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 th 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,8αβ)-)
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, 1-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, (methylONN-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-L-lyxohexopyranosyl)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-octa-hydro,(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)aminol]-)
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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