192.04 is added to read as follows:

§ 192.04 Corrective Action.

If the groundwater concentration limits established for disposal sites under provisions of § 192.02(c) are found or projected to be exceeded, a corrective action program shall be placed into operation as soon as is practicable, and in no event later than eighteen (18) months after a finding of exceedance. This corrective action program will restore the performance of the system of disposal to the original concentration limits established under § 192.02(c)(3), to the extent reasonably achievable, and, in any case, as a minimum shall:

(a) Conform with the groundwater provisions of § 192.02(c)(3), and

(b) Clean up groundwater in conformance with subpart B, modified as appropriate to apply to the disposal site.

6. Table 1 is added to subpart A to read as follows:

TABLE 1 TO SUBPART A.—MAXIMUM CONCENTRATION OF CONSTITUENTS FOR GROUNDWATER PROTECTION

Constituent concentration [1]	Maximum
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Nitrate (as N)	10.
Molybdenum	0.1
Combined radium-226 and radium-228.	5 pCi/liter
Combined uranium-234 and uranium-238 [2]	30 pCi/liter
Gross alpha-particle activity (excluding radon and uranium).	15 pCi/liter
Endrin (1,2,3,4,10,10-hexachloro-6,7-exposy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo,endo-5,8-dimethanonaphthalene).	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma insomer).	0.004
Methoxychlor (1,1,1-trichloro-2,2'-bis(p-methoxyphenylethane)).	0.1
Toxaphene ($C_{10}H_{10}Cl_6$, technical chlorinated camphene, 67–69 percent chlorine).	0.005
2,4-D (2,4-dichlorophenoxyacetic acid).	0.1
2,4,5-TP Silvex (2,4,5-trichlorophenoxypropionic acid).	0.01

[1] Milligrams per liter, unless stated otherwise.

[2] Where secular equilibrium obtains, this criterion will be satisfied by a concentration of 0.044 milligrams per liter (0.044 mg/l). For conditions of other than secular equilibrium, a corresponding value may be derived and applied, based on the measured site-specific ratio of the two isotopes of uranium.

Subpart B—Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites

7. Section 192.11 is amended by revising paragraph (a) and adding paragraph (e) to read as follows:

192.11 Definitions.

(a) Unless otherwise indicated in this subpart, all terms shall have the same meaning as defined in subpart A.

* * * * *

(e) *Limited use groundwater* means groundwater that is not a current or potential source of drinking water because (1) the concentration of total dissolved solids is in excess of 10,000 mg/l, or (2) widespread, ambient contamination not due to activities involving residual radioactive materials from a designated processing site exists that cannot be cleaned up using treatment methods reasonably employed in public water systems, or (3) the quantity of water reasonably available for sustained continuous use is less than 150 gallons per day. The parameters for determining the quantity of water reasonably available shall be determined by the Secretary with the concurrence of the Commission.

8. In § 192.12, the introductory text is republished without change and paragraph (c) is added to read as follows:

192.12 Standards.

Remedial actions shall be conducted so as to provide reasonable assurance that, *as a result of residual radioactive materials from any designated processing site:*

* * * * *

(c) The Secretary shall comply with conditions specified in a plan for remedial action which provides that contamination of groundwater by listed constituents from residual radioactive material at any designated processing site (§ 192.01(1)) shall be brought into compliance as promptly as is reasonably achievable with the provisions of § 192.02(c)(3) or any supplemental standards established under § 192.22. For the purposes of this subpart:

(1) A monitoring program shall be carried out that is adequate to define backgroundwater quality and the areal extent and magnitude of groundwater contamination by listed constituents from residual radioactive materials (§ 192.02(c)(1)) and to monitor compliance with this subpart. The Secretary shall determine which of the constituents listed in Appendix I to part 192 are present in or could reasonably be derived from residual radioactive material at the site, and concentration limits shall be established in accordance with § 192.02(c)(3).

(2) (i) If the Secretary determines that sole reliance on active remedial procedures is not appropriate and that cleanup of the groundwater can be more reasonably accomplished in full or in part through natural flushing, then the period for remedial procedures may be extended. Such an extended period may extend to a term not to exceed 100 years if:

(A) The concentration limits established under this subpart are projected to be satisfied at the end of this extended period,

(B) Institutional control, having a high degree of permanence and which will effectively protect public health and the environment and satisfy beneficial uses of groundwater during the extended period and which is enforceable by the administrative or judicial branches of government entities, is instituted and maintained, as part of the remedial action, at the processing site and wherever contamination by listed constituents from residual radioactive materials is found in groundwater, or is projected to be found, and

(C) The groundwater is not currently and is not now projected to become a source for a public water system subject to provisions of the Safe Drinking Water Act during the extended period.

(ii) Remedial actions on groundwater conducted under this subpart may occur before or after actions under Section 104(f)(2) of the Act are initiated.

(3) Compliance with this subpart shall be demonstrated through the monitoring program established under paragraph (c)(1) of this section at those locations not beneath a disposal site and its cover where groundwater contains listed constituents from residual radioactive material.

Subpart C—Implementation

9. In § 192.20, paragraphs (a)(2) and (a)(3) and the first sentence of paragraph (b)(l) are revised and paragraphs (a)(4) and (b)(4) are added to read as follows:

192.20 Guidance for implementation.

* * * * *

(a)(1) * * *

(2) Protection of water should be considered on a case-specific basis, drawing on hydrological and geochemical surveys and all other relevant data. The hydrologic and geologic assessment to be conducted at each site should include a monitoring program sufficient to establish background groundwater quality through one or more upgradient or other appropriately located wells. The groundwater monitoring list in Appendix IX of part 264 of this chapter (plus the additional constituents in Table A of this paragraph) may be used for screening purposes in place of Appendix I of part 192 in the monitoring program. New depository sites for tailings that contain water at greater than the level of "specific retention" should use aliner or equivalent. In considering design objectives for groundwater protection, the implementing agencies should give priority to concentration levels in the order listed under § 192.02(c)(3)(i). When considering the potential for health risks caused by human exposure to known or suspected carcinogens, alternate concentration limits pursuant to paragraph 192.02(c)(3)(ii) should be established at concentration levels which represent an excess lifetime risk, at a point of exposure, to an average individual no greater than between 10^{-4} and 10^{-6}.

TABLE A TO § 192.20(a)(2)—ADDITIONAL LISTED CONSTITUENTS

Nitrate (as N)
Molybdenum
Combined radium-226 and radium-228
Combined uranium-234 and uranium-238
Gross alpha-particle activity (excluding radon and uranium)

(3) The plan for remedial action, concurred in by the Commission, will specify how applicable requirements of subpart A are to be satisfied. The plan should include the schedule and steps necessary to complete disposal operations at the site. It should include an estimate of the inventory of wastes to be disposed of in the pile and their listed constituents and address any need to eliminate free liquids; stabilization of the wastes to a bearing capacity sufficient to support the final cover; and the design and engineering specifications for a cover to manage the migration of liquids through the stabilized pile, function without maintenance, promote drainage and minimize erosion or abrasion of the cover, and accommodate settling and subsidence so that cover integrity is maintained. Evaluation of proposed designs to conform to subpart A should be based on realistic technical judgments and include use of available empirical information. The consideration of possible failure modes and related corrective actions should be limited to reasonable failure assumptions, with a demonstration that the disposal design is generally amenable to a range of corrective actions.

(4) The groundwater monitoring list in Appendix IX of part 264 of this chapter (plus the additional constituents in Table A in paragraph (a)(2) of this section) may be used for screening purposes in place of Appendix I of part 192 in monitoring programs. The monitoring plan required under § 192.03 should be designed to include verification of site-specific assumptions used to project the performance of the disposal system. Prevention of

contamination of groundwater may be assessed by indirect methods, such as measuring the migration of moisture in the various components of the cover, the tailings, and the area between the tailings and the nearest aquifer, as well as by direct monitoring of groundwater. In the case of vicinity properties (§ 192.01(l)(2)), such assessments may not be necessary, as determined by the Secretary, with the concurrence of the Commission, considering such factors as local geology and the amount of contamination present. Temporary excursions from applicable limits of groundwater concentrations that are attributable to a disposal operation itself shall not constitute a basis for considering corrective action under § 192.04 during the disposal period, unless the disposal operation is suspended prior to completion for other than seasonal reasons.

(b)(l) Compliance with § 192.12(a) and (b) of subpart B, to the extent practical, should be demonstrated through radiation surveys. * * *

* * * * *

(4) The plan(s) for remedial action will specify how applicable requirements of subpart B would be satisfied. The plan should include the schedule and steps necessary to complete the cleanup of groundwater at the site. It should document the extent of contamination due to releases prior to final disposal, including the identification and location of listed constituents and the rate and direction of movement of contaminated groundwater, based upon the monitoring carried out under § 192.12(c)(1). In addition, the assessment should consider future plume movement, including an evaluation of such processes as attenuation and dilution and future contamination from beneath a disposal site. Monitoring for assessment and compliance purposes should be sufficient to establish the extent and magnitude of contamination, with reasonable assurance, through use of a carefully chosen minimal number of sampling locations. The location and number of monitoring wells, the frequency and duration of monitoring, and the selection of indicator analytes for long-term groundwater monitoring, and, more generally, the design and operation of the monitoring system, will depend on the potential for risk to receptors and upon other factors, including characteristics of the subsurface environment, such as velocity of groundwater flow, contaminant retardation, time of groundwater or contaminant transit to receptors, results of statistical evaluations of data trends, and modeling of the dynamics of the groundwater system. All of these factors should be incorporated into the design of a site-specific monitoring program that will achieve the purpose of the regulations in this subpart in the most cost-effective manner. In the case of vicinity properties (§ 192.01(l)(2)), such assessments will usually not be necessary. The Secretary, with the concurrence of the Commission, may consider such factors as local geology and amount of contamination present in determining criteria to decide when such assessments are needed. In cases where § 192.12(c)(2) is invoked, the plan should include a monitoring program sufficient to verify projections of plume movement and attenuation periodically during the extended cleanup period. Finally, the plan should specify details of the method to be used for cleanup of groundwater.

10. In § 192.21, the introductory text and paragraph (b) are revised, paragraph (f) is redesignated as paragraph (h), and new paragraphs (f) and (g) are added to read as follows:

§ 192.21 Criteria for applying supplemental standards

Unless otherwise indicated in this subpart, all terms shall have the same meaning as defined in Title I of the Act or in subparts A and B. The implementing agencies may (and in the case of paragraph (h) of this section shall) apply standards under § 192.22 in lieu of the standards of subparts A or B if they determine that any of the following circumstances exists:

* * * * *

(b) Remedial actions to satisfy the cleanup standards for land, § 192.12(a), and groundwater, § 192.12(c), or the acquisition of minimum materials required for control to satisfy §§ 192.02(b) and (c), would, notwithstanding reasonable measures to limit damage, directly produce health and environmental harm that is clearly excessive compared to the health and environmental benefits, now or in the future. A clear excess of health and environmental harm is harm that is long-term, manifest, and grossly disproportionate to health and environmental benefits that may reasonably be anticipated.

* * * * *

(f) The restoration of groundwater quality at any designated processing site under § 192.12(c) is technically impracticable from an engineering perspective.

(g) The groundwater meets the criteria of § 192.11(e).

* * * * *

11. In § 192.22, paragraphs (a) and (b) are revised and paragraph (d) is added to read as follows:

192.22 Supplemental standards.

* * * * *

(a) When one or more of the criteria of § 192.21(a) through (g) applies, the Secretary shall select and perform that alternative remedial action that comes as close to meeting the otherwise applicable standard under § 192.02(c)(3) as is reasonably achievable.

(b) When § 192.21(h) applies, remedial actions shall reduce other residual radioactivity to levels that are as low as is reasonably achievable and conform to the standards of subparts A and B to the maximum extent practicable.

* * * * *

(d) When § 192.21(b), (f), or (g) apply, implementing agencies shall apply any remedial actions for the restoration of contamination of groundwater by residual radioactive materials that is required to assure, at a minimum, protection of human health and the environment. In addition, when § 192.21(g) applies, supplemental standards shall ensure that current and reasonably projected uses of the affected groundwater are preserved.

12. Appendix I is added to part 192 to read as follows:

Appendix I to Part 192—Listed Constituents

Acetonitrile
Acetophenone (Ethanone, 1-phenyl)
2-Acetylaminofluorene (Acetamide, N-9H-fluoren-2-yl-)
Acetyl chloride
1-Acetyl-2-thiourea (Acetamide, N-(aminothioxymethyl)-)
Acrolein (2-Propenal)
Acrylamide (2-Propenamide)
Acrylonitrile (2-Propenenitrile)
Aflatoxins
Aldicarb (Propenal, 2-methyl-2-(methylthio)-,O-[(methylamino)carbonyl]oxime
Aldrin (1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro(1α,4α,4aβ,5α,8α,8aβ)-)
Allyl alcohol (2-Propen-1-ol)
Allyl chloride (1-Propane,3-chloro)
Aluminum phosphide
4-Aminobiphenyl ([1,1'-Biphenyl]-4-amine)
5-(Aminomethyl)-3-isoxazolol (3(2H)-Isoxazolone,5-(aminomethyl)-)
4-Aminopyridine (4-Pyridineamine)
Amitrole (lH-1,2,4-Triazol-3-amine)
Ammonium vanadate (Vanadic acid, ammonium salt)
Aniline (Benzenamine)
Antimony and compounds, N.O.S.[1]

[1] The abbreviation N.O.S. (not otherwise specified) signifies those members of the general class not specifically listed by name in this appendix.

Aramite (Sulfurous acid, 2-chloroethyl 2-[4-(1,1-dimethylethyl)phenoxy]-1-methylethyl ester)
Arsenic and compounds, N.O.S.
Arsenic acid (Arsenic acid H_3AsO_4)
Arsenic pentoxide (Arsenic oxide As_2O_5)
Auramine (Benzamine, 4,4'-carbonimidoylbis[N,N-dimethyl-])
Azaserine (L-Serine, diazoacetate (ester))
Barium and compounds, N.O.S.
Barium cyanide
Benz[c]acridine (3,4-Benzacridine)
Benz[a]anthracene (1,2-Benzanthracene)
Benzal chloride (Benzene, dichloromethyl-)
Benzene (Cyclohexatriene)
Benzenearsonic acid (Arsenic acid, phenyl-)
Benzidine ([1,1'-Biphenyl]-4,4'-diamine)
Benzo[b]fluoranthene (Benz[e]acephananthrylene)
Benzo[j]fluoranthene
Benzo[k]fluoranthene
Benzo[a]pyrene
p-Benzoquinone (2,5-Cyclohexadiene-1,4-dione)
Benzotrichloride (Benzene, (trichloromethyl)-)
Benzyl chloride (Benzene, (chloromethyl)-)
Beryllium and compounds, N.O.S.
Bromoacetone (2-Propanone, 1-bromo-)
Bromoform (Methane, tribromo-)
4-Bromophenyl phenyl ether (Benzene, l-bromo-4-phenoxy-)
Brucine (Strychnidin-10-one, 2,3-dimethoxy-)
Butyl benzyl phthalate (1,2-Benzenedicarbozylic acid, butyl phenylmethyl ester)
Cacodylic acid (Arsinic acid, dimethyl)
Cadmium and compounds, N.O.S.
Calcium chromate (Chromic acid H_2CrO_4, calcium salt)
Calcium cyanide ($Ca(CN)_2$)
Carbon disulfide
Carbon oxyfluoride (Carbonic difluoride)
Carbon tetrachloride (Methane, tetrachloro-)
Chloral (Acetaldehyde, trichloro-)
Chlorambucil (Benzenebutanoic acid, 4-[bis(2-chloroethyl)amino]-)
Chlordane (4,7-Methano-1H-indene,1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-)
Chlorinated benzenes, N.O.S.
Chlorinated ethane, N.O.S.
Chlorinated fluorocarbons, N.O.S.
Chlorinated naphthalene, N.O.S.
Chlorinated phenol, N.O.S.
Chlornaphazin (Naphthalenamine, N,N'-bis(2-chlorethyl)-)
Chloroacetaldehyde (Acetaldehyde, chloro-)
Chloroalkyl ethers, N.O.S.
p-Chloroaniline (Benzenamine, 4-chloro-)
Chlorobenzene (Benzene, chloro-)
Chlorobenzilate (Benzeneacetic acid, 4-chloro-α-(4-chlorophenyl)-α-hydroxy-, ethyl ester)
p-Chloro-m-cresol (Phenol, 4-chloro-3-methyl)
2-Chloroethyl vinyl ether (Ethene, (2-chloroethoxy)-)
Chloroform (Methane, trichloro-)
Chloromethyl methyl ether (Methane, chloromethoxy-)
β-Chloronapthalene (Naphthalene, 2-chloro-)
o-Chlorophenol (Phenol, 2-chloro-)
1-(o-Chlorophenyl)thiourea (Thiourea, (2-chlorophenyl-))
3-Chloropropionitrile (Propanenitrile, 3-chloro-)
Chromium and compounds, N.O.S.
Chrysene
Citrus red No. 2 (2-Naphthalenol, 1-[(2,5-dimethoxyphenyl)azo]-)
Coal tar creosote
Copper cyanide (CuCN)
Creosote
Cresol (Chresylic acid) (Phenol, methyl-)
Crotonaldehyde (2-Butenal)
Cyanides (soluble salts and complexes), N.O.S.
Cyanogen (Ethanedinitrile)
Cyanogen bromide ((CN)Br)
Cyanogen chloride ((CN)Cl)
Cycasin (beta-D-Glucopyranoside, (methyl-ONN-azoxy)methyl)
2-Cyclohexyl-4,6-dinitrophenol (Phenol, 2-cyclohexyl-4,6-dinitro-)
Cyclophosphamide (2H-1,3,2-Oxazaphosphorin-2-amine,N,N-bis(2-chloroethyl)
tetrahydro-,2-oxide)
2,4-D and salts and esters (Acetic acid, (2,4-dichlorophenoxy)-)
Daunomycin (5,12-Naphthacenedione,8-acetyl-10-[(3-amino-2,3,6-trideoxy-α-Llyxo-hexopyranosyl)oxy]-7,8,9,10-tetrahydro-6,8,11-trihydroxy-1-methoxy-,(8S-cis))
DDD (Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-)
DDE (Benzene, 1,1-(dichloroethylidene)bis[4-chloro-)
DDT (Benzene, 1,1'-(2,2,2-trichloroethlyidene)bis[4-chloro-)
Diallate (Carbomothioic acid, bis(1-methylethyl)-,S-(2,3-dichloro-2-propenyl) ester)
Dibenz[a,h]acridine
Dibenz[a,j]acridine
Dibenz[a,h]anthracene
7H-Dibenzo[c,g]carbazole
Dibenzo[a,e]pyrene (Naphtho[1,2,4,5-def]crysene)
Dibenzo[a,h]pyrene (Dibenzo[b,def]crysene)
Dibenzo[a,i]pyrene (Benzo[rst]pentaphene)
1,2-Dibromo-3-chloropropane (Propane, 1,2-dibromo-3-chloro-)
Dibutylphthalate (1,2-Benzenedicarboxylic acid, dibutyl ester)
o-Dichlorobenzene (Benzene, 1,2-dichloro-)
m-Dichlorobenzene (Benzene, 1,3-dichloro-)
p-Dichlorobenzene (Benzene, 1,4-dichloro-)
Dichlorobenzene, N.O.S. (Benzene; dichloro-, N.O.S.)
3,3'-Dichlorobenzidine ([1,1'-Biphenyl]-4,4'-diamine, 3,3'-dichloro-)
1,4-Dichloro-2-butene (2-Butene, 1,4-dichloro-)
Dichlorodifluoromethane (Methane, dichlorodifluoro-)
Dichloroethylene, N.O.S.
1,1-Dichloroethylene (Ethene, 1,1-dichloro-)
1,2-Dichloroethylene (Ethene, 1,2-dichloro-,(E)-)
Dichloroethyl ether (Ethane, 1,1'-oxybis[2-chloro-)
Dichloroisopropyl ether (Propane, 2,2'-oxybis[2-chloro-)
Dichloromethoxy ethane (Ethane, 1,1'-[methylenebis(oxy)bis[2-chloro-)
Dichloromethyl ether (Methane, oxybis[chloro-)
2,4-Dichlorophenol (Phenol, 2,4-dichloro-)
2,6-Dichlorophenol (Phenol, 2,6-dichloro-)
Dichlorophenylarsine (Arsinous dichloride, phenyl-)
Dichloropropane, N.O.S. (Propane, dichloro-,)
Dichloropropanol, N.O.S. (Propanol, dichloro-,)
Dichloropropene; N.O.S. (1-Propane, dichloro-,)
1,3-Dichloropropene (1-Propene, 1,3-dichloro-)
Dieldrin (2,7:3,6-Dimethanonaphth[2,3-b]oxirene,3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a,octahydro-,(1aα,2β,2aα,3β,6β,6aα,7β,7aα)-)
1,2:3,4-Diepoxybutane (2,2'-Bioxirane)
Diethylarsine (Arsine, diethyl-)
1,4 Diethylene oxide (1,4-Dioxane)
Diethylhexyl phthalate (1,2-Benzenedicarboxlyic acid, bis(2-ethylhexl) ester)
N,N-Diethylhydrazine (Hydrazine, 1,2-diethyl)
O,O-Diethyl S-methyl dithiophosphate (Phosphorodithioic acid, O,O-diethyl S-methyl ester)
Diethyl-p-nitrophenyl phosphate (Phosphoric acid, diethyl 4-nitrophenyl ester)
Diethyl phthalate (1,2-Benzenedicarboxylic acid, diethyl ester)
O,O-Diethyl O-pyrazinyl phosphorothioate (Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester)
Diethylstilbesterol (Phenol, 4,4'-(1,2-diethyl-1,2-ethenediyl)bis-,(E)-)
Dihydrosafrole (1,3-Benxodioxole, 5-propyl-)
Diisopropylfluorophosphate (DFP) (Phosphorofluoridic acid, bis(1-methyl ethyl) ester)
Dimethoate (Phosphorodithioic acid, O,O-dimethyl S-[2-(methylamino) 2-oxoethyl] ester)
3,3'-Dimethoxybenzidine ([1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethoxy-)
p-Dimethylaminoazobenzene (Benzenamine, N,N-dimethyl-4-(phenylazo)-)
7,12-Dimethylbenz[a]anthracene (Benz[a]anthracene, 7,12-dimethyl-)
3,3'-Dimethylbenzidine ([1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethyl-)
Dimethylcarbamoyl chloride (carbamic chloride, dimethyl-)
1,1-Dimethylhydrazine (Hydrazine, 1,1-dimethyl-)
1,2-Dimethylhydrazine (Hydrazine, 1,2-dimethyl-)
α,α-Dimethylphenethylamine (Benzeneethanamine, α,α-dimethyl-)
2,4-Dimethylphenol (Phenol, 2,4-dimethyl-)
Dimethylphthalate (1,2-Benzenedicarboxylic acid, dimethyl ester)
Dimethyl sulfate (Sulfuric acid, dimethyl ester)
Dinitrobenzene, N.O.S. (Benzene, dinitro-)
4,6-Dinitro-o-cresol and salts (Phenol, 2-methyl-4,6-dinitro-)
2,4-Dinitrophenol (Phenol, 2,4-dinitro-)
2,4-Dinitrotoluene (Benzene, 1-methyl-2,4-dinitro-)
2,6-Dinitrotoluene (Benzene, 2-methyl-1,3-dinitro-)
Dinoseb (Phenol, 2-(1-methylpropyl)-4,6-dinitro-)
Di-n-octyl phthalate (1,2-Benzenedicarboxylic acid, dioctyl ester)
1,4-Dioxane (1,4-Diethyleneoxide)
Diphenylamine (Benzenamine, N-phenyl-)

1,2-Diphenylhydrazine (Hydrazine, 1,2-diphenyl-)
Di-n-propylnitrosamine (1-Propanamine,N-nitroso-N-propyl-)
Disulfoton (Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)ethyl] ester)
Dithiobiuret (Thioimidodicarbonic diamide $[(H_2N)C(S)]_2NH$)
Endosulfan (6,9,Methano-2,4,3-benzodioxathiepin,6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9ahexahydro,3-oxide)
Endothall (7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid)
Endrin and metabolites (2,7:3,6-Dimethanonaphth[2,3-b]oxirene,3,4,5,6,9,9-hexachloro1a,2,2a,3,6,6a,7,7a-octahydro,(1aα,2β,2aβ,3α,6α,6aβ,7β,7aα)-)
Epichlorohydrin (Oxirane, (chloromethyl)-)
Epinephrine (1,2-Benzenediol,4-[1-hydroxy-2-(methylamino)ethyl]-,(R)-,)
Ethyl carbamate (urethane) (Carbamic acid, ethyl ester)
Ethyl cyanide (propanenitrile)
Ethylenebisdithiocarbamic acid, salts and esters (Carbamodithioic acid, 1,2-Ethanediylbis-)
Ethylene dibromide (1,2-Dibromoethane)
Ethylene dichloride (1,2-Dichloroethane)
Ethylene glycol monoethyl ether (Ethanol, 2-ethoxy-)
Ethyleneimine (Aziridine)
Ethylene oxide (Oxirane)
Ethylenethiourea (2-Imidazolidinethione)
Ethylidene dichloride (Ethane, 1,1-Dichloro-)
Ethyl methacrylate (2-Propenoic acid, 2-methyl-, ethyl ester)
Ethylmethane sulfonate (Methanesulfonic acid, ethyl ester)
Famphur (Phosphorothioic acid, O-[4-[(dimethylamino)sulphonyl]phenyl] O,O-dimethyl ester)
Fluoranthene
Fluorine
Fluoroacetamide (Acetamide, 2-fluoro-)
Fluoroacetic acid, sodium salt (Acetic acid, fluoro-, sodium salt)
Formaldehyde (Methylene oxide)
Formic acid (Methanoic acid)
Glycidylaldehyde (Oxiranecarboxyaldehyde)
Halomethane, N.O.S.
Heptachlor (4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-)
Heptachlor epoxide (α, β, and γ isomers) (2,5-Methano-2H-indeno[1,2-b]-oxirene, 2,3,4,5,6,7,7-heptachloro-1a,1b,5,5a,6,6a-hexa-hydro-,(1aα,1bβ,2α,5α,5aβ,6β,6aα)-)
Hexachlorobenzene (Benzene, hexachloro-)
Hexachlorobutadiene (1,3-Butadiene, 1,1,2,3,4,4-hexachloro-)
Hexachlorocyclopentadiene (1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-)
Hexachlorodibenzofurans
Heptachlorodibenzo-p-dioxins
Hexachloroethane (Ethane, hexachloro-)
Hexachlorophene (phenol, 2,2'-Methylenebis[3,4,6-trichloro-)
Hexachloropropene (1-Propene, 1,1,2,3,3,3-hexachloro-)
Hexaethyl tetraphosphate (Tetraphosphoric acid, hexaethyl ester)
Hydrazine
Hydrocyanic acid
Hydrofluoric acid
Hydrogen sulfide (H_2S)
Indeno(1,2,3-cd)pyrene
Isobutyl alcohol (1-Propanol, 2-methyl-)
Isodrin (1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro, (1α,4α,4aβ,5β,8β,8aβ)-)
Isosafrole (1,3-Benzodioxole, 5-(1-propenyl)-)
Kepone (1,3,4-Metheno-2H-cyclobuta[cd]pentalen-2-one, 1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-)
Lasiocarpine (2-Butenoic acid, 2-methyl-,7-[[2,3-dihydroxy-2-(1-methoxyethyl)-3-methyl-1-oxobutoxy]methyl]-2,3,5,7a-tetrahydro-1H-pyrrolizin-l-yl ester)
Lead and compounds, N.O.S.
Lead acetate (Acetic acid, lead(2+) salt)
Lead phosphate (Phosphoric acid, lead(2+) salt(2:3))
Lead subacetate (Lead, bis(acetato-O)tetrahydroxytri-)
Lindane (Clohexane, 1,2,3,4,5,6-hexachloro-, (1α,2α,3β,4α,5α,6β)-)
Maleic anhydride (2,5-Furandione)
Maleic hydrazide (3,6-Pyridazinedione, 1,2-dihydro-)
Malononitrile (Propanedinitrile)
Melphalan (L-Phenylalanine, 4-[bis(2-chloroethyl)amino]]-)
Mercury and compounds, N.O.S.
Mercury fulminate (Fulminic acid, mercury(2+) salt)
Methacrylonitrile (2-Propenenitrile, 2-methyl-)
Methapyrilene (1,2-Ethanediamine, N,N-dimethyl-N'-2-pyridinyl-N'-(2-thienylmethyl)-)
Metholmyl (Ethamidothioic acid, N-[[(methylamino)carbonyl]oxy]thio-, methyl ester)
Methoxychlor (Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-methoxy-)
Methyl bromide (Methane, bromo-)
Methyl chloride (Methane, chloro-)
Methyl chlorocarbonate (Carbonchloridic acid, methyl ester)
Methyl chloroform (Ethane, 1,1,1-trichloro-)
3-Methylcholanthrene (Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-)
4,4'-Methylenebis(2-chloroaniline) (Benzenamine, 4,4'-methylenebis(2-chloro-)
Methylene bromide (Methane, dibromo-)
Methylene chloride (Methane, dichloro-)
Methyl ethyl ketone (MEK) (2-Butanone)
Methyl ethyl ketone peroxide (2-Butanone, peroxide)
Methyl hydrazine (Hydrazine, methyl-)
Methyl iodide (Methane, iodo-)
Methyl isocyanate (Methane, isocyanato-)
2-Methyllactonitrile (Propanenitrile, 2-hydroxy-2-methyl-)
Methyl methacrylate (2-Propenoic acid, 2-methyl-, methyl ester)
Methyl methanesulfonate (Methanesulfonic acid, methyl ester)
Methyl parathion (Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester)
Methylthiouracil (4(1H)Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo-)
Mitomycin C (Azirino[2',3':3,4]pyrrolo[1,2-a]indole-4,7-dione,6-amino-8-[[(aminocarbonyl) oxy]methyl]-1,1a,2,8,8a,8b-hexahydro-8a-methoxy-5-methy-, [1aS-(1aα,8β,8aα,8bα)]-)
MNNG (Guanidine, N-methyl-N'-nitro-N-nitroso-)
Mustard gas (Ethane, 1,1'-thiobis[2-chloro-)
Naphthalene
1,4-Naphthoquinone (1,4-Naphthalenedione)
α-Naphthalenamine (1-Naphthylamine)
β-Naphthalenamine (2-Naphthylamine)
α-Naphthylthiourea (Thiourea, 1-naphthalenyl-)
Nickel and compounds, N.O.S.
Nickel carbonyl ($Ni(CO)_4$ (T-4)-)
Nickel cyanide ($Ni(CN)_2$)
Nicotine and salts (Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S)-)
Nitric oxide (Nitrogen oxide NO)
p-Nitroaniline (Benzenamine, 4-nitro-)
Nitrobenzene (Benzene, nitro-)
Nitrogen dioxide (Nitrogen oxide NO_2)
Nitrogen mustard, and hydrochloride salt (Ethanamine, 2-chloro-N-(2-chloroethyl)-N-methyl-)
Nitrogen mustard N-oxide and hydrochloride salt (Ethanamine, 2chloro-N-(2-chloroethyl)N-methyl-, N-oxide)
Nitroglycerin (1,2,3-Propanetriol, trinitrate)
p-Nitrophenol (Phenol, 4-nitro-)
2-Nitropropane (Propane, 2-nitro-)
Nitrosamines, N.O.S.
N-Nitrosodi-n-butylamine (l-Butanamine, N-butyl-N-nitroso-)
N-Nitrosodiethanolamine (Ethanol, 2,2'-(nitrosoimino)bis-)
N-Nitrosodiethylamine (Ethanamine, N-ethyl-N-nitroso-1)
N-Nitrosodimethylamine (Methanamine, N-methyl-N-nitroso-)
N-Nitroso-N-ethylurea (Urea, N-ethyl-N-nitroso-)
N-Nitrosomethylethylamine (Ethanamine, N-methyl-N-nitroso-)
N-Nitroso-N-methylurea (Urea, N-methyl-N-nitroso-)
N-Nitroso-N-methylurethane (Carbamic acid, methylnitroso-, ethyl ester)
N-Nitrosomethylvinylamine (Vinylamine, N-methyl-N-nitroso-)
N-Nitrosomorpholine (Morpholine, 4-nitroso-)
N-Nitrosonornicotine (Pyridine, 3-(1-nitroso-2-pyrrolidinyl)-, (S)-)
N-Nitrosopiperidine (Piperidine, 1-nitroso-)
Nitrosopyrrolidine (Pyrrolidine, 1-nitroso-)
N-Nitrososarcosine (Glycine, N-methyl-N-nitroso-)
5-Nitro-o-toluidine (Benzenamine, 2-methyl-5-nitro-)
Octamethylpyrophosphoramide (Diphosphoramide, octamethyl-)
Osmium tetroxide (Osmium oxide OsO_4, (T-4)-)
Paraldehyde (1,3,5-Trioxane, 2,4,6-tri methyl-)
Parathion (Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester)
Pentachlorobenzene (Benzene, pentachloro-)
Pentachlorodibenzo-p-dioxins
Pentachlorodibenzofurans
Pentachloroethane (Ethane, pentachloro-)
Pentachloronitrobenzene (PCNB) (Benzene, pentachloronitro-)
Pentachlorophenol (Phenol, pentachloro-)
Phenacetin (Acetamide, N-(4-ethoxyphenyl)-)
Phenol
Phenylenediamine (Benzenediamine)
Phenylmercury acetate (Mercury, (acetato-O)phenyl-)

Phenylthiourea (Thiourea, phenyl-)
Phosgene (Carbonic dichloride)
Phosphine
Phorate (Phosphorodithioic acid, O,O-diethyl S-[(ethylthiomethyl] ester)
Phthalic acid esters, N.O.S.
Phthalic anhydride (1,3-isobenzofurandione)
2-Picoline (Pyridine, 2-methyl-)
Polychlorinated biphenyls, N.O.S.
Potassium cyanide (K(CN))
Potassium silver cyanide (Argentate(l-), bis(cyano-C)-, potassium)
Pronamide (Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-)
1,3-Propane sultone (1,2-Oxathiolane, 2,2-dioxide)
n-Propylamine (1-Propanamine)
Propargyl alcohol (2-Propyn-1-ol)
Propylene dichloride (Propane, 1,2-dichloro-)
1,2-Propylenimine (Aziridine, 2-methyl-)
Propylthiouracil (4(1H)-Pyrimidinone, 2,3-dihydro-6-propyl-2-thioxo-)
Pyridine
Reserpinen (Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxybenzoyl)oxy]-smethyl ester, (3β,16 β,17α,18β,20α)-)
Resorcinol (1,3-Benzenediol)
Saccharin and salts (1,2-Benzisothiazol-3(2H)-one, 1,1-dioxide)
Safrole (1,3-Benzodioxole, 5-(2-propenyl)-)
Selenium and compounds, N.O.S.
Selenium dioxide (Selenious acid)
Selenium sulfide (SeS_2)
Selenourea
Silver and compounds, N.O.S.
Silver cyanide (Silver cyanide Ag(CN))
Silvex (Propanoic acid, 2-(2,4,5-trichlorophen oxy)-)
Sodium cyanide (Sodium cyanide Na(CN))
Streptozotocin (D-Glucose, 2-deoxy-2-[[(methylnitrosoamino)carbonyl]amino]-)
Strychnine and salts (Strychnidin-10-one)
TCDD (Dibenzo[b,e][1,4]dioxin, 2,3,7,8-, tetrachloro-)
1,2,4,5-Tetrachlorobenzene (Benzene, 1,2,4,5-tetrachloro-)
Tetrachlorodibenzo-p-dioxins
Tetrachlorodibenxofurans
Tetrachloroethane, N.O.S. (Ethane, tetrachloro-, N.O.S.)
1,1,1,2-Tetrachloroethane (Ethane, 1,1,1,2-tetrachloro-)
1,1,2,2-Tetrachloroethane (Ethane, 1,1,2,2-tetrachloro-)
Tetrachloroethylene (Ethene, tetrachloro-)
2,3,4,6-Tetrachlorophenol (Phenol, 2,3,4,6-tetrachloro-)
Tetraethyldithiopyrophosphate (Thiodiphosphoric acid, tetraethyl ester)
Tetraethyl lead (Plumbane, tetraethyl-)
Tetraethyl pyrophosphate (Diphosphoric acid, tetraethyl ester)
Tetranitromethane (Methane, tetranitro-)
Thallium and compounds, N.O.S.
Thallic oxide (Thallium oxide Tl_2O_3)
Thallium (I) acetate (Acetic acid, thallium (1+) salt)
Thallium (I) carbonate (Carbonic acid, dithallium (1+) salt)
Thallium (I) chloride (Thallium chloride TlCl)
Thallium (I) nitrate (Nitric acid, thallium (1+) salt)
Thallium selenite (Selenius acid, dithallium (1+) salt)
Thallium (I) sulfate (Sulfuric acid, thallium (1+) salt)
Thioacetamide (Ethanethioamide)
3,Thiofanox (2-Butanone, 3,3-dimethyl-1-(methylthio)-, O-[(methylamino)carbonyl] oxime)
Thiomethanol (Methanethiol)
Thiophenol (Benzenethiol)
Thiosemicarbazide (Hydrazinecarbothioamide)
Thiourea
Thiram (Thioperoxydicarbonic diamide [(H_2N)C(S)]$2S_2$, tetramethyl-).
Toluene (Benzene, methyl-)
Toluenediamine (Benzenediamine, ar-methyl-)
Toluene-2,4-diamine (1,3-Benzenediamine, 4-methyl-)
Toluene-2,6-diamine (1,3-Benzenediamine, 2-methyl-)
Toluene-3,4-diamine (1,2-Benzenediamine, 4-methyl-)
Toluene diisocyanate (Benzene, 1,3-diisocyanatomethyl-)
o-Toluidine (Benzenamine, 2-methyl-)
o-Toluidine hydrochloride (Benzenamine, 2-methyl-, hydrochloride)
p-Toluidine (Benzenamine, 4-methyl-)
Toxaphene
1,2,4-Trichlorobenzene (Benzene, 1,2,4-trichloro-)
1,1,2-Trichloroethane (Ethane, 1,1,2-trichloro-)
Trichloroethylene (Ethene,trichloro-)
Trichloromethanethiol (Methanethiol, trichloro-)
Trichloromonofluoromethane (Methane, trichlorofluoro-)
2,4,5-Trichlorophenol (Phenol, 2,4,5-trichloro-)
2,4,6-Trichlorophenol (Phenol, 2,4,6-trichloro-)
2,4,5-T (Acetic acid, 2,4,5- trichloro-phenoxy-)
Trichloropropane, N.O.S.
1,2,3-Trichloropropane (Propane, 1,2,3-trichloro-)
O,O,O-Triethyl phosphorothioate (Phosphorothioic acid, O,O,O-triethyl ester)
Trinitrobenzene (Benzene, 1,3,5-trinitro-)
Tris(1-aziridinyl)phosphine sulfide (Aziridine, 1,1',1''phosphinothioylidynetris-))
Tris(2,3-dibromopropyl) phosphate (1-Propanol, 2,3-dibromo-, phosphate (3:1))
Trypan blue (2,7-Naphthalendisulfonic acid, 3,3'-[(3,3'-dimethyl[1,1'-biphenyl]-4,4'-diyl)bis(azo)]bis(5-amino-4-hydroxy-, tetrasodium salt)
Uracil mustard (2,4-(1H,3H)-Pyrimidinedione, 5-[bis(2-chloroethyl)amino]-)
Vanadium pentoxide (Vanadium oxide V_2O_5)
Vinyl chloride (Ethene, chloro-)
Wayfarin (2H-1-Benzopyran-2-one, 4-hydroxy-3-(3-oxo-1-phenlybutyl)-)
Zinc cyanide ($Zn(CN)_2$)
Zinc phosphide (Zn_3P_2)

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APPENDIX B

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT METHODOLOGIES FOR THE UMTRA GROUND WATER PROJECT

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ABSTRACT

This document presents the method used to evaluate human health and ecological risks associated with ground water contamination at inactive uranium processing sites. The method to evaluate human health risk 1) develops probabilistic distributions for exposure variables where data are sufficient, 2) simulates predicted exposure distributions using Monte Carlo techniques, and 3) develops toxicity ranges that reflect human data when available, animal data if human data are insufficient, regulatory levels, and uncertainties. Risk interpretation is based on comparison of the potential exposure distributions with the derived toxicity ranges. Using this information, baseline risk assessments are prepared to provide the public and remedial action decision-makers with information about the health risks that might be expected at each site due to direct or indirect exposure to contaminated ground water. Graphic presentations are an essential element of this semiquantitative interpretation and are expected to increase understanding of potential risks by the public and decision-makers based on relative toxicity, likelihood and severity of effect. Screening level ecological risk assessments determine potential risks by comparing contaminant concentrations to published aquatic and terrestrial screening level benchmarks, regulatory criteria, and other guidelines. Potential risks are then evaluated and data gaps, if any, are identified.

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LIST OF ACRONYMS

Acronym	Definition
ACL	alternate concentration limit
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ESADDI	estimated safe and adequate daily dietary intake
HEAST	Health Effects Assessment Summary Tables
IRIS	Integrated Risk Information System
MCL	maximum concentration limit
NEPA	National Environmental Policy Act
QA	quality assurance
QC	quality control
RAGS	risk assessment guidance for Superfund
RDA	recommended dietary allowance
RMSE	root mean squared error
SOWP	site observational work plan
SPEAR	Software Program for Environmental analysis and Reporting
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
UCL	upper confidence limit

B1.0 BACKGROUND

B1.1 RISK ASSESSMENT APPLICATIONS ON THE UMTRA GROUND WATER PROJECT

Risk assessment is a tool that aids decision-making on the Uranium Mill Tailings Remedial Action (UMTRA) Ground Water Project. The Uranium Mill Tailings Radiation Control Act (UMTRCA) (42 USC § 7901 *et seq.*) directs the U.S. Department of Energy (DOE) to ensure compliance with the standards established by the U.S. Environmental Protection Agency (EPA) (40 CFR Part 192). The EPA-established health and environmental protection standards for the UMTRA Project specify maximum concentration limits (MCL) for some contaminants and background concentrations for others. EPA also considers implementation of alternate concentration limits (ACL) and supplemental standards as the potential strategies for meeting the standards. To meet EPA standards, including ACLs, the DOE needs to demonstrate that the standards will not adversely affect human health and the environment and projected uses of ground water resources. Risk-based decision making will be implemented on the Project because:

- Background concentrations may be needlessly restrictive for contaminants for which MCLs have not been established.
- MCLs or background concentrations may not be restrictive enough; multiple contaminants may be additive, synergistic, or potentiating with respect to toxicity.
- For sites where poor background water quality precludes the use of ground water for drinking, concentrations less stringent than background concentrations or MCLs may be applicable for ground water uses other than drinking.
- Risk-based ACLs may be sought at sites where it can be determined that the ground water constituents will not pose a substantial present or potential hazard to human health and the environment as long as the ACLs are not exceeded.

The methodology presented here has and will be used to prepare multiple site-specific documents such as baseline risk assessments and site observational work plans (SOWP). The risk assessments are called "baseline" in that they describe preremediation ground water conditions at the site, with ground water quality only partially characterized. Critical data gaps identified in the risk assessments are answered in SOWPs. Upon completion of site characterization and identification of a proposed compliance strategy in the SOWP, impacts of the proposed compliance strategy are analyzed in a site-specific National Environmental Policy Act (NEPA) document. In some cases, the NEPA documents further evaluate risks using the risk assessment methodology described below and incorporating any recently acquired data.

B1.2 DEVELOPMENT OF THE HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

The risk assessment methodology for the UMTRA Project sites follows the basic EPA framework for evaluating potential adverse human health impacts at hazardous waste sites (EPA, 1989a). This risk assessment guidance for Superfund (RAGS) framework consists of 1) data evaluation, 2) exposure assessment, 3) toxicity assessment, and 4) risk characterization.

This framework is incorporated into the UMTRA Project methodology, which was developed to evaluate current human health risk and to estimate risk from potential future use of contaminated ground water or surface water that has mixed with contaminated ground water near the former uranium processing sites; Monte Carlo (probabilistic) simulations are used where ever possible to assess human exposure to inorganic contaminants in drinking water. Other potential exposure pathways (such as dermal contact with ground water while bathing, and human consumption of meat and milk from livestock or garden produce) are evaluated using a standard EPA deterministic approach. The EPA RAGS method involves determining a point estimate for excess cancer risk from current or potential carcinogenic exposures and a hazard quotient (ratio of the exposure intake to an acceptable intake) for noncarcinogenic exposures. This method is a useful screening tool for comparing diverse sites on a relatively equivalent basis. The UMTRA Project, however, comprises 24 sites, 23 of which have contaminants of concern and pathways that are largely the same (no ground water contamination is known to occur at one site). A more detailed and comprehensive toxicological evaluation, including the probabilistic evaluation of possible human exposures, describes potential health effects from ground water contamination more accurately than if the RAGS method were used.

Within the RAGS framework, the application of probabilistic methods to exposure assessment and methods to improve the characterization of uncertainties and toxicity were explored and implemented to the extent possible.

B2.0 METHODOLOGY

This document summarizes the probabilistic and toxicity range approach used for all UMTRA Project risk assessments. This section shows the format of the baseline risk assessments (e.g., Citizens' Summary, Introduction, Site Description, etc.). The topics and data used in each section of the baseline risk assessments are described, along with the methodology used to evaluate and interpret those data. It should be noted that each UMTRA Project site is unique in that ground water conditions, the degree of their characterization, the likelihood for complete potential exposure pathways, and existing environmental receptors can be different at each site. Therefore, all aspects of the methodology described in this document may not be appropriate for all sites. For example, existing data may not be sufficient to generate probability exposure distributions for contaminants at some UMTRA Project sites; consequently, standard RAGS point estimates of exposure may be used. Where the methods deviate from those described in this document, the methods used are presented in the site-specific baseline risk assessment.

B2.1 CITIZENS' SUMMARY

Although the citizens' summary is placed at the beginning of the risk assessment, it often is the last section to be written. It summarizes, in terms understandable to the general public, the document's basic purpose and the methodology used to produce it. Also summarized are the exposure pathways evaluated, the results (in terms of the primary contaminants of potential concern for human health and environmental risk), and possible adverse effects that could result from exposure to these potential contaminants.

B2.2 INTRODUCTION

This section describes the purpose of the risk assessment, the status of the site with respect to surface and ground water activities, and the overall approach to risk assessment. The concept of probabilistic risk assessment, if appropriate for a given site, is introduced here. The EPA's basic framework for evaluating risk at Superfund sites is followed. At sites with sufficient available data, probabilistic distributions are used to evaluate exposure and to incorporate known, properly characterized sources of variability. The toxicity of specific contaminants is summarized graphically in dose ranges that are not associated with adverse health effects and those that lead to various types and severities of adverse health effects. Risk is evaluated by combining these two aspects in a semiquantitative graphical presentation.

B2.3 SITE DESCRIPTION

The history of uranium milling operations and subsequent land use at the site is presented in this section. This history includes relevant background information such as geographical location and climate. A hydrogeological summary of ground water occurrence and movement in the site region defines all relevant aquifers and gives the locations of monitor wells. Surface water occurrence and movement is described, land use in the region is summarized, and ground water use by area residents is specified. A recent survey of ground water use is included with any regional drinking water supply information that may alter either the use of ground water or the source of residents' drinking water (for example, plans for new municipal wells or the alteration of central distribution systems to service additional regions). Additionally, current and possible future land uses are discussed in this section. The determination of alternate future land uses is based on available information and professional judgment. The types of informational sources that should be used, if available, include projections that activities associated with current land use will be different under an alternate future use; city or county projections of future land use; U.S. Bureau of the Census projections; and established trends in the general area and the area immediately surrounding the site. Because residential land use is most often associated with the greatest exposure, it is generally the most conservative option when future alternate land use is considered.

B2.4 EXTENT OF CONTAMINATION

In this section, chemical analysis data from ground water wells are used to develop a geochemical characterization of background and site ground water quality. The horizontal and vertical extent of contamination is estimated to the extent possible. The selection of wells and water sampling dates for use in the characterization is defended for each water-bearing unit discussed. This section typically contains tables summarizing recent ground water quality data from background, on-site, and/or downgradient wells. Using defensible statistical inferential methods and knowledge of the site, contaminants are identified by comparing on-site water quality to background levels. A subset of these contaminants will represent the contaminants of potential concern to human health. The methodologies used to evaluate data and determine contaminants of potential concern are discussed more fully below. For each contaminant of potential concern, Section 3.0 of the baseline risk assessment discusses probable speciation, mechanisms controlling transport in the environment, and mechanisms controlling attenuation in the aquifer matrices.

Depending on the site, this section of the baseline risk assessment may include a discussion of surface water and sediment quality.

Identification of site-related contaminants

To evaluate the risk associated with the ground water at a site, site-related contaminants first must be identified and concentrations of these contaminants must be quantified. The goal of the UMTRA Project risk assessments is to determine a reasonable maximum exposure. Unless site-specific mechanisms prohibit access to ground water under all or part of a site, risks are based on data from monitor wells drilled into the most contaminated ground water at the site.

Water quality data collected by the DOE from monitoring wells on and near the site are reviewed to find the probable location of the most contaminated ground water. Occasionally data from other sources such as the Bureau of Reclamation are included in this evaluation, if sample collection and analysis activities result in data quality that meets UMTRA Project data quality objectives. These data are used to assess the presence of contamination at or near the site. All data used are provided in the baseline risk assessment supplement (see Section B3.0 of this appendix).

Differences in the mobility of different contaminants and multiple sources of contamination (e.g., tailings piles, ponds, ore storage areas) may result in multiple plumes under a site. In such cases, plume water quality is quantified using data from wells that exhibit the highest levels of each contaminant. This approach creates a single hypothetical plume typifying the worst water quality that could be found anywhere on the site. Although this may seem excessively conservative, well coverage at a site is often not sufficient to rule out the possibility that such water quality may in fact exist at some unsampled location.

Background water quality is the quality that would exist at a site if uranium processing activities had not occurred. Background wells typically are located upgradient or crossgradient of the site in areas not influenced by site contamination. In the absence of unaffected upgradient or crossgradient wells, far downgradient wells can be used to represent local background if it can be demonstrated that they are located in areas that could not receive contamination from the site. At a minimum, background wells access ground water from the same aquifer as on-site wells and are above suspicion of having been impacted by site activities. Ideally, background wells also are completed in similar formations and geochemical environments as the on-site wells. Background wells are selected according to location, information in well completion logs, and hydrologic properties such as water levels; background wells also must show stable concentrations of major constituents during several sampling rounds. Furthermore, because background water quality is likely to vary geographically, more than one background well is included in background water quality evaluation whenever possible.

At sites where background is reasonably well characterized, site contaminants are identified by statistical comparison of background to on-site ground water quality data. A constituent is identified as a site contaminant if the average on-site level in one or more wells exceeds background levels at a given level of statistical significance. The statistical comparison method used at a site depends on several site-specific factors such as the amount of data, their analytical quality, the presence or absence of long-term or seasonal trends in on-site concentration levels, the frequency of nondetects in the database, and the validity of assumptions required for the statistical comparison method. The significance level chosen for statistical testing also reflects site-specific conditions such as the amount of data and the number of multiple comparisons required in the assessment. A statistician's report is included in the supplement to each baseline risk assessment.

At a few sites, background ground water quality cannot be determined. At these sites, regional ground water chemistry data, if available, can be used to characterize background ground water quality near the site. The selection of site-related contaminants will also consider site history (e.g., whether a contaminant can reasonably be expected, based on knowledge of the chemical extraction processes used at the site), evidence from other UMTRA Project processing sites, the frequency of detection for trace constituents, and the concentration levels measured.

Determination of contaminants of potential concern

Constituents identified statistically as exceeding background levels for site-related contaminants subsequently are screened for their potential to cause adverse health effects. A constituent may be eliminated from further consideration if levels found in plume waters are in the nutritional range when added to expected dietary intakes or if the constituent is known to have very low toxicity. Constituents that are not eliminated in the screening process are considered throughout the risk assessment.

Some inorganic contaminants associated with the UMTRA Project sites are essential nutrients. Tables B2.1 through B2.3 list those contaminants with applicable nutritional guidelines. Depending on the constituent, nutritional guidelines include the recommended dietary allowance (RDA), the estimated safe and adequate daily dietary intake (ESADDI), and the minimum daily requirement. RDAs are federal standards that reflect the best estimate of the intake level required to meet the nutritional needs of nearly all healthy people. RDAs are recommendations (not requirements), and they include generous safety margins both above and below the range of intake that is considered safe. RDAs have been established for calcium, iodine, iron, magnesium, phosphorous, selenium, and zinc. Minimum daily intake requirements have been established for sodium, chloride, and potassium. ESADDIs have been established for minerals for which data are sufficient to estimate a range of requirements but insufficient to establish RDAs. These minerals include chromium, copper, fluoride, manganese, and molybdenum. The upper limit of the ESADDIs should not be habitually exceeded since the toxic level for many of the trace elements may be only slightly greater than the usual intake levels.

Several additional factors must be considered when contaminants of potential concern are screened on a nutritional basis. First, what level of a nutrient does the diet typically provide and what increment to this amount can be tolerated without adverse effects? Some nutrients, such as calcium, can be tolerated at levels several times their nutritional criteria. For others, such as molybdenum, the margin between nutritional allowance and toxicity is relatively small. When evaluating toxicity in comparison to dietary values, it is also important to consider whether the nutrient has a greater bioavailability (and potentially greater toxicity) in water than in food. Additional considerations in screening nutrient metal contaminants are 1) if the contaminant is likely to interact additively or synergistically with, or to enhance the effects of, other

Table B2.1 Recommended dietary allowances

	Age (yr)	Weight (kg)	Ca (mg)	Mg (mg)	Fe (mg)	Zn (mg)	Se (μg)
Infants	0-0.5	6	400	40	6	5	10
	0.5-1	9	600	60	10	5	15
Children	1-3	13	800	80	10	10	20
	4-6	20	800	120	10	10	20
	7-10	28	800	170	10	10	30
Males	11-14	45	1200	270	12	15	40
	15-18	66	1200	400	12	15	50
	19-24	72	1200	350	10	15	70
	25-50	79	800	350	10	15	70
	51+	77	800	350	10	15	70
Females	11-14	46	1200	280	15	12	45
	15-18	55	1200	300	15	12	50
	19-24	58	1200	280	15	12	55
	25-50	63	800	280	15	12	55
	51+	65	800	280	10	12	55
Pregnant			1200	300	30	15	65
Lactating			1200	340-355	15	16-19	75
			Dietary range				
			700-1300 (male mean) 750-1000 (female mean) mg/day	349 mg/day	9-35 mg/day	5.5-15 mg/day	83-129 μg/day

From National Research Council (1989).

Note: Values are expressed as average daily intakes over time. Recommended dietary allowances are designed for the maintenance of good nutrition of practically all healthy people in the United States.

Ca – calcium.
Fe – iron.
Mg – magnesium.
Se – selenium.
Zn – zinc.
kg – kilogram.
mg – milligram.
mg/day – milligrams per day.
μg – microgram.
μg/day – micrograms per day.
yr – year.

Table B2.2 Estimated safe and adequate daily dietary intakes of selected trace elements

	Age (yr)	Weight (kg)	Cu (mg)	Mn (mg)	F (mg)	Cr (μg)	Mo (μg)
Infants	0-0.5	6	0.4-0.6	0.3-0.6	0.1-0.5	10-40	15-30
	0.5-1	9	0.6-0.7	0.6-1.0	0.2-1.0	20-60	20-40
Children and adolescents	1-3	13	0.7-1.0	1.0-1.5	0.5-1.5	20-80	25-50
	4-6	20	1.0-1.5	1.5-2.0	1.0-2.5	30-120	30-75
	7-10	28	1.0-2.0	2.0-3.0	1.0-2.5	50-200	50-150
	11+	45	1.5-2.5	2.0-5.0	1.5-2.5	50-200	75-250
Adults			1.5-3.0	2.0-5.0	1.5-2.5	50-200	
					1.5-4.0		
			Dietary range				
			0.45-1.2 mg/day	1.1-2.8 mg/day	0.23-1.8 mg/day	up to 100 μg/day	120-240 μg/day

From National Research Council (1989).

Note: Values expressed as ranges of recommended intake because limited information is available on which to base allowances. Because the toxic levels for many trace elements may be only several times higher that usual intakes, the upper levels for the trace elements given here should not be habitually exceeded.

Cr – chromium.
Cu – copper.
F – fluoride.
Mn – manganese.
Mo – molybdenum.
kg – kilogram.
mg – milligram.
mg/day – milligrams per day.
μg – microgram.
μg/day – micrograms per day.
yr – year.

Table B2.3 Estimated minimum requirements for healthy persons

	Age (yr)	Weight (kg)	Na (mg/day)	Cl (mg/day)	K (mg/day)
Months	0-5	4.5	120	180	500
	6-11	8.9	200	300	700
Years	1	11.0	225	350	1000
	2-5	16.0	300	500	1400
	6-9	25.0	400	600	1600
	10-18	50.0	500	750	2000
	>18	70.0	500	750	2000
Pregnant			569		
Lactating			635		
			Dietary range		
			1800-5000 mg/day	6000 mg/day	2500 mg/day

From National Research Council (1989).

Cl – chloride.
K – potassium.
Na – sodium.
kg – kilogram.
mg – milligram.
mg/day – milligrams per day.
yr – year.

contaminants; 2) if the contaminant could biomagnify in the food chain to the extent that food pathways contribute more than the estimated drinking water intake; and 3) if near the site, normal dietary intake of certain constituents is higher than national averages due to specific dietary habits of local residents and/or relatively high background levels. The confidence level of the toxicity data must also be considered.

Contaminants other than nutrients may be eliminated from the list of contaminants of potential concern because of their low toxicity and because levels detected at the site would not be associated with adverse effects. Some of these contaminants may have EPA-derived acceptable intake levels (reference doses). To account for the potential additive effects of contaminants, a contaminant with a reference dose generally can be screened out if drinking water ingestion would result in intakes of less than one-tenth the reference dose. As in screening nutrient contaminants of potential concern, the following factors must be considered in screening contaminants with low toxicity: additional dietary intake; margin of safety below toxicity and the severity of the potential toxicity; bioavailability; biomagnification; additive, synergistic, or potentiating interactions with other contaminants; and uncertainty in the toxicity data.

B2.5 EXPOSURE ASSESSMENT

Pathways

Pathways of concern for contaminated ground water at UMTRA Project sites are summarized in the generic conceptual model shown in Figure B2.1. Exposure through inhalation is not evaluated because the primary ground water contaminants evaluated are nonvolatile (i.e., metals, nitrate, and sulfate). Although inhaling mists could result from showers or irrigation, the exposure dose from inhaling inorganics is considered to be negligible compared to water ingestion. However, further evaluation of the inhalation exposure route may be warranted under some conditions. Similarly, irrigation could cause contaminant buildup in soil that may be of concern in some exposure scenarios. Additionally, because the tailings piles and contaminated soils are being removed and relocated to disposal cells under the UMTRA Surface Project, soil and air exposure pathways (such as incidental soil ingestion, dermal contact with soil, or inhalation of particulates) are not evaluated in the baseline risk assessments. The following human exposure pathways typically are evaluated:

- Ingestion of contaminated ground water as drinking water.
- Dermal contact with contaminated ground water while bathing.
- Consumption of garden produce irrigated with contaminated ground water.

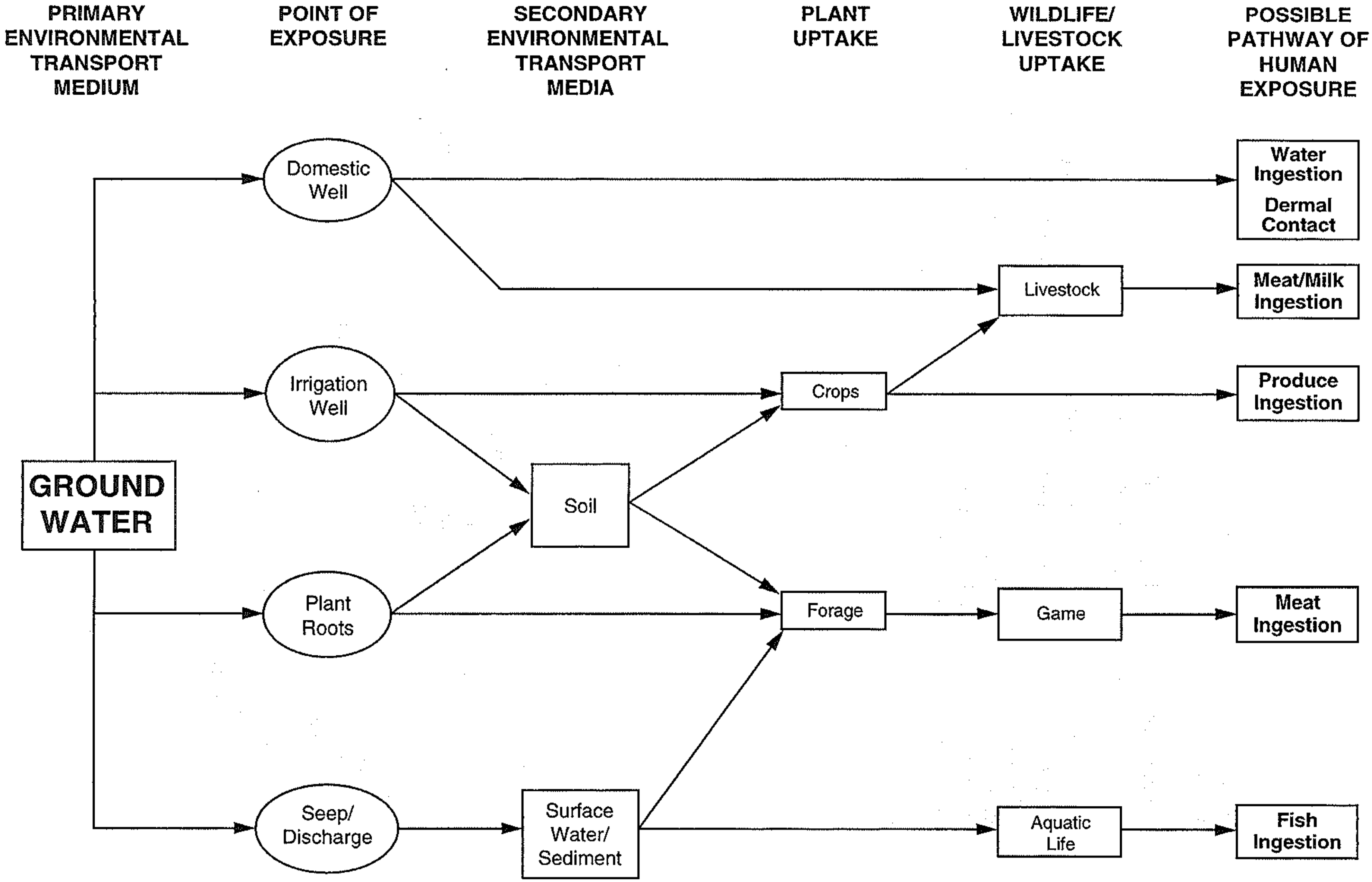

FIGURE B2.1
GENERIC CONCEPTUAL MODEL

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- Consumption of meat and milk from livestock watered with contaminated ground water.
- Consumption of fish obtained from surface water impacted by contaminated ground water.
- Dermal contact with and ingestion of contaminated surface water and sediment while using surface water for recreational purposes.

Typically, drinking water ingestion is the ground water exposure route that leads to the greatest contaminant intake. That route includes direct consumption as well as ingestion of water used in food preparation. In the baseline risk assessments, a relative and absolute contribution of all appropriate exposure pathways at a site to the exposure dose from the drinking water pathway is estimated. The exposure dose for each exposure pathway is calculated using the appropriate equations presented in RAGS. The general equation RAGS uses for calculating exposure is shown below:

$$\text{Exposure dose (mg/kg-day)} = \frac{C \times IR \times EF \times ED}{BW \times AT} \qquad \text{(Equation 1)}$$

C = Contaminant concentration in the medium.
IR = Intake/contact rate.
EF = Exposure frequency.
ED = Exposure duration.
BW = Body weight.
AT = Averaging time (exposure duration x 365 days per year for noncarcinogens, and 70 years x 365 days per year for chemical carcinogens).

The risks associated with the exposure doses from all exposure pathways are then evaluated in the risk assessment. Because there are no chemical-specific dermal absorption factors (dermal permeability constants) for most inorganic chemicals, contaminants are assumed to absorb across intact skin at the same rate as water. Because metals generally are poorly absorbed across intact skin, this assumption likely overestimates the potential contribution of the dermal exposure route. When this dermal dose estimate is compared to the standard intake of drinking water (2 liters [L] per day for a person weighing 70-kilogram [kg]) for the same exposure duration assumptions, this exposure route contributes an estimated 0.2 percent of the dose associated with drinking water. Because the assumptions for this dermal dose calculation are believed to overestimate exposure, and because this route provides less than a 1 percent incremental contribution to total exposure dose, this pathway is not evaluated further in the baseline risk assessments unless site-specific factors (such as the absolute amount of the dermal exposure dose) indicate an evaluation is appropriate.

Because some metals biomagnify in plants, the irrigated produce ingestion exposure pathway may contribute notably to total exposure. This exposure pathway, however, cannot be evaluated meaningfully, based on current data. Therefore, plant uptake studies are being conducted for the UMTRA Ground Water

Project. This exposure pathway analysis is deferred until results of these studies are available. For most sites, the baseline risk assessment is conducted without these results, which are presented in the site-specific NEPA document. Because meat/milk ingestion exposure pathways also are dependent on these results, these exposure pathway analyses (where applicable) also are deferred.

Section 6.0, Human Health Risk Evaluation, in the baseline risk assessments, discusses how the health risks caused by these exposure doses are evaluated.

Exposure algorithms

The dominant human exposure pathway for ground water toxicity is likely to be drinking contaminated ground water. Exposures are evaluated separately for the noncarcinogenic and carcinogenic effects of contaminants. A contaminant may have only noncarcinogenic effects (for example, molybdenum) or both noncarcinogenic and carcinogenic effects (for example, arsenic). The effects of chemical carcinogens and radionuclide carcinogens are estimated separately.

The toxicity of noncarcinogenic contaminants in drinking water depends primarily on the average intake of contaminant per kilogram of body weight per day. These intakes can be calculated for short- or long-term exposures. The same algorithm is used to calculate carcinogenic risk from chemical (nonradionuclide) carcinogens. Although carcinogenicity is considered cumulative over a lifetime, the exposure for chemical carcinogens is calculated in milligrams per kilogram per day (mg/kg-day). This is because EPA-derived cancer slope factors (risk per mg/kg-day) for chemical carcinogens correlate estimated daily intakes averaged over a lifetime (measured in mg/kg-day) to incremental cancer risk.

Risk from radioactive contaminants in the ground water depends on total exposure over time rather than on average daily exposure. In addition, the body weight factor is relatively insignificant in determining carcinogenic risk. Exposure to a carcinogenic radionuclide therefore is quantified as total exposure to radioactivity throughout an individual's exposure duration.

The variables specified above can encompass a wide range of possible values. Ground water conditions are dynamic, and people naturally vary in body weight, consumption habits, and their length of residency within an affected area. Additionally, some individuals and/or subpopulations could be more vulnerable to potential exposure than the general population. These sensitive populations could include infants, children, the elderly; people with existing illness, such as diabetics; and individuals with preexisting occupational and/or dietary exposures (dietary intake of certain contaminants may be elevated due to naturally elevated soil/water constituent levels). These differences are considered in the UMTRA Project risk assessments, whenever possible. Because health risks associated with ground water consumption varies among members of the population, probability distributions are used to adequately describe a population's range of potential exposure when data are sufficient to construct distributions.

Development of concentration distributions

A probability distribution for an exposure variable provides a range of possible values for the variable and measures the relative likelihood of occurrence of each value in the range. For ground water contaminant concentrations, continuous (smooth) probability distributions are selected to model the observed statistical behavior of concentration data collected over time from wells that access the most contaminated ground water at the site. The probability assigned by the distribution to any particular concentration value is interpreted as the likelihood that an individual using this ground water as a drinking water source would consume that level of contamination throughout the exposure period. This model interpretation assumes relatively small measurement errors in the concentration data. The probability distributions used for UMTRA Project risk assessments describe random variation in water quality within a relatively small geographical area and for relatively short time intervals. Typically, the interval between sampling events is 1 year or less, which optimizes the distributions for assessment of acute to subchronic exposures. This generally is appropriate since several contaminants at some UMTRA Project sites are at concentrations associated with acute toxicity.

Selecting a contaminant concentration probability distribution typically follows the steps below:

1. One or more wells are identified that show comparable levels of contamination consistently higher than all other monitor wells screening the same aquifer.

2. A previous time interval is determined for which it is appropriate to include data (e.g., the interval during which contaminant levels in these wells have remained relatively stable, quality assurance/quality control (QA/QC) of data was conducted, and detection limits are acceptable).

3. All independent measurements taken from the wells during this time interval are pooled into a single data set. Data are displayed graphically using histograms and/or box plots.

4. A theoretical probability distribution is selected that mimics the basic shape of the sample data. The mean and standard deviation of the theoretical distribution are set equal to the mean and standard deviation of the sample data.

5. The theoretical distribution is truncated in the right tail at the 99th percentile to set an upper limit on the level of realistic potential contamination. This truncation level is somewhat arbitrary, but in practice it has resulted in an upper limit approximately 5 to 10 percent above the highest observed level of a contaminant in the sample data.

This procedure assumes that variation in historical data can be used to predict near-future variation in on-site concentrations. This assumption is questionable when historical data show an obvious upward or downward trend over time. In these cases, linear regression methods are used to predict the current level of the contaminant and to estimate the amount of random variation around the trend line (the root mean squared error [RMSE]). The probability distribution then is centered on the predicted current concentration of the contaminant, with standard deviation set equal to the RMSE. Figure B2.2 shows an example of a concentration distribution for molybdenum.

Development of other exposure factors

Body weight and average daily water intake distributions, by age group, are based on data from large national surveys. Extensive national data on weights and ages of men and women were collected for the National Health and Nutrition Survey between 1976 and 1980. These data were used to develop lognormal probability distributions for body weight by age and separately by gender. The distributions for each gender then were combined using census data on the national ratio of men to women within each age group. Body weight distributions for the three age groups are shown in Figure B2.3.

Lognormal probability distributions, by age, also were used to describe variation in area residents' average daily intake of tap water. These distributions were developed from data the U.S. Department of Agriculture collected during a 1977-1978 nationwide food consumption survey (Roseberry and Burmaster, 1992). The survey recorded total tap water consumption during a 3-day period for 26,081 survey participants. Distributions were developed for body weight and ingestion rates for 0- to 1-year-olds, 1- to 10-year-olds, and 11- to 64-year-olds. This age grouping was selected because intake-to-body-weight ratios are similar and toxicokinetics typically are comparable within these groups. These ingestion rate distributions are shown in Figure B2.4. Although these two variables are treated as independent variables in the exposure distributions, there likely is a positive correlation between weight and water ingestion rates.

Use of distributions based on national data requires an assumption that the distributions of body weight and water ingestion as well as the ratio of men to women among residents in the vicinity of an UMTRA Project site are comparable to those of the nation as a whole. This assumption is probably reasonable for body weight and gender ratios. Since many sites are in the arid west, however, site-specific ingestion rates could vary considerably from the national average.

The exposure frequency (days per year) and the exposure duration (years) are also likely to vary from individual to individual within a community. Part-time residency and vacation patterns among full-time residents affect exposure frequency. Variance in exposure duration results principally from the movement of residents in and out of the community. These variables are clearly site-specific, and national averages may be inappropriate for the specific communities in the vicinity of UMTRA Project former processing sites. Many sites are in rural areas or near small towns where residency is stable. The population of such sites may reasonably be considered lifetime residents. This general pattern probably is followed by Native American populations in the vicinity of five UMTRA Project sites (Mexican Hat, Utah;

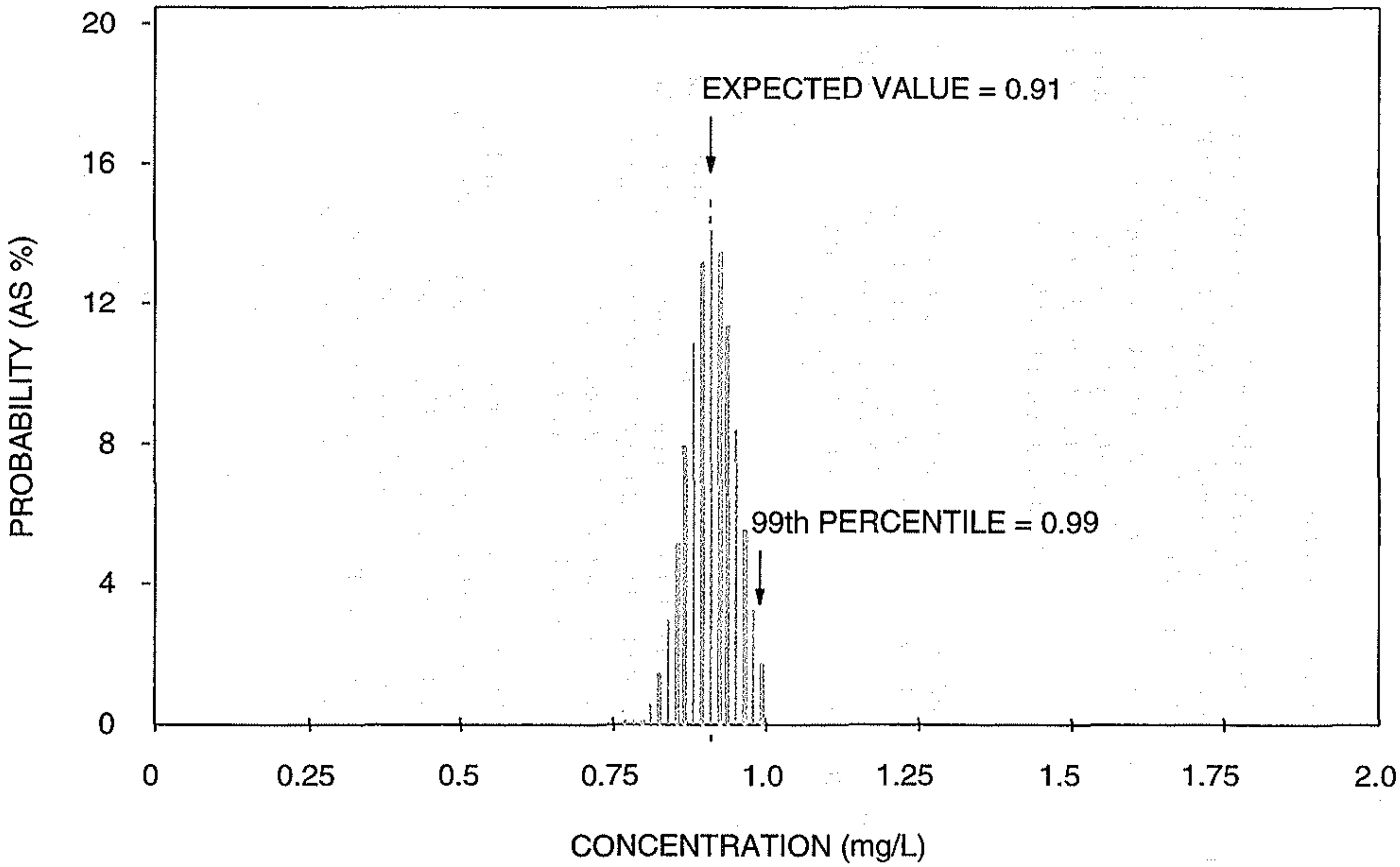


FIGURE B2.2
PROBABILITY DISTRIBUTION OF MOLYBDENUM CONCENTRATIONS

PATH I:\FL3.01\PEISAPPB

MOLYCONC.DRW

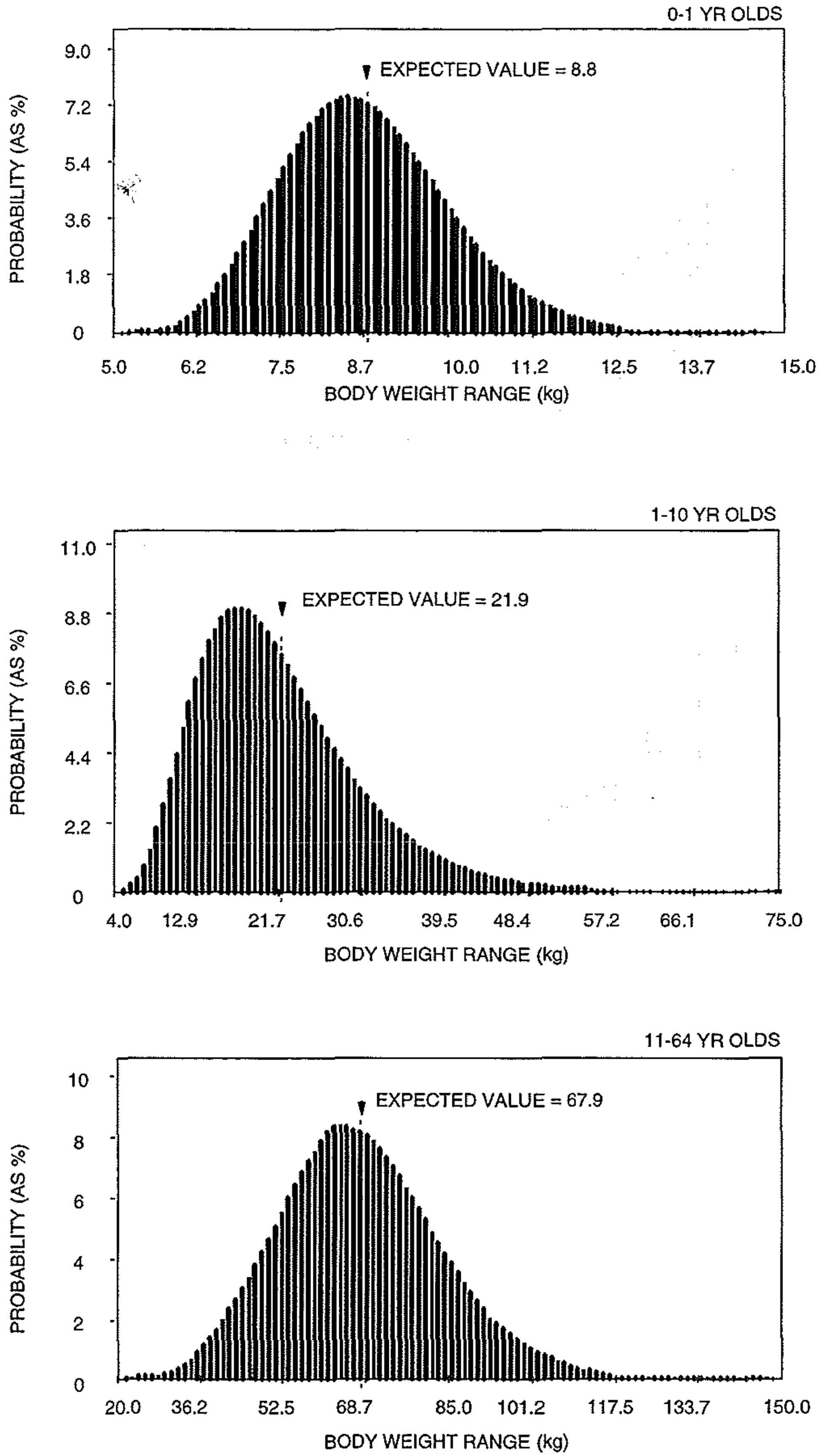


FIGURE B2.3
PROBABILITY DISTRIBUTIONS FOR BODY WEIGHT

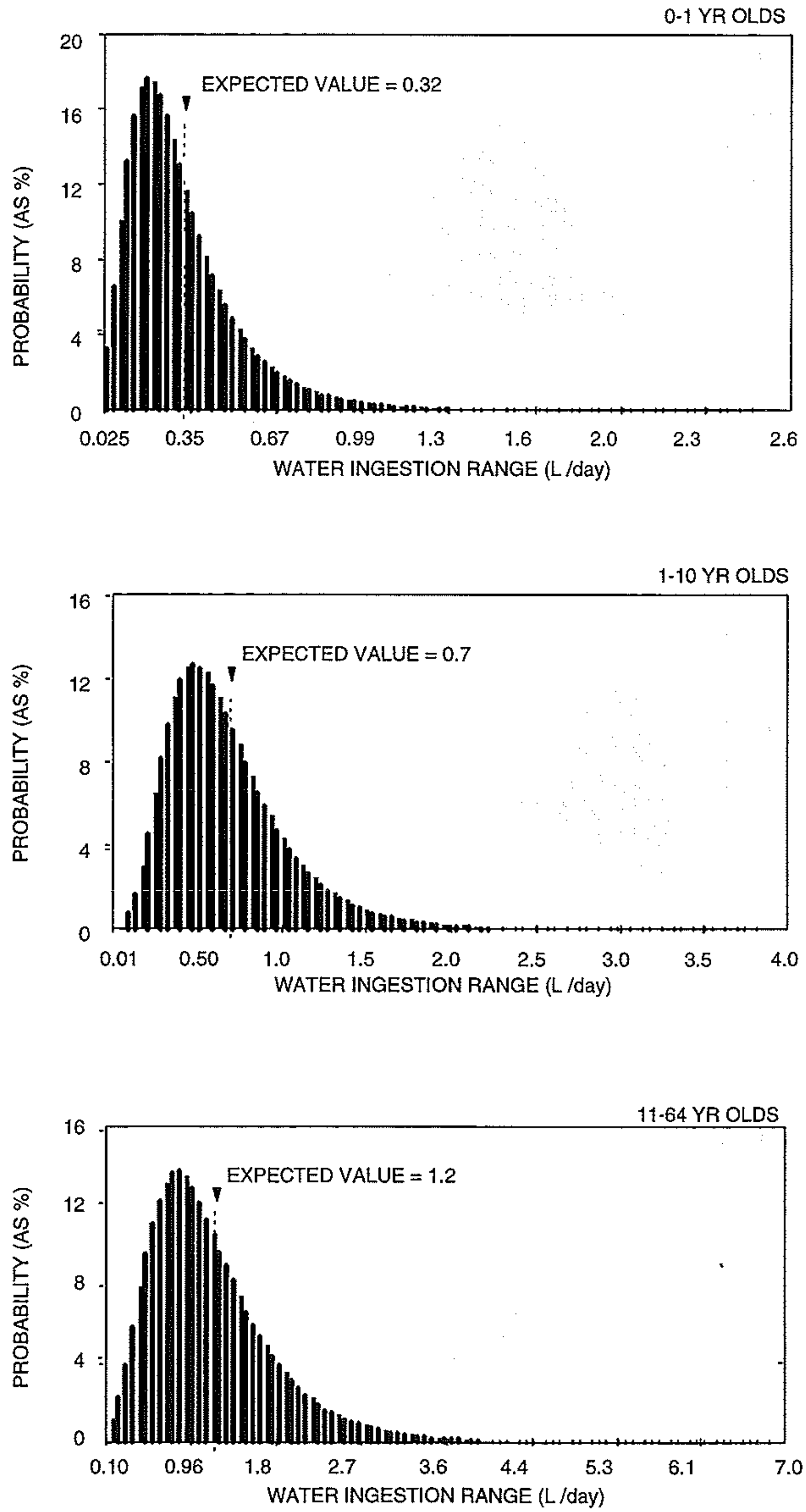


FIGURE B2.4
PROBABILITY DISTRIBUTIONS FOR TAP WATER INGESTION RATES

Monument Valley, Arizona; Shiprock, New Mexico; Riverton, Wyoming; and Tuba City, Arizona); the farming region in the vicinity of the Belfield/Bowman, North Dakota, and Falls City, Texas, sites; and some rural/ranching communities.

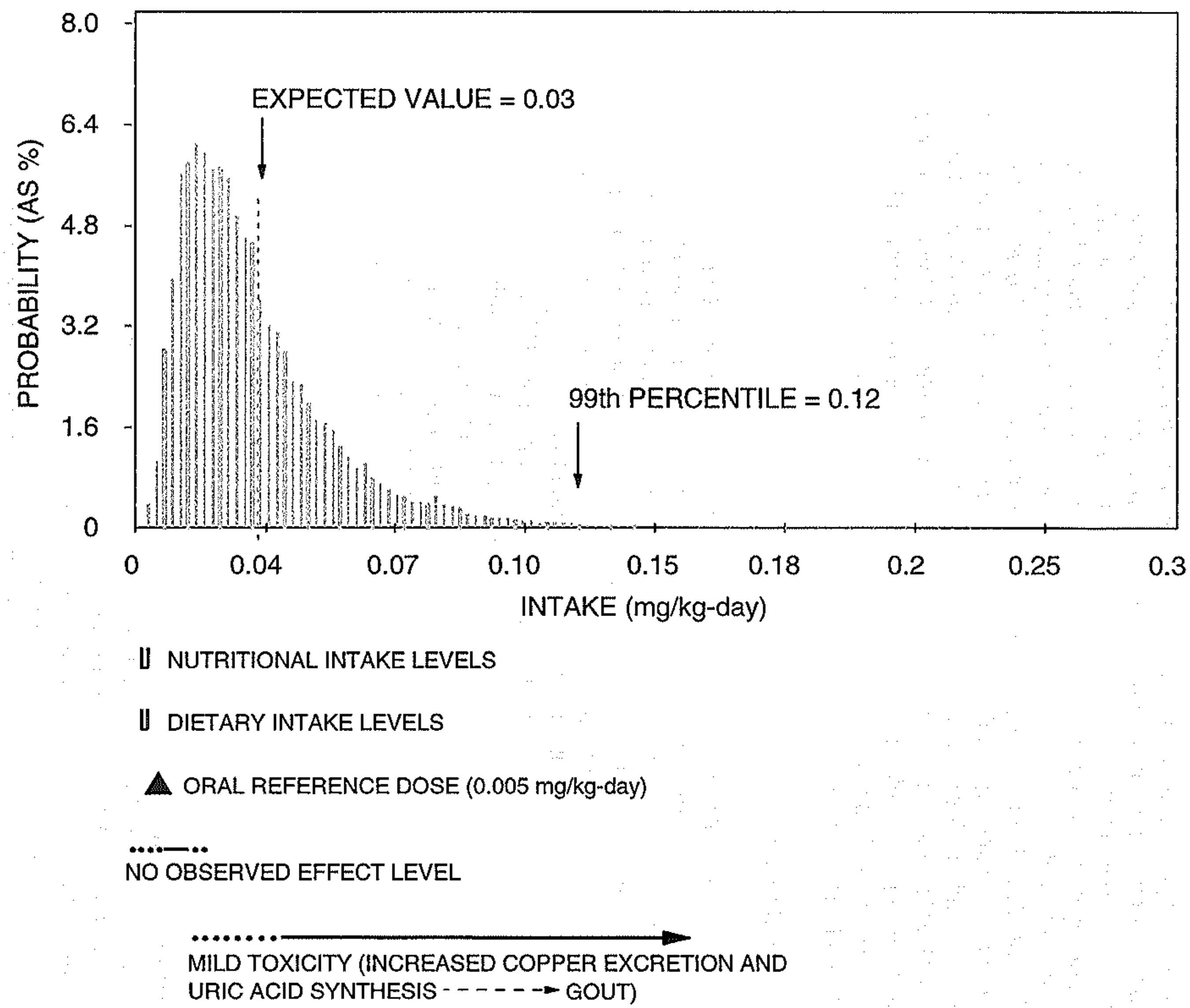
Because exposure frequency and duration data are not available in sufficient detail to allow construction of site-specific distributions, assumed default values are used for these two variables. Since exposure frequency and exposure duration essentially cancel out with averaging time in calculations for noncarcinogens (see Equation (1)), these factors are primarily of concern for estimating lifetime cancer risks and do not affect acute or chronic toxicity interpretations. However, for radionuclide carcinogens, the exposure frequency default value used is 350 days per year, which allows a 2-week vacation or absence from the residence. For estimating lifetime cancer risks, exposure duration defaults are 30 years for towns with a strong economic base; 50 years for farm, ranch, or rural communities; and 70 years for other sites where the population has a history of permanent residency, such as Native American populations.

Simulated exposure distributions

Distributions of potential exposures are calculated using Monte Carlo simulations. These simulations repeatedly select numerical values for each input variable (contaminant concentration, body weight, and ingestion rate), insert the selected values into the equations described above, and calculate the resulting exposure. Each iteration of this process selects numerical values according to the probability distributions for the input variable; therefore, numbers with a higher probability of occurrence in the distribution are chosen more frequently. This process is repeated 10,000 times, and the exposure values resulting from these iterations are displayed in a histogram representing the range of calculated exposures. Ten thousand iterations produce a smooth distribution in a short amount of computer time and provide reliable estimates of the mean and extreme percentiles. These simulations indicate the relative likelihood that various exposure levels will occur at a site. From this distribution, percentile values can be determined that indicate the percentage of exposures expected to fall above or below a given reference point. Figure B2.5 shows an example of this intake distribution.

B2.6 TOXICITY ASSESSMENT

Toxicity assessment is one of the weakest aspects of the widely used standard risk assessment methodology. The UMTRA Project methodology is designed to strengthen this part of the assessment. In the standard method, the noncarcinogenic evaluation results in the calculation of a hazard quotient, which is the ratio of estimated intake to the reference dose or acceptable intake. This quotient is of limited use because, when the ratio exceeds 1, the quotient conveys no information regarding the type or severity of potential adverse effects. An additional limitation of the use of this ratio is that the reference dose often includes a substantial factor to account for uncertainty in the toxicity data. These factors can range from 1 to 1000, which can make hazard quotients for various contaminants



NOTE: 30% OF THE PREDICTED EXPOSURES FOR CHILDREN LIE IN THE RANGE WHERE MILD TOXICITY COULD BE EXPECTED.

FIGURE B2.5
HEALTH EFFECTS OF POTENTIAL MOLYBDENUM EXPOSURE RANGES FOR CHILDREN

difficult to compare. Perhaps the most significant drawback to the hazard quotient/index approach is that these numbers mean little to the public and to decision-makers. The UMTRA Project risk assessment method attempts to avoid those shortcomings.

The primary source of toxicological information that is used to write the toxicity profiles for the contaminants of potential concern is the Integrated Risk Information System (IRIS). IRIS is supplemented by 1) the Agency for Toxic Substances and Disease Registry toxicological profiles; 2) the *Handbook on the Toxicology of Metals* (Friberg et al., 1986); 3) the Health Effects Assessment Summary Tables (HEAST); and 4) primary literature searches to supplement evaluations with additional recent data when only limited data are available from the secondary source material. Human data are preferred, but animal toxicity data are included if human data are insufficient to determine a given contaminant's toxic effect or particular exposure range. Toxicity data obtained from drinking water exposures are weighted more heavily than data from other of exposure pathways because for some contaminants of potential concern, bioavailability of the contaminant in water versus food can influence toxicity. Additionally, chemical speciation of the contaminants under the site-specific ground water conditions is considered with respect to the ability of chemical form to alter potential toxicity.

To allow comparison across studies and with other databases, toxicity data reported in the literature surveyed are converted to milligram intake per kilogram body weight per day based on the following conversion factors:

Adults: 2 L of water ingested per day; 70 kg body weight.
Children: 0.7 L of water ingested per day; 22 kg body weight.
Infants: 0.64 L of water ingested per day; 4 kg body weight.

The conversion factors for adults are EPA default values (EPA, 1989a) and are similar to the values from the UMTRA probability distributions (expected value for ingestion =1.2 L per day; weight = 68 kg). For children, EPA does not specify default values for the 1-to-10-year range; therefore, the expected values from the modeled distributions are used.

The expected values from the probability distributions for infants vary significantly from the EPA default values used in IRIS. The amount of domestic drinking water consumption can vary dramatically in this group because some infants are fed exclusively on canned liquid formula or breast milk while others consume more water from reconstituted liquid concentrate or powdered formula. The simulated distribution takes all infants into account and therefore results in a much lower average ingestion rate (0.32 L per day) than the default value. In addition, the EPA value defines infants as less than 4 months old, while the simulated distributions define infants as less than 1 year old. Because the IRIS infant data came primarily from the younger age group, the EPA default values were used for conversion. However, the distribution reflects the entire infant population likely to occur at UMTRA Project sites. Therefore, infants drinking only formula reconstituted with tap water belong at the upper end of the exposure distribution. These ingestion values could exceed the expected value by as much as 300 percent, but still would fall within the exposure distribution range.

The toxicity values obtained in the above manner are presented on the graphs as ranges, incorporating dietary and/or nutritional information and available regulatory values (such as EPA oral reference doses) for each contaminant. The exposure range at UMTRA Project sites includes mild, severe, acute, and chronic toxic effects. Because toxicity data for most contaminants are incomplete, uncertainties are characterized on the figures by dotted lines. Animal data are represented by widely spaced dotted lines. Uncertainty about the beginning or ending points of toxic effects associated with particular exposure ranges is represented by closely spaced dots. Any potential interactions of the various contaminants present at a site are discussed qualitatively at the end of the toxicity assessment section of the document.

B2.7 HUMAN HEALTH RISK EVALUATION

The potential toxicity ranges are superimposed graphically on the simulated exposure distributions and presented with semiquantitative interpretations of adverse health effects that might be anticipated. Combining the distributions presented in Figures B2.2, B2.3, and B2.4, Figure B2.5 presents the potential molybdenum exposure for children that results from the Monte Carlo simulation. Children are used in this example because they represent the group with the greatest exposure per body weight. The exposure ranges that would cause specific nutritional or toxic effects are shown below the respective intake distribution graphs. Dashed lines or dots show where a toxic effect is suggested but not well established.

Although acute toxicity could preclude chronic exposure to certain contaminants, both short-term and chronic noncarcinogenic adverse health effects and carcinogenic effects are evaluated in this section. This is because ground water contaminants may flush out at different rates and because remedial action strategies may differ for different contaminants. Specific toxicological sensitivities of human subpopulations to contaminants of potential concern (such as previous occupational exposure or site-specific dietary intakes) and health effects resulting from possible toxicological interactions between components of site-specific chemical mixtures are addressed qualitatively, whenever possible.

As presented in Figure B2.5, potential exposures to molybdenum indicate nearly all potential exposures exceed the EPA oral reference dose of 0.005 mg/kg-day. Approximately 30 percent of the potential exposure distribution falls within the range where mild toxicity would be expected based on literature information. The additional contribution expected from background dietary intake, plus the small contribution (1 to 5 percent) anticipated from other sources, would result in a greater percentage of the distribution falling within the range of toxicity. That toxicity manifests largely as increased copper excretion leading to copper deficiency. Intakes in the uppermost tail of the distribution might be expected to result in gout-like symptoms.

The simulations cover only the drinking water exposure pathway; therefore, additional intake from previously screened alternate exposure pathways can be compared to toxicity ranges. That comparison helps determine whether these intake levels would be associated with adverse health effects either when combined with the drinking water intake or when the sole exposure source is from the alternate pathway. This information is examined to determine the expected toxicity when any of these pathways occur independently of the drinking water ingestion pathway when there is a notable incremental increase to the simulated exposures.

Because cancer is a single-effect endpoint estimated for a cumulative lifetime exposure, and because cancer risks are regulated separately under the National Contingency Plan, a somewhat different approach to probability distribution is required for carcinogens. Carcinogenic risks associated with radiological exposure from ground water ingestion can be simulated if there are enough site data to create a meaningful distribution for concentration over time and for exposure duration. Because exposure to these contaminants is estimated over a lifetime, this simulation is performed for the adult population; it is measured in picocuries per lifetime because the carcinogenic risk of radionuclides is related to its radiological properties. The carcinogenic potential of exposures in this range are estimated using oral slope factors from HEAST.

B2.8 ECOLOGICAL, LIVESTOCK, AND AGRICULTURAL RESOURCES RISK EVALUATION

This section describes the qualitative methodology used to evaluate the ecological risk at UMTRA sites. The *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation* (EPA, 1989b) is the primary guidance document used for ecological evaluations.

The EPA recommends conducting ecological assessments in a phased approach to ensure the most effective use of resources while all necessary work is conducted (EPA, 1992). This approach consists of four increasingly complex phases, starting with identifying potentially exposed habitats (phase 1), collecting analytical data from potentially affected media such as surface water and sediment (phase 2), collecting biological samples such as plant and animal tissue (phase 3), and conducting toxicity testing (phase 4). If the early phases of the assessment indicate contaminants may be adversely affecting the ecological receptors, a higher level of analysis may be warranted. However, if the early phases of the evaluation indicate little or no potential for ecological risk, the assessment will likely be complete.

Phases 1 and 2, and to a limited extent phase 3, were completed during the ecological risk evaluations for UMTRA Project sites. Therefore, the ecological evaluations are a screening level assessment of the risks associated with the potential exposure of terrestrial and aquatic biological communities to contaminated ground water or to environmental media potentially affected by ground water, such as surface water and sediment. Using the qualitative approach, contaminant concentrations detected in environmental media are compared to aquatic life criteria and sediment, vegetation, wildlife, livestock watering, and crop irrigation guidelines to determine if the contaminants of potential concern pose a potential risk to ecological, livestock, and agricultural receptors.

Sources of uncertainty in the ecological assessments can arise from limited media analyses and limited toxicological information, and from the inherent complexity of the ecosystem. In addition, methods of predicting nonchemical stresses (e.g., drought), biotic interactions, behavior patterns, biological variability (differences in physical conditions, nutrient availability), and resiliency and recovery capacities are often unavailable. Therefore, it is often difficult to determine if contaminants can affect the biological component of an ecosystem and to predict whether estimated exposures will cause adverse effects to the ecosystem.

In evaluating the ecological environment at UMTRA Project sites, the following general processes are used:

- Potentially impacted environmental media are identified (e.g., ground water, surface water, or sediment).
- Potentially impacted receptors are identified (e.g., plants, crops, livestock, wildlife, aquatic life.
- Contaminants of potential ecological concern are selected for each medium identified as potentially impacted by contaminated ground water. For the media selected, contaminants of potential concern are the contaminants that exceed background levels.
- Potential current and hypothetical future exposure pathways are identified. Concentrations of contaminants of potential concern are compared to appropriate criteria or guidance values protective of aquatic and terrestrial biological communities and agricultural resources.
- Potential adverse impacts to receptors are discussed. If this screening assessment indicates contaminants may be adversely affecting the ecological receptors, further investigation of ecological conditions may be warranted. Any data gaps identified in the risk assessment will be addressed in the SOWP for the specific site.

B2.9 INTERPRETATION AND RECOMMENDATIONS

This section summarizes the risk assessment results and explains the assessment's limitations. The uncertainties and limitations below can be associated with the risk assessments.

- Fluctuations and trends in contaminant concentrations.
- Use of ground water data from filtered samples.

- Completeness of ground water data (for example, has the most contaminated part of the plume been located? Were analyses performed for all relevant contaminants?).

- Use of data not specific to sites to derive exposure parameters.

- Exposure pathways eliminated at the screening stage based on poorly defined uptake parameters.

- Limitations in available toxicity data.

- Limitations in the data available to evaluate contaminant interactions.

This section also summarizes the EPA ground water standards established for UMTRA Project sites and any other relevant health advisories or standards. If the site presents an imminent risk to public health, risk mitigation measures are described. This generally involves characterization of potential interim institutional controls that may be pursued to prevent access to contaminated ground water while the site is studied further and/or remediated.

Recommendations comprise the last component of this section. Recommendations include any further site characterization needed to better evaluate risks for remedial action decisions.

B3.0 RISK ASSESSMENT SUPPLEMENT

Supplemental information, bound under separate cover, will be available for all UMTRA Project baseline risk assessments. The supplements include (at a minimum) the following:

- A copy of the *Human Health Risk Assessment Methodology for the UMTRA Ground Water Project* (DOE, 1994).

- Water use information, if water use surveys were performed for private well users in the site area.

- Hydrogeologic calculations. Any hydrogeologic calculations that are not referenced in another document, such as the remedial action plan, must be included in the supplement (e.g., the calculation a plume length). The QC cover sheet, which indicates that calculations were checked, must be signed and dated by the generator of the calculations and by the person who checked and approved the calculations. The QC sheet is included in the project file rather than in the supplement.

- The complete Software Program for Environmental Analysis and Reporting (SPEAR) analytical data set of all available data, including all media that were evaluated in the baseline risk assessment (such as ground water, surface water, and/or sediment). Because unvalidated data are or have been used in the baseline risk assessments while historical validation is under way, the supplement includes a copy of the unvalidated data evaluated in the baseline risk assessment, and a copy of the validation report.

- Statistical summary report containing

  - @Risk parameter input report. The QC cover sheet, which indicates that the calculations in the @Risk program were checked, must be signed and dated by the generator of the @Risk results and by the person who checked the spreadsheets.

  - 95th upper confidence limit (UCL) calculations. The QC cover sheet, which indicates that the UCL calculations were checked, must be signed and dated by the generator of the UCL calculations and by the person who checked the spreadsheets. The QC sheet is included in the project file rather than in the supplement.

  - Other pertinent statistical information (as determined by the statistician).

- Geochemical modeling report. Calculations for speciation and saturation indices for ground water include modeling printout, data rounds, wells used, and assumptions made. The supplement also includes any hand calculations not presented in the text (e.g., a solubility product of a mineral not in the PHREEQE database, and computation of a Kd, or dispersion effect on a major element). The QC cover sheet, which indicates that calculations were checked, must be signed and dated by the person who generated the calculations and by the person who checked and approved the calculations.

- Monitor well completion report. This report includes the SPEAR database monitor well report, which is a summary page, and copies of boring logs for all monitor wells with reference to source.

- Contaminant of potential concern worksheets. Examples of these worksheets include recommended daily allowances, normal dietary daily intakes, and standards.

- Derivation report for drinking water ingestion rate distributions.

- Derivation report for body weight distributions.

- Spreadsheet calculations for screening exposure pathways. The QA cover sheet, which indicates that spreadsheet calculations were checked, must be signed and dated by the person who generated the spreadsheets and by the person who checked the spreadsheets.

This section must cross reference the SPEAR analytical data set from Section 3.0 in reference to relevant ground water, surface water, or sediment data. The entire analytical data set for fish, invertebrates, or vegetation samples must be included in the supplement for this section.

B4.0 FILES TO DOCUMENT CONTROL

All calculations and spread sheets, memos, or meeting minutes that summarize discussions affecting the content/direction of the risk assessment and any other relevant documentation are filed in the UMTRA Project Document Control Center. This enables external parties to trace the evolution of decisions affecting the evaluation of site-related risks. All site-specific correspondence from the public, regulators, or other consultants should also be included in the document control file.

B5.0 RISK ASSESSMENT LIMITATIONS

The procedures described here represent a methodology that incorporates exposure probability distributions with superimposed toxicity range information and criteria. Additional work can be directed toward a better characterization and reduction of uncertainties and extension of the potential applications of this method.

For many UMTRA Project sites, an extensive evaluation of just the drinking water pathway may be sufficient. However, the analysis of other pathways may become increasingly important for remedial action decision-making at other UMTRA Project sites because at some sites drinking is not a potential use of the ground water. At these sites, risk-based levels other than MCLs may need to be developed from other pathways (e.g., naturally poor water quality or yield may mean that while people do not drink the water, it still may be used for livestock or for bathing).

The following areas are identified for further development, with the goal of eventually providing risk analyses that support site-specific remedial action decisions more firmly.

DATA EVALUATION

- Because most historical data are for filtered samples, concentration probability distributions for contaminants are almost always based on filtered water quality data. However, exposure is likely to be to unfiltered ground water. More work is needed to assess the impact of filtering for the constituents most often associated with uranium mill processes.

- Risk assessment could use environmental fate and transport theory and estimates of contaminant concentration time trends to improve projections of future concentrations in the ground water. This may be important for carcinogens because carcinogenic risks are calculated for long-term exposure.

- More thought should be given to relevant sources of variability in data when developing and interpreting contaminant concentration probability distributions. For example, random ups and downs in contaminant concentrations tend to average out over a long time. As a result, the concentration distributions used to evaluate chronic exposure may be different from those used to assess single dose or acute toxicity.

EXPOSURE ASSESSMENT

- Joint probability distributions are needed to reflect the positive correlation between the ingestion rate and body weight, especially for infants and children. The use of joint probability distributions would reduce the variability in average daily intake distributions. A separate distribution should be included to quantify water ingestion rates of infants fed exclusively on reconstituted formula.

- Probabilistic exposure assessment could be extended to other pathways if realistic distributions were available for such variables as meat and milk transfer coefficients, site-specific plant uptake values, and produce, meat, and milk ingestion rates.

- Additional information is needed to develop site-specific exposure frequency and exposure duration distributions.
- A more detailed evaluation of ground water contaminant concentration trends with time is needed to determine the significance of carcinogenic exposures.

TOXICITY ASSESSMENT

- Additional toxicity data available from other sources should be incorporated for completeness.
- Combined toxicity and contaminant interactions could be presented graphically if quantitative interpretation of a net result of interaction were possible with available toxicity data.
- Site contaminants may pose special risks to certain sensitive subpopulations such as diabetics, the elderly, pregnant women, alcoholics, or individuals with prior exposure to site contaminants (for example, occupational exposures). Identification and discussion of these problems should receive additional attention in future risk assessment documents.
- Further improvement in representing toxicity data and uncertainties could be explored.
- When available, plant uptake data should be incorporated.

Many of these limitations will be addressed in the SOWPs and other ongoing studies that will be completed prior to compliance strategy decision making.

B6.0 METHODOLOGY CONCLUSIONS

Risk assessment methodologies were reviewed from the literature and in discussions with regulatory agencies, scientists, and professionals in the field. Based on the UMTRA Project experience and this research, the consensus is that current risk assessment methodologies are imperfect in many respects. Many risk assessors believe that incorporation of probabilistic analysis would resolve some of these problems. Work with UMTRA data indicates that while probabilistic methods offer a means of incorporating variability into assessments, data often are insufficient to allow development of valid distributions. Distributions based on inadequate data can introduce additional uncertainty and potential sources of confusion rather than increasing the value of the assessment.

The major areas where data are insufficient for constructing probability distributions involve toxicity assessment; human data are often unavailable, accurate dose reconstructions are not always possible, and extrapolations from animal data to human situations are often questionable. However, databases needed to assess many aspects of exposure are often adequate to allow probability distributions to be constructed with a high degree of confidence. This approach incorporates probability distributions for all variables where adequate databases are available for the exposure assessment.

To convey as much information as possible to the public and to decision-makers, the baseline risk assessments present a semiquantitative interpretation of toxicity and potential health risk. Available toxicity data from the literature are translated into a graphic form that is superimposed on the exposure ranges. Toxicity ranges can be defined from existing human data on nutritional and/or dietary intakes, through a full range of toxic effects from minor to severe. These can be supplemented with animal data if human data do not exist and if the animal data are notated accordingly. This approach clarifies 1) the overlap of exposure ranges where adverse health effects have been reported and potential exposures from using ground water at UMTRA Project sites, and 2) severity of the potential effect.

Although all human health risk assessments are limited by the database available, managing risk will be facilitated by providing the public and decision-makers with a graphic representation that improves their ability to make informed decisions based on relative toxicity, likelihood of effect, and severity of effect. Although no safety factors are directly incorporated in the present baseline risk assessment methodology, decision-makers and the public are given information that should allow such concerns to be addressed based on realistic site-specific assumptions. This will enable the UMTRA Project to make better decisions that adequately protect public health and to effectively communicate those decisions to the public.

B7.0 REFERENCES

DOE (U.S. Department of Energy), 1994. *Human Health Risk Assessment Methodology for the UMTRA Ground Water Project*, DOE/AL/62350-170, prepared for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

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National Research Council, 1989. *Recommended Daily Allowances*, tenth edition, National Academy Press, Washington, D.C.

Roseberry, A. M., and D. E. Burmaster, 1992. "Lognormal Distributions for Water Intake by Children and Adults," *Risk Analysis*, Vol. 12, No. 1, pp. 99-104.

CODE OF FEDERAL REGULATIONS

40 CFR Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*, U.S. Environmental Protection Agency.

UNITED STATES CODE

42 USC § 7901 *et seq.*, *Uranium Mill Tailings Radiation Control Act*, 8 November 1978.

APPENDIX C

GROUND WATER REMEDIATION METHODS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Definition
DOE	U.S. Department of Energy
EPA	Environmental Protection Agency
UMTRA	Uranium Mill Tailings Remedial Action

1.0 INTRODUCTION

This appendix describes proven technologies and selected innovative technologies for ground water remediation. Two general types of technologies are discussed: natural flushing and active ground water remediation.

Ground water remediation by natural flushing allows the natural ground water movement and geochemical processes to decrease the contaminant concentrations to levels below regulatory limits in a specified period of time. To select a natural flushing remediation design at a specified Uranium Mill Tailings Remedial Action (UMTRA) Project site, the U.S. Department of Energy (DOE) would conduct scientific and engineering investigations to demonstrate the design's effectiveness at achieving U.S. Environmental Protection Agency (EPA) ground water standards and protecting human health and the environment.

Active ground water remediation methods involve the engineered alteration of ground water flow, quantity, or quality to achieve compliance with the EPA ground water standards. Investigations would be conducted to select an active remediation method or methods for a specific site and to demonstrate the effectiveness of achieving EPA ground water standards. Active remediation methods could be used in combination with natural flushing.

2.0 NATURAL FLUSHING GROUND WATER REMEDIATION

With natural flushing, contaminants in ground water are dispersed or removed by the natural flow of ground water (Figure C.1). Under Subpart B of the EPA ground water protection standards, this method may be used to achieve compliance with the standards if the following can be demonstrated:

- Compliance would occur in 100 years or less.
- The ground water is not now, and is not projected to be, used for a community water supply (or other beneficial use) within the natural flushing period.
- Established concentration limits are not projected to be exceeded at the end of the natural flushing period.
- Adequate monitoring would be established and maintained throughout the flushing period.

Institutional controls would be used along with natural flushing; these controls must effectively protect human health and the environment and, where practicable, satisfy beneficial uses of ground water during natural flushing.

Natural flushing could be employed as the sole method for ground water remediation, or it could be used in conjunction with active methods. For example, natural flushing could be used in conjunction with gradient manipulation to control the migration of ground water contaminants and to ensure that the EPA ground water compliance standards are achieved within the 100-year period. Natural flushing could be a useful method of ground water remediation at sites with high ground water velocities, locations near points of ground water discharge into surface water bodies, or aquifer properties that disperse and/or absorb contaminants.

Generally, aquifers with high ground water velocities and dispersivities have the capacity to decrease contaminant concentrations by the processes of dilution and dispersion. When a ground water contaminant plume discharges into a river, ground water contaminants may be diluted because the ground water discharge volume is very small compared to the volume of river flow.

Numerical solute transport modeling would be one tool used to evaluate the effectiveness of natural flushing. Numerical modeling would predict contaminant movement in response to ground water flow and geochemical reactions. Geochemical attenuation studies would be required to assess migration rates of specific contaminants of interest. Geochemical studies, including column leach tests or consecutive batch leach tests, could be used to determine the migration rate of species that adsorb onto the aquifer matrix and desorb from the matrix.

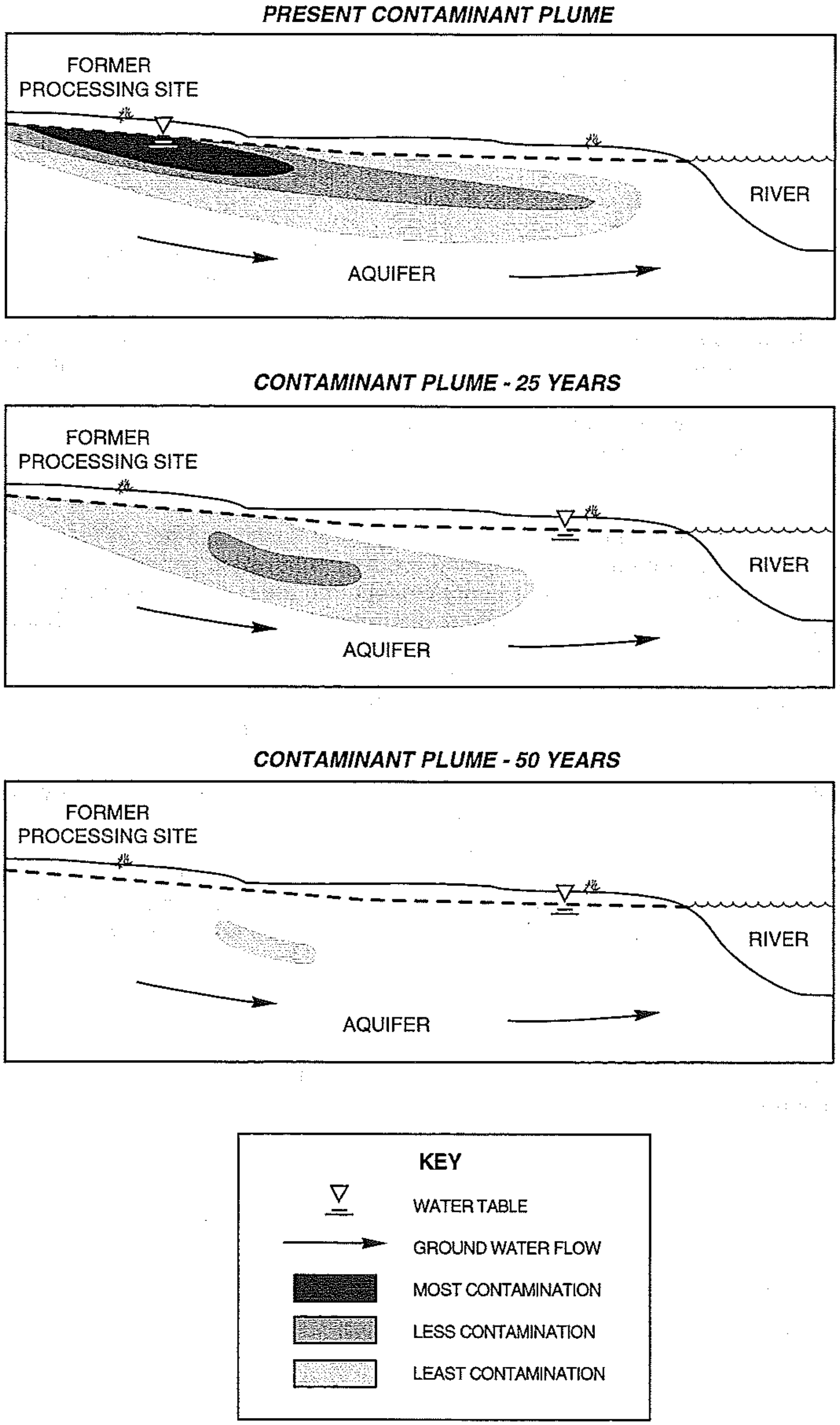

FIGURE C.1
CROSS SECTION VIEW OF NATURAL FLUSHING

3.0 ACTIVE GROUND WATER REMEDIATION METHODS

3.1 METHODS EXCLUDING GROUND WATER TREATMENT

3.1.1 Gradient manipulation

With gradient manipulation, wells, trenches, or ditches are constructed to add water to an aquifer. The added water changes the gradient of the water table to increase ground water velocity in a specific direction. This method could be used to deflect a contaminant plume into a surface water body that is large enough or flows quickly enough to adequately dilute the ground water contaminants to concentrations below regulatory limits (Figure C.2). This would eliminate the need for engineered water treatment. Such discharge does not require a National Pollutant Discharge Elimination System permit; however, the potential effect on the surface water quality would be analyzed as part of the risk assessments.

Gradient manipulation could be used with natural flushing to decrease concentrations of contaminants during the natural flushing period at a faster rate and to prevent the migration of contaminants into areas where ground water was not previously contaminated or where institutional controls cannot be effectively applied. Conversely, in cases where contaminated ground water discharges into a small surface water body and the surface water quality could be degraded, gradient manipulation could be used to prevent discharge into the surface water by hydraulically diverting the contaminated ground water flow.

Well systems could also be used to manipulate the hydraulic gradients by injecting or withdrawing ground water. The injection of water can form a mounding of the water table, which acts as a hydraulic barrier to ground water flow. Such a system could also be used to increase hydraulic gradients or manipulate the hydraulic gradient so that a contaminant plume can be flushed directly into a surface water body. This system has been used on other projects to control migration of contaminants in ground water.

Design criteria for gradient manipulation as an active method of ground water remediation combine the effectiveness demonstrations necessary for natural flushing with the principles of well and trench construction. Numerical solute transport modeling would be required to demonstrate the effectiveness of gradient manipulation at UMTRA Project processing sites. Geochemical studies, including column leach tests or consecutive batch leach tests, could also be used to determine the migration rate of adsorbed species. Chemicals that cause desorption of contaminants (lixiviants) may be investigated to ascertain their effectiveness to increase concentrations of contaminants in solution.

3.1.2 Containment and control of contamination sources and ground water contaminant plumes

Ground water contamination sources may be in the form of residual leachate or adsorbed hazardous constituents in the unsaturated zone above the water table.

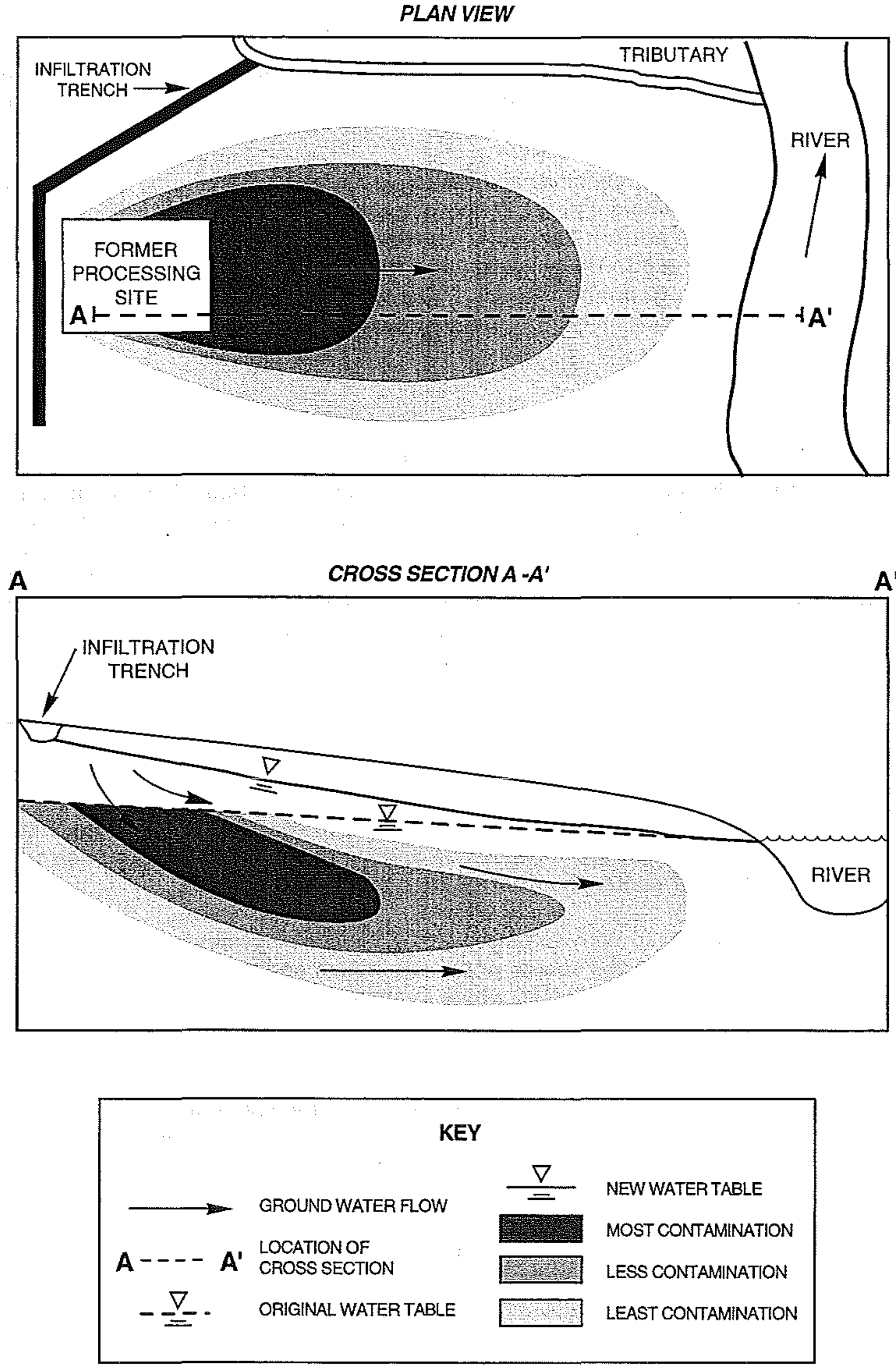

FIGURE C.2
GRADIENT MANIPULATION

MAC: NONSITE/PEIS95/APPC/GRADMAN

Zones of contamination in shallow ground water below a processing site could also be considered ground water contamination sources. These types of ground water contamination sources could be mitigated through engineered measures to control or contain their hazardous constituents.

Surface water control, capping, and contaminant isolation could be used to reduce or eliminate a contaminant source from entering the ground water. These technologies could prevent hazardous constituents remaining in soils at processing sites from migrating into the ground water or to prevent leachate contamination in perched ground water from migrating into an aquifer. These applications would likely be limited to small areas of contaminated material at UMTRA Project processing sites.

Surface water control

Surface water control measures minimize the amount of surface water flowing onto a site, thus reducing the amount of potential infiltration. Reducing the amount of infiltration slows the leaching of hazardous constituents from the unsaturated zone to the saturated zone. A slower rate of leaching increases the potential of an aquifer to naturally decrease hazardous constituent concentrations. Surface water control measures represent a relatively inexpensive means of minimizing infiltration. Surface water runoff can be minimized by using standard civil engineering techniques such as diversion berms and drainage ditches.

Capping

Capping of a site minimizes the infiltration of any surface water or precipitation that occurs at the site. An engineered surface (impermeable) cap is designed to minimize infiltration into the unsaturated zone by maximizing surface runoff and evapotranspiration. Surface caps can be used in ground water remediation to prevent leaching of contaminants from soils at processing sites.

The key steps involved with surface capping are the placement of the low-permeability layer over the source of contamination and the regrading and revegetation of the site. In areas where evapotranspiration greatly exceeds precipitation, a low-permeability layer may not be necessary. Regrading maximizes surface runoff and channels it away from the site. Revegetation allows for evapotranspiration of water that soaks into the cover soil, and surface capping prevents any remaining water from infiltrating into the waste and migrating down to the ground water. Both surface water runoff and ground water quality should be monitored.

Surface capping could be an economic alternative to excavation when the quantity of waste is very large. Surface capping would be effective in reducing the leaching of hazardous constituents to ground water at humid UMTRA Project sites.

Waste isolation

Low-permeability waste-isolation barriers such as sheet piling, grouting, and slurry walls could be used as part of a ground water cleanup strategy by inhibiting the outward flow of leachate or highly contaminated ground water. A hydraulic barrier could be used to isolate a ground water contamination area of high hazardous constituent concentrations. Once isolated from the surrounding ground water, the highly contaminated ground water could be extracted much more efficiently (Figure C.3).

Sheet piling

Sheet piling involves driving lengths of interconnected steel into the ground to form a thick, impermeable, permanent barrier to ground water flow. Sheet piling is generally used with drains or pumping wells that lower the potentiometric surface on the inside of the barrier and allow contaminated ground water to be contained and extracted. The hydraulic barrier created by sheet piling can prevent lowering of the water table on the other side of the barrier so that existing wells outside the contaminated area are not affected.

The design of sheet piling for waste isolation should consider several factors:

- Depth to water: Deep water tables or sites where contaminants have dispersed vertically to great depth in the aquifer limit the effectiveness of sheet piling.
- Presence of low-permeability beds: Waste isolation with sheet piling is effective when it can be driven into a low-hydraulic conductivity bed to prevent underflow around the bottom of the sheet piling.
- Depressurizing: Drains, wells, or surface capping often may be required to prevent the buildup of hydraulic head on the inside of the waste isolation unit created by sheet piling.

Grouting

Grouting can create an impermeable barrier to ground water flow to isolate contaminated ground water. Grouting is the process of injecting a liquid, slurry, or emulsion under pressure into the soil. The injected fluid moves away from the point of injection and occupy the available pore spaces. As time passes, the mixture partially solidifies, thus decreasing the original soil permeability.

Slurry walls

Slurry walls encapsulate an area either to prevent ground water pollution or to restrict the movement of contaminated ground water. The technology involves digging a trench around an area and backfilling with an impermeable material. Slurry walls can be placed either upgradient from a waste site to prevent influx of ground water into the site or around a site to prevent movement of contaminated

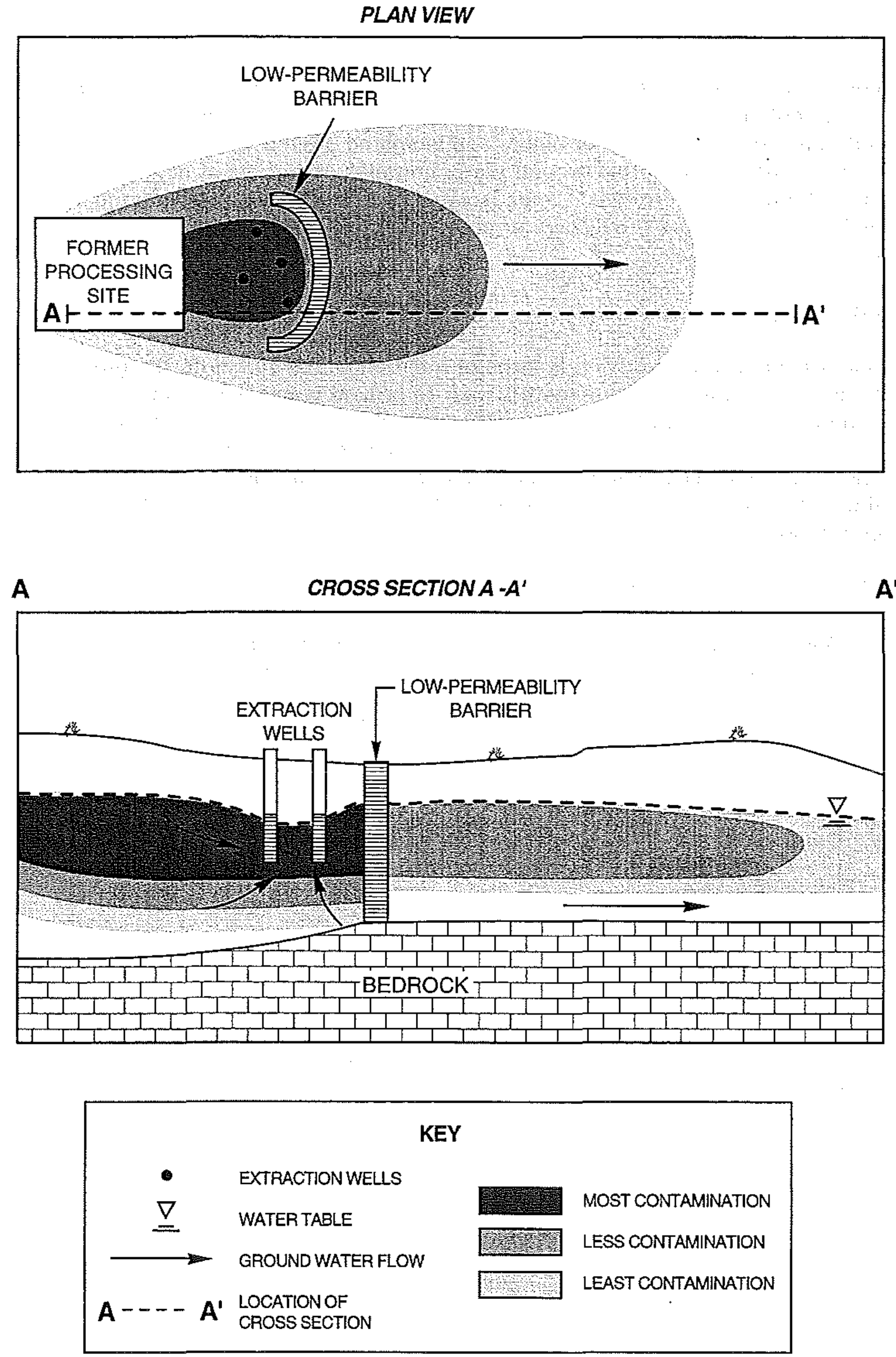

FIGURE C.3
LOW-PERMEABILITY BARRIER TO ENHANCE GROUND WATER EXTRACTION

MAC: NONSITE/PEIS95/APPC/ISOPERBAR

ground water away from a site. Usually, slurry walls require a complementary technology, such as surface capping, extraction wells, or drains.

3.2 EXTRACTION AND TREATMENT OF GROUND WATER

3.2.1 Ground water extraction

Extraction wells and well points

Well systems could be used to extract contaminated ground water for treatment or to create hydraulic barriers to ground water flow to increase the efficiency of extraction. These wells would be pumped at specified rates to control the movement of contaminated ground water (Figure C.4). Extraction wells are commonly used in ground water contamination remediation.

Before well systems are designed, site hydrogeologic characterization must take place to define the contaminant distribution and potentiometric surface. Aquifer parameters should be quantified, and boundary conditions including recharge, discharge, and impermeable boundaries should be identified. This information could be used along with the concepts of well hydraulics to establish the number and spacing of wells needed. Existing monitor wells could be used to extract ground water if they are properly developed and have a sufficiently large radius for pump installation.

The design of a well system requires using a set pumping rate, calculating the capture zone and drawdown associated with that rate, and checking the capture zone against the plume dimensions. Performance of the flow system could also be estimated using numerical ground water flow models.

Well point systems consist of closely spaced, shallow wells connected to a main pipe (header or manifold) with a centrally located suction lift pump. Well point systems are used mainly for shallow water table aquifers because the maximum lift obtainable by suction pumping is approximately 25 feet (8 meters) or less. Well point systems can create an effective hydraulic barrier by capturing contaminated ground water. The design of well point systems must consider whether the aquifer is confined or unconfined and the distance to a recharge boundary. The distance between wells and the pumping rates are adjusted to optimize the drawdown in a well and, at the midpoint between the wells, to create a hydraulic barrier or to extract contaminants.

The objective of ground water extraction is to control movement of contaminated ground water and remove it from the aquifer. Through data obtained from the initial hydrogeologic study and through the principles of well hydraulics, the number, depths, spacing, and pumping or injection rate of the wells could be specified. In addition, the time required for the remedial actions could be estimated roughly.

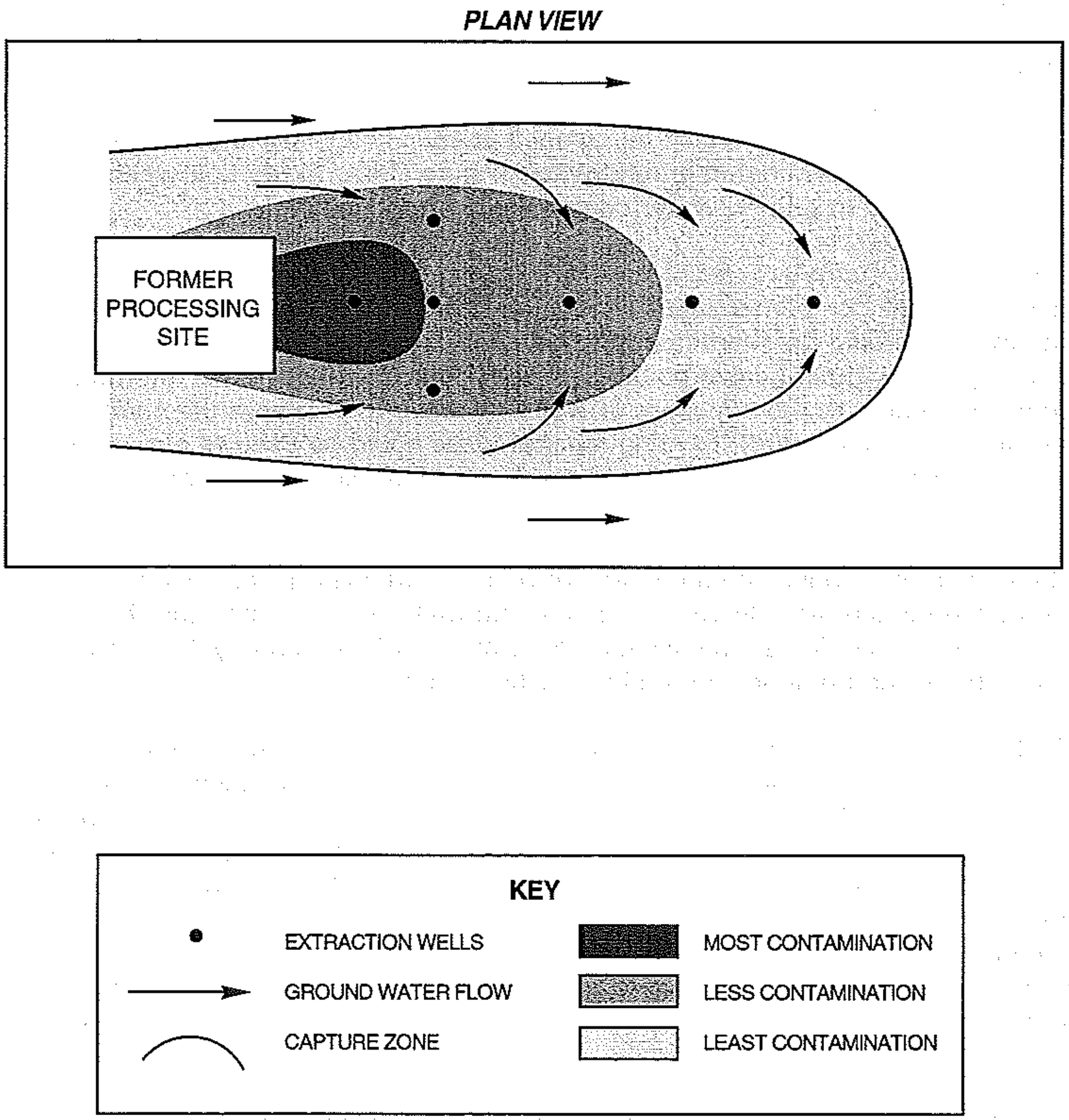

FIGURE C.4
GROUND WATER EXTRACTION

MAC: NONSITE/PEIS95/APPC/GWEXTR

Extraction rates could be varied to increase efficiency of contaminant mass extraction. In certain cases, ground water extraction could be performed intermittently. The period when pumps are off would allow contaminants to desorb from the aquifer matrix or diffuse out of less permeable zones. When equilibrium concentrations are reestablished, ground water extraction could resume. The duration of pumping and nonpumping periods are site-specific and can be optimized only by analyzing field data acquired during operation (EPA, 1990).

Interceptor systems

In interceptor systems, a drain or trench is excavated below the water table, and a permeable backfill and/or perforated pipe is installed in the trench. Subsurface drains or trenches, when used as interceptor systems, function like a line of extraction wells by creating a continuous zone of potentiometric depression over the length of the drainage trench. Subsurface drains are used primarily to manipulate the potentiometric surface, whereas trenches may also be used to extract ground water for treatment. They are used in low-hydraulic conductivity materials at shallow depths, where extraction wells or piezometers may not remove ground water efficiently. An advantage of interceptor systems is the relatively simple construction. The major disadvantage is the requirement for continuous monitoring and maintenance.

3.2.2 Disposal of contaminated ground water

Following the extraction (and treatment, if necessary) of contaminated ground water, the water would be discharged. Options for discharge include the following:

- Discharge to surface water.
- Land application for irrigation.
- Evaporation.
- Infiltration.
- Reinjection.

Discharge to surface water

Discharge of extracted ground water to a surface water body could take place either with or without water treatment. The most likely case would be discharge after some form of treatment. The discharge rate and quality of effluent from a treatment process would be monitored and regulated to meet National Pollutant Discharge Elimination System requirements.

Land application

The land application option of ground water disposal would use extracted ground water for agricultural irrigation. Extracted ground water would undergo treatment before use as irrigation water when necessary. This option would be used at processing sites located close to agricultural lands. Processing sites with ground water contaminant plumes containing nitrates would be the most likely candidates for this type of water disposal design.

Evaporation

Evaporation of extracted ground water could occur at sites located in arid environments. Water would be stored in holding ponds with large surface areas for evaporation to occur. The size or number of holding ponds would depend on the rate of ground water extraction. Sludge or precipitates formed at the bottom of the ponds would have to be disposed of in accordance with applicable regulations.

Infiltration

Extracted ground water could be disposed of through infiltration back into the shallow aquifer. Passive infiltration systems rely on gravity to drain water to the aquifer. This could be accomplished with infiltration trenches or galleries. Infiltration systems could be placed so that ground water flow to extraction wells is increased. Infiltration would be implemented after water treatment so that additional ground water degradation would not occur. This type of water disposal would be suited for processing sites that are located a distance from surface water bodies or where ground water supplies are limited and must be replenished.

Reinjection

Extracted ground water could also be returned to the aquifer through injection wells. Treatment of the extracted water may also be required with this option. Injection wells could be placed so that hydraulic barriers are created that increase flow to extraction wells.

3.2.3 Treatment of extracted ground water

Treatment of extracted contaminated ground water before discharge or reinjection into an aquifer depends on the concentrations of contaminants in the extracted ground water and the regulations regarding effluent discharge. Contaminants in water can be removed by physical, chemical, and biological methods. Physical operations and chemical processes are more common than biological methods. Physical treatment methods include sedimentation and filtration. Chemical treatment methods include chemical precipitation, coagulation/flocculation, oxidation/reduction, ion exchange, membrane separation, and adsorption. In addition, biological treatment can be used to remediate nitrate. The preferred treatment methods depend on the specific mix of contaminants, the concentration of the contaminants, the general water quality, the volumetric flow of the treatment stream, and the available area for treatment facilities. Most contaminated ground water at UMTRA Project sites would generate a sludge that would have to be disposed of in accordance with applicable regulations. The volume and toxic characteristics of the sludge would be considered in the selection of the treatment methods.

Physical treatment methods

A treatment operation in which removal occurs by applying physical forces is classified as a physical unit operation (Tchobanoglous and Schroeder, 1985). Typical physical treatment methods include screening, mixing, sedimentation, and filtration. The latter two methods are discussed in detail below because they are more complicated.

Sedimentation—Sedimentation is a process by which suspended materials are removed from the liquid phase by gravity settling. Sedimentation is the most common method used in water treatment systems. Sedimentation tanks, with the components needed for chemical addition, can be easily integrated into most water treatment systems. A disadvantage is that the process is nonselective with respect to specific constituents. Another problem is that weather conditions, especially wind or freezing conditions, can adversely affect the removal efficiency of the process.

Filtration—Filtration is accomplished by applying water to the top of the filter medium and allowing the water to pass through the medium. Particles in the water are removed by a variety of mechanisms, including mechanical and chance contact straining, impaction, interception, adsorption, flocculation, and sedimentation (Metcalf and Eddy Inc., 1979). The underdrain supports the medium while allowing the filtered effluent to drain freely. Filters are backwashed to prevent clogging and breakthrough of contaminants.

Filtration is a proven technology and is easily integrated into any treatment system. Filtration systems are also relatively simple to operate and maintain.

The principal disadvantage of filtration is that, like sedimentation, it is a nonselective process. In addition, dissolved constituents may be removed by filtration in an unpredictable manner.

Chemical treatment processes

Lowering the concentrations of contaminants in water by chemical addition or by chemical reactions is classified as a chemical treatment method. Chemical precipitation, coagulation/flocculation, and oxidation are three important examples of chemical unit processes. Although flocculation is a physical process, it is always linked to the chemical process of coagulation.

Precipitation—Precipitation is a physicochemical process wherein dissolved inorganic species are transformed into a less soluble species. The alteration of dissolved constituents to insoluble compounds facilitates their removal by physical processes, such as sedimentation and filtration.

Chemical precipitation, like the previously described physical processes, is a well-established technology. Precipitation treatment units can be integrated into more complex systems, although not as readily as physical process units because of potential problems related to varying the pH of the water. In addition, relatively low sludge volumes (waste) are produced as compared to the volume of water treated, and scale-up from bench (laboratory) tests are generally reliable.

Several caveats should be addressed with regard to chemical precipitation. The process requires continuous addition of chemicals and qualified operators to run the system efficiently. Also, the performance of a precipitation system depends greatly on the water chemistry of the influent. Changes in water chemistry can greatly reduce, or in some cases increase, removal efficiencies. Precipitation, like other conventional treatment processes, is nonselective in that ions not specifically targeted for removal often settle out with other compounds.

<u>Coagulation/flocculation</u>—Coagulation is a chemical process that destabilizes particles so that particle growth can occur. Flocculation is a physical treatment operation in which particle collisions are brought about though hydrodynamic forces. Those forces are generated by slow mixing with large blades or paddles. When coagulated particles in water collide they tend to agglomerate; thus, flocculation creates larger particles.

The advantages and disadvantages of coagulation and flocculation are the same as those associated with chemical precipitation. Including a coagulation/flocculation process in a treatment system with other physical and chemical operations, such as filtration and precipitation, should be relatively straightforward.

<u>Oxidation/reduction</u>—Like the previously discussed technologies, oxidation/reduction processes are a proven and effective way of treating contaminated water. In an oxidation/reduction system, one compound is oxidized (or gives up electrons), and the other is reduced (or accepts electrons). Oxidation/reduction (redox) reactions are used to change the solubility, stability, and other chemical properties of an ionic species.

In practice, compounds that accept electrons (oxidizing agents) are added to a water stream to change the species of an ion to one that is easier to remove by other treatment processes, such as filtration or precipitation. Commonly used oxidizing agents include chlorine, potassium permanganate, and ozone.

A redox system requires very careful laboratory and pilot studies to determine dosages and reaction times. Both parameters are especially important, considering that incomplete reactions may generate toxic substances in water. In addition, treating a chemically complex ground water with oxidation/reduction may not be desirable because numerous species may be affected in an uncontrollable manner during the process. Other redox technologies are described under the biological treatment methods paragraph below.

<u>Biological treatment methods</u>—Treatment processes that remove contaminants by biological reactions are classified as biological unit processes. The principal use of biological treatment is for removal of organic material from wastewater. However, four other common uses of the method are the oxidation of ammonia nitrogen

(nitrification); the reduction of oxidized nitrogen (denitrification) to gaseous nitrogen; the removal of phosphorus; and the oxidation and stabilization of organic sludge (Tchobanoglous and Schroeder, 1985).

Biological treatment systems can be classified in a number of ways. Common divisions are aerobic and anaerobic (according to metabolic activity) and suspended and attached growth (according to the location of the microorganism). In some systems, processes from these two classifications are combined.

Some of the more common biological treatment methods include the activated sludge processes (suspended growth) and trickling filters (attached growth). Activated sludge can be used to remove both organic materials and inorganic constituents from water.

Biological treatment is a well-established technology and is used at many municipal wastewater treatment plants. The major advantage of biological treatment is the relatively small volume of waste (sludge) generated by most biological unit processes as compared to the volume of waste (brine) produced by ion exchange and membrane separation methods.

A limitation of biological treatment is the strong dependence on environmental factors that influence microbial metabolism. Bacteria require relatively precise levels of substrate (food) and dissolved gases, such as oxygen and carbon dioxide, to effectively metabolize and degrade contaminants in raw water. Other limitations of biological treatment linked to environmental factors are microbial sensitivity to variations in influent contaminant concentrations, temperature changes, and fluctuations in pH.

Unlike chemical and physical unit processes, biological systems cannot be readily turned on and off and thus must be operated continuously. In addition, it is often difficult and time-consuming to establish steady-state bacterial growth conditions, both at initial system start-up and after some unforeseen occurrence, such as chemical poisoning of the bacterial biomass.

<u>Ion exchange</u>—Ion exchange is a process by which ions of a particular species are displaced from an insoluble exchange material by ions of a different species in solution. The exchange material is referred to as a resin.

The ion exchange process must be selective for the ions to be removed and must be reversible. Once all the ions of a resin or zeolite have been replaced with ions in solution, the medium is saturated or exhausted and must be regenerated with a solution (regenerant) that provides a concentrated supply of the originally bound ion.

Exchange resins that are selective for a wide variety of inorganic constituents are readily available. An advantage of the ion exchange process is that it can easily be automated and requires minimal operator control or oversight, especially if the feedwater is of consistent quality and the flow rate is steady. Another advantage of the process is that adding multiple ion exchange units to a treatment train provides constant on-line operation and relatively inexpensive system redundancy.

The disadvantages of ion exchange include the need to use hazardous chemicals as regenerants (hydrochloric acid) and the need to pretreat water that contains total dissolved solids in concentrations greater than 2000 to 4000 milligrams per liter.

Membrane separation—All membrane separation systems, including reverse osmosis, ultrafiltration, advanced membrane filtration, and electrodialysis reversal, are classified as through-membrane processes. The gradient across the membrane is provided by pressure, electrical energy, or both. Reverse osmosis is a process by which the natural osmotic flow is reversed by applying sufficient force to the concentrated solution to overcome the natural osmotic pressure of the dilute solution (ASCE-AWWA, 1990).

Membrane separation processes are among the most effective methods for reducing the concentrations of inorganic and radiological contaminants in water to very low levels.

However, several technical drawbacks with through-membrane systems exist. The membranes, especially reverse osmosis membranes, are easily fouled (clogged) by water containing high concentrations of calcium, sulfate, iron, manganese, and barium. Therefore, these substances are usually removed prior to membrane separation treatment. An alternative to pretreatment would be to add precipitation inhibitors to the raw water. Another major disadvantage of both electrodialysis reversal and pressure membrane processes is the large volume of reject water produced during the treatment operation. Besides the large quantity of wastewater, the reject stream would likely contain hazardous constituents.

Adsorption—Activated alumina adsorption removes a variety of inorganic substances from solution. Activated alumina is aluminum oxide and, like the more commonly known activated carbon, is a highly porous, granular material. Activated alumina is commercially available in granules ranging in size from a powder to 1.5 inches (4 centimeters) in diameter (ACSE-AWWA, 1990).

Activated alumina is effective for removing selenium in a +4 state and arsenic in a +5 state from water. The chief advantage of activated alumina is that its removal efficiency and capacity are not affected by the sulfate and chloride concentrations in the untreated water (ASCE-AWWA, 1990).

There are several disadvantages in using activated alumina. Although the period between regenerations is usually long, the process cycle of alumina columns is often complicated and requires careful monitoring by a trained operator.

3.3 *IN SITU* TREATMENT OF GROUND WATER

In situ treatment entails chemical, physical, or biological agents in the affected ground or ground water that degrade, remove, or immobilize the contaminants. It also includes methods for delivering solutions to the subsurface and methods for controlling the spread of contaminants and treatment reagents beyond the treatment zone. Detailed discussions of *in situ* treatment are included in references by EPA (1985; 1992).

In situ treatment processes are generally divided into three categories: biological, chemical, and physical. *In situ* biodegradation, commonly called bioremediation, is based on acceleration, or enhancing the rate of bioflora to metabolize the organic contaminants. At UMTRA Project sites, bioremediation would be used to solubilize or immobilize inorganic contaminants in the water or soil. *In situ* chemical treatment involves the injection of a specific chemical or chemicals into the ground or ground water to degrade, immobilize, or release contaminants that are in the ground water or attached to the soil particles. Physical *in situ* methods involve the physical change of the soil or ground water using heat, electric energy, or other means to immobilize or to expedite the release or movement of contaminants from the soil or water. In some instances, a combination of *in situ* and aboveground treatment would be required to achieve the most cost-effective treatment at the UMTRA Project sites.

In situ treatment of contaminated ground water would require extensive site characterization to determine the contamination level and areal extent of contamination in the soils, the aquifer matrix, and the ground water. A successful *in situ* treatment system that utilizes injection of materials for chemical or biological treatment must provide the following:

- Adequate contact between treatment agents and contaminated solids or ground water.
- Hydrologic control of treatment agents and contaminants to prevent their migration beyond the treatment area.
- Complete recovery of spent treatment solutions and/or contaminants when necessary.

In situ treatment is applied either by gravity flow through infiltration galleries or drains or by pressure through injection and extraction wells. Where it is desirable to treat contamination in the unsaturated zone and the soils are relatively permeable, or the ground water contamination is relatively shallow and under water table conditions, a gravity flow system could be used. However, if the depth to ground water is more than 20 feet (6 meters) and the contaminants are distributed over a fairly deep profile within the aquifer, injection and extraction wells would be required. This involves installing a bank of injection wells along the upgradient edge of the ground water contamination and within the contaminant plume. A treatment agent would be pumped into the aquifer through the injection wells. Extraction wells could be required to capture treatment agents and provide potentiometric control of the system or to allow for additional abovegrade treatment of contaminated ground water before discharge or reinjection.

Physical *in situ* treatment systems would generally be useful for a limited area because the costs of physically manipulating the ground and/or ground water to immobilize or detoxify contaminants would be high.

Specific treatment agents could be used to mitigate different types of contamination. The two major types of *in situ* treatment of hazardous constituents are microbiological and chemical processes.

3.3.1 Bioremediation

Microbiological treatment has been applied widely in situations where organic materials, including hydrocarbon fuels, solvents, and pesticides, have been released into the environment through spills, leaking transfer systems, and storage tanks. It also may have some efficacy in the treatment of nitrates in ground water. Bioremediation could also be used to produce biomass within an aquifer for metal sorption. Under certain conditions, microorganisms could solubilize heavy metals, which would aid in removing them from the aquifer. Environmental factors that influence the effectiveness of *in situ* biodegradation are the dissolved oxygen level, pH, temperature, predators and competition (including the presence of toxins and growth inhibitors), oxidation/reduction potential, availability of nutrients, salinity, and concentration of compounds that need to be biodegraded.

Anaerobic bioreclamation, in which nitrates or sulfates may be used as a terminal election acceptor, may be applicable to ground water remediation at UMTRA Project sites. Nitrates are a contaminant of concern at several sites. Removal of nitrates in the ground water could be accomplished with microorganisms. This process is called denitrification. It is practiced in Europe for removal of nitrates from ground water at potable water treatment facilities and in other countries, including the United States, at wastewater treatment plants.

Nitrate removal (denitrification) is accomplished by nitrate respiration, whereby the bacteria, including *pseudomonas, micrococcus, archromabacter* and *bacillus*, utilize the nitrate or oxygen as electron acceptors while oxidizing organic matters in the water (EPA, 1975). Denitrification of ground water requires a carbon source feed, since the water is usually deficient in carbon. Nutrients are injected into ground water to enhance bioremediation rates.

Sulfate-reducing bacteria use the sulfate as the electron acceptor when utilizing the organic material in the water. As a result of this process, sulfides are produced that will form insoluble metal precipitates. These precipitates will remain attached to the soil due to the low solubility of the sulfide precipitates. Several studies have been done on the precipitation of hazardous metals in uranium mill processing waste ponds on the effectiveness of these sulfide-producing bacteria (Kaufman et al., 1986).

Sulfide-producing bacteria at UMTRA Project sites with high sulfate concentrations could be used in a manner similar to a process by which nitrate is removed by adding a carbon source for the bacteria. Use of sulfide-producing bacteria for metals immobilization may be more appropriate by pumping out the ground water and then passing the water over specially prepared and drained soil beds. Periodic removal and disposal of the immobilized metals and soil would then be a function of the quantity of metals removed. The soil and metals would be disposed of in accordance with appropriate disposal regulations.

3.3.2 Chemical treatment

In situ chemical treatment can be used to immobilize, mobilize (for extraction), or detoxify inorganic and organic hazardous constituents. Technologies for immobilization include precipitation, chelation, and polymerization. Treatments to mobilize contaminants for extraction include the addition of lixiviants (flushing agents), dilute acids or bases, and water. Detoxification includes oxidation, reduction, neutralization, and hydrolysis. To some extent, each of these treatments may serve one or more purposes.

Two types of *in situ* chemical treatment could be considered for the removal of hazardous constituents from ground water at UMTRA Project sites. The first is to add chemical lixiviants to the injection solutions to enhance the mobility of hazardous constituents in ground water during either natural flushing or extraction for treatment. The second is to construct permeable treatment beds that function as geochemical barriers to remove and immobilize hazardous constituents in ground water.

Chemical lixiviants

Lixiviants are chemicals added to ground water that cause desorption and mobilization of metals to allow for their remediation. For *in situ* treatment using chemical lixiviants to be a viable remediation method, any lixiviants added would have to be relatively inexpensive and not contribute to the exceedance of applicable ground water standards. Examples include the injection of carbon dioxide or a weak solution of sulfuric acid to create an acidic environment, soda ash to create an alkaline environment, or hydrogen peroxide injection to create an oxidizing environment and increase the solubility of uranium. Uranium is soluble under oxidizing conditions, and these injection solutions can raise the oxidation/reduction potential or change the pH of the ground water. Mobilizing uranium with lixiviants could also dissolve other hazardous constituents such as arsenic, chromium, molybdenum, selenium, and vanadium. This could facilitate their migration to extraction wells for aboveground treatment.

If the solubility of hazardous constituents needed to be enhanced, an injection well system could be used to add chemicals to the fluid transfer stream. Because the amount of material to be added is on the order of a few milligrams per liter and the injection rate would probably be a few liters per minute, small metering pumps and relatively small mixing tanks would be all the equipment necessary.

Geochemical barriers

A second mode of *in situ* chemical treatment could involve geochemical barriers. In areas where natural conditions or engineered subsurface barriers channel the contaminated ground water into a restricted area, it may be possible to install a geochemical barrier perpendicular to ground water flow that will remove contaminants from ground water and allow the clean ground water to migrate through the downgradient edge of the barrier. A potential geochemical barrier would consist of a mixture of compounds that would either precipitate or adsorb the hazardous constituents in the ground water. Some of the materials that could be used in geochemical barriers are hydrated lime, limestone or crushed sea shell, peat or coal, activated carbon, glauconitic green sands, zeolites, smectites, and synthetic ion exchange resins.

Using geochemical barriers to remove hazardous constituents from seepage at disposal sites was investigated by DOE (1989). The investigation examined three potential geochemical modifiers to determine their ability to immobilize inorganic contaminants derived from uranium mill processing. These modifiers were hydrated lime, limestone, and a sphagnum-moss peat. The results of the investigation show that all of the modifiers were moderately effective in removing hazardous constituents from solution.

Neutralization removed contaminants that were present as simple cations and reduced the concentrations of species that form oxyanions in aqueous solutions. Hydrated lime (at 2 percent mass concentration) achieved a 90 percent reduction of concentrations of arsenic, cadmium, selenium, uranium, and sulfate. Limestone was somewhat less effective than hydrated lime at reducing contaminant concentrations. Peat (at 1 percent mass concentration) removed over 90 percent of arsenic, lead, uranium, and sulfate. Unfortunately, in the peat experiment it was not possible to determine whether the removal was due to adsorption or reduction and precipitation. The barriers investigated had little effect on nitrate concentrations. Kinetic and/or mass transfer limitations are important to consider in constructing a geochemical barrier because sufficient time must be allowed for immobilization to occur.

The clay minerals, especially the smectite group, and glauconite green sands, zeolites, and synthetic resins have high ion adsorption capacities and can remove ground water contaminants such as arsenic, cadmium, copper, mercury, nickel, uranium, and radium. In addition, oyxhydroxides of iron, manganese, and aluminum may remove by adsorption molybdenum, copper, and selenium in addition to removing some of the previously mentioned hazardous constituents (Leckie et al., 1979).

Hallberg and Martinelli (1976) reported on a geochemical barrier method developed in Finland for cleaning up ground water with high iron and manganese concentrations. In the method, a series of aerated water injection wells is placed around a water supply well, and high oxygenated fluids (hydrogen peroxide) are injected into the aquifer. The injected fluids cause iron and manganese to precipitate in the vicinity of the aeration wells, and the water extracted through the water supply well is clean. This approach is a modification of the geochemical barrier and perhaps could be used for treatment of hazardous constituents.

Construction of a geochemical barrier would require an evaluation of the restricted fluid flow path, the depth to the bottom of the contamination plume, the contaminant species to be removed from solution, and the amount of fluid expected to pass through the barrier. Once this evaluation was completed, a method for placing the barrier materials could be proposed. In some cases, the materials could be injected via wells; in others, it would be necessary to excavate a trench and key the barrier into the bedrock.

3.4 INNOVATIVE TECHNOLOGIES

Innovative technologies consist of methods that may have been used in other fields such as mining, wastewater treatment, or chemical processing, but which have not been applied to ground water remediation problems. It also includes development or modification of existing ground water treatment methods in a new or different manner. In some cases, entirely new ideas and methods will be developed that may offer the possibility of significantly lowering costs or completing the remediation effort in a shorter time period. Some other innovative *in situ* methods, products, or technologies that are being developed, and which may prove useful for UMTRA Project site ground water remediation, are described in the following paragraphs.

Vitrification

Physical treatment methods currently used or being developed involve physical manipulation of the subsurface in order to immobilize or detoxify waste constituents. These technologies, such as vitrification and *in situ* heating, are moving out of the stage of development and are being tested or currently used. Both of these methods are innovative methods for ground water and soil remediation.

Horizontal drilling

Horizontal drilling could be used instead of trenching or installing vertical wells to recover or inject fluids. This technology would be used with pump-and-treat processes.

Alginate resins

Alginate resins are ion exchange resins manufactured from dead algal cells that can be tailored to remove specific metals. These resins would be used in a pump-and-treat process.

Artificial wetlands

Artificial wetlands could be constructed to accommodate microbiological and plant species that can remove various metals, organics, and other constituents and to produce water that can be reinjected into the aquifer or discharged to surface water. This technology would most likely be used in a pump-and-treat process for final processing of an effluent before its release back into the environment.

Soil columns

Soil columns are aboveground soil beds with underlying drains to collect the applied ground water. These soil columns are kept in an anaerobic state. Organic material and other nutrients are added to the ground water to stimulate anaerobic bacterial growth, resulting in the formation of insoluble metallic sulfide precipitants. Upon completion of the ground water remediation work, the soil and metal precipitants would be removed and disposed of at an approved disposal site.

Other technologies

Other innovative treatment technologies that have been identified for ground water treatment are an electrocoagulation sulfide precipitation system for metals removal and anaerobic fluidized beds for nitrate removal. These technologies are now in use at industrial wastewater treatment facilities.

Summary

Innovative treatment methods would be evaluated, selected, and used in conjunction with proven ground water remediation methods. For those technologies that have been field tested for ground water treatment or that are proven technologies in other wastewater or hazardous waste treatment areas, the evaluation of the technology and cost estimates would be comparatively straightforward. Where little, if any, data are available on a technology for ground water remediation and treatment, basic treatment data would have to be obtained. This information would be obtained through UMTRA Project special studies and through cooperative agreements with DOE national laboratories, other federal agencies, or universities. In those cases where a technology is patented, a contract would be developed with the patent holder for use of the technology.

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