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16 July 1985

Mr. John D'Antonio
Department of Energy
c/o Jacobs Engineering Group, Inc.
5301 Central Avenue N.E., Suite 1700
Albuquerque, New Mexico 87108

WM Record File

WM Project 39

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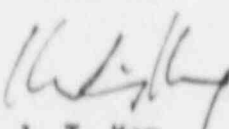
Subject: UMTRA PROJECT - GEN
Review Comments on Documents for Working
Group 4 - Water Resources

Dear Mr. D'Antonio:

I am enclosing my comments marked on a copy of the draft document, "Preliminary Draft - Technical Approach Document - Hydrogeology" by Jacobs-Weston, distributed to Working Group 4 at the July 2, 1985 meeting of the DOE, NRC, TAC and RAC at NRC Headquarters in Silver Springs.

By copy of this letter, I am forwarding comments to John Thackston of the TAC and Mike Weber of the NRC.

Sincerely,


J. T. Kam
Hydrologist

JTK:kfb

cc: John Thackston
Jim Oldham
Mike Weber ✓

Enclosure: Marked Copy of "Preliminary Draft - Technical Approach Document - Hydrogeology".

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Marked by J. Kam

PRELIMINARY DRAFT
TECHNICAL APPROACH DOCUMENT
HYDROGEOLOGY

3.3 PROTECTION OF WATER QUALITY

The United States Environmental Protection Agency (EPA) Standards (40 CFR Part 192) (EPA, 1983a) require site characterization of the hydrogeologic regime at and around each Uranium Mill Tailings Remedial Action (UMTRA) Project site. Also "judgements on the possible need for remedial or protective actions for ground water aquifers should be guided by relevant considerations described in EPA's hazardous waste management system (47 FR 32274) (EPA, 1983b) and by relevant state and Federal water quality criteria for anticipated or existing uses of water over the term of the stabilization." Thus a hydrogeologic characterization of all alternative disposal sites is also required. The following section describes the generic technical approach that DOE will use to meet the EPA standards.

3.3.1 Characterization

The DOE will conduct investigations at each mill processing and potential tailings disposal site to define the presence and extent of significant ground water bearing unit. Characteristics of each geohydrologic unit will be defined which are pertinent to determining the degree of present and potential contamination of ground water and surface water by the milling operations and tailings.

3.3.1.1 Background water quality

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Characterization activities will include determining background water quality at all sites. Background water quality is the water quality that existed in local surface waters and ground waters prior to uranium recovery activities. Because such pre-recovery data are generally lacking or are inadequate, samples will be collected from nearby surface and ground water sites that are upgradient hydraulically from any known uranium recovery activities.

In addition, such sites should be free of any airborne contamination related to uranium recovery. Sites that have these characteristics will hereafter be referred to as background sites.

3.3.1.1.1 Ground waters

Characterization of background water quality will proceed as follows:

- o Review of existing data/literature. Such a review would include existing well and spring data (drillers logs, geophysics, water analyses), geologic reports and surficial radiation surveys (Bendix).

o Develop a preliminary conceptual model of ground water flow within the immediate vicinity of the site.

o Inventory, make measurements of water level and/or yield, and sample in the area designated as background. Samples would include determinations of the constituents listed in Table 1.

o Complete and sample a minimum of three background wells per water-bearing unit. Chemical constituents to be determined are listed in Table 1.

o Compile a data set of background water quality data from:

- three background wells per water-bearing unit;
- background springs; and
- Area of recharge
- existing wells in background areas.

This data set could be augmented with water quality data from existing uncontaminated wells and springs yielding from the appropriate aquifers within the region

should also obtain data from wells that are downgradient of the site before disposal activities to ~~provide~~ complete background water quality

For each water-bearing unit, monitoring wells at different depths will be sampled to determine any vertical variation of groundwater quality.

Table 1 Revised list of constituents and detection limits for water analysis

| Constituents | Detection limit (mg/l) | Constituent | Detection limit (mg/l) |
|-------------------------------------|------------------------|------------------------------|------------------------|
| Chloride (CL) | 1.0 | Iron (Fe) | 0.03 |
| Sulfate (SO ₄) | 0.1 | Lead (Pb) | 0.01 |
| Sodium (Na) | 0.002 | Manganese (Mn) | 0.01 |
| Potassium (K) | 0.01 | Mercury (Hg) | 0.0002 |
| Magnesium (Mg) | 0.001 | Molybdenum (Mo) | 0.01 |
| Calcium (Ca) | 0.01 | Nickel (Ni) | 0.04 |
| Boron (B) | 0.1 | Selenium (Se) | 0.005 |
| Fluoride (F) | 0.1 | Silver (Ag) | 0.01 |
| Cyanide (CN) | 0.01 | Strontium (Sr) | 0.1 |
| Hydrogen Sulfide (H ₂ S) | 0.1 | Tin (Sn) | 0.005 |
| Carbonate (CO ₃) | 1.0 | Uranium (U) | 0.003 |
| Bicarbonate (HCO ₃) | 1.0 | Vanadium (V) | 0.01 |
| Ammonium (NH ₄) | 0.1 | Zinc (Zn) | 0.005 |
| Nitrate (NO ₃) | 0.1 | Total Dissolved Solids (TDS) | 10 |
| Nitrate (NO ₂) | 1.0 | Total Organic Carbon (TOC) | 1.0 |
| Nitrate & Nitrite | 0.1 | | |
| Silica (SiO ₂) | 2.0 | | |
| Phosphate (PO ₄) | 0.1 | | |
| Aluminum (Al) | 0.1 | Radionuclide | pCi/l |
| Antimony (Sb) | 0.003 | Lead-210 (Pb-210) | 1.5 |
| Arsenic (As) | 0.01 | Polonium-210 (Po-210) | 1.0 |
| Barium (Ba) | 0.1 | Radium-226 (Ra-226) | 1.0 |
| Cadmium (Cd) | 0.001 | Radium-228 (Ra-228) | 1.0 |
| Chromium (Cr) | 0.01 | Thorium-230 (Th-230) | 1.0 |
| Cobalt (Co) | 0.05 | Gross Alpha | 2 |
| Copper (Cu) | 0.02 | Gross Beta | 3 |

(i.e., within a 20 to 30 mile radius of the site). Such data would expand the data set, making it more acceptable to determine background concentrations using simple statistical approaches.

Background constituent concentrations will be determined by compiling a table with the following headings.

Background water quality

| Constituent | Concentration range (ug/l) | Mean \bar{x}_b | Median | Standard deviation (S_b) | Back-ground conc. range |
|-------------|----------------------------|------------------|--------|------------------------------|-------------------------|
| U Mo | | | | | 10-20 ug/l |

Background concentration ranges would be determined by calculating $\bar{x}_b \pm S_b$, or $\bar{x}_b \pm S_{QA}$, whichever results in the more comprehensive range. (S_{QA} is the value of one standard deviation in the precision data for U, as determined from the quality assurance (QA) program.)

Background concentration ranges would be used in defining the areal extent of any contaminant plume.

3.3.1.1.2 Surface waters

As with ground waters, selection of background surface water sites will follow a preliminary data/literature review phase. Sites will be chosen in areas unaffected by known uranium recovery activities, upstream of the site. Water would be collected as grab-samples from either bank in a well mixed zone. Routine samples will be filtered through 0.45-micrometer membrane filters, and analyzed for the constituents in Table 1. Where appropriate, unfiltered samples will also be collected and analyzed.

3.3.1.2 Presence and extent of plumes

3.3.1.2.1 Ground water

Major characterization tasks involve: 1) identifying the presence and quality of significant water-bearing strata which may lie along the flow path of contamination emanating from the tailings pile, and 2) determining the area and vertical extent of any plume.

Steps necessary to characterize the extent of any ground water plumes are:

- o Preliminary data and literature review (see discussion in Background section).
- o Identify strata most likely to be/become contaminated.
- o Develop a conceptual model(s) of ground water flow pathways. Using existing geologic, water quality, geophysical, and drilling data, develop preliminary ideas about the direction(s) of ground water flow, presence of hydrologic barriers, leakage, etc. Concept development would include simple analyses of flow using Darcy's Law and values of hydraulic conductivity ^{and storage coefficient} from the literature. Such analyses would provide gross indications of the potential extent of contaminant migration and would aid in designing future aquifer tests.

Note: need storage coefficient to define migration of plume with time

- o Design preliminary drilling program. Selection of monitoring well locations would be intended to delineate the areal and vertical extent of any plume. Emphasis would be placed on siting wells near strategic locations (i.e., near dwellings, rivers, drinking water facilities, likely discharge points). Well siting decisions would also be based on insights gained from the previous conceptual modeling exercises.

o Vadose zone monitoring if necessary (may include soil/water sample analysis)

o Well siting and sampling. The first boreholes drilled should be sited, in the presumed downgradient area, near the base of the tailings pile(s).

These wells would be sampled for the constituents listed in Table 1. In addition, an analysis for all Priority Pollutant Organic Compounds will be performed at up to three wells dispersed throughout the downgradient to the base of the pile. If significant concentration of Priority Pollutant Organic Compounds were detected near the pile, a decision to monitor for these compounds throughout the area would be made. Under the present scope of work, it has been assumed that such compounds are not normal components of uranium-recovery wastes. However, it has been deemed prudent to collect these reconnaissance samples.

may include
list of
Priority
Pollutant Organic
Compounds
in Table 1

To define the areal extent of the plume, additional wells will be sited at progressively greater distances from the pile(s) until measured concentrations of contaminant indicators (sulfate, uranium, and possibly molybdenum, selenium and radium) are less than or equal to their respective background concentrations. The majority of wells will be located in presumed downgradient regions. Selected sites will have several wells constructed close together and completed at differing intervals (nests). Selection of these completion intervals would be based on both the conceptual flow models developed for the site hydrogeology, and on field screening techniques employed during drilling. Such

how
about
vertical
extent of
plume?

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techniques include monitoring borehole waters for specific conductance, sulfate and chloride. Whenever possible, the deepest monitoring wells would be completed, in zones below any contaminations. Such siting decisions would be refined by compiling water-level maps in the field. Additional screening in the field could be accomplished by making determinations of specific conductance, sulfate, and chloride on borehole waters. Less rapid, but still useful plume detection information will be gained by receiving uranium concentration data verbally within one week of sample submittal.

Water quality samples will be collected from all completed wells on a quarterly basis. The constituents listed in Table 1 will be determined for all wells in the first two rounds of sampling. Following interpretation of these data, selected constituents would be dropped from subsequent quarterly samples.

As a minimum, the areal extent of plumes will be portrayed by constructing iso-concentration contour maps of contaminant indicator constituents. Interpretations of site hydrogeology will also include hydrogeologic cross-sections.

Definition of chemical background and plume extent require exceptionally reliable water quality data. To accomplish this, the following quality assurance/quality control procedures will be employed at all sites. Water

may be
more informative
to prepare
Table 1 with
sampling frequency
for each
constituent
and period
involved

samples will be divided into lots (groups) of approximately nine water samples or less. Accompanying each lot of samples from the field will be one prepared known solution (spike) including the majority of chemical parameters to be analyzed in the lab.

Comparison of the lab analytical values for the known solution with the known concentration values will provide a basis for establishing accuracy of the lab analyses of the other samples in the lot. If pre-established accuracy requirements for the lab results are not met the lab will be required to reanalyze the sample until acceptable accuracy is achieved.

Precision of the analyses will be established by submitting a total of five replicate aliquots (identified as different samples) for one of the samples in each lot to the lab for analyses. The replicate analyses will be used to establish confidence intervals of sampling and analytical precision (error bars) which are indicative of the total error associated with each measurement. These confidence intervals will be tabulated and discussed in the interpretative sections of the report relating to background concentrations, and contaminant plume definition.

Ground water quality and hydrogeologic data will be synthesized into the following types of interpretive products to delineate the locations of contaminants:

For clarification,

- may use flow chart to indicate procedure and decision points
- may mention the types of significance testing:
 - t-test,
 - Mann-Whitney?
 - Li-test
 - variance ratio test

- o Hydrogeologic cross-sections, including hydrochemical facies where possible.
- o Water quality cross-sections, delineating concentrations of contaminant indicator constituents with depth.
- o Plan-view, iso-concentration contour maps of contaminant indicator constituents (relative to background concentrations).
- o Piezometric maps.
- o Figures (graphics, tables, cross-sections) comparing measured contaminant concentrations to appropriate state and Federal standards.

- *Area of recharge*
- *potential area for surface/groundwater intersection*

3.3.1.2.2. Surface waters

The proximity of the site to surface water will be determined from available information, aerial reconnaissance or field surveys. A map will be drafted to show bogs, swamps, seeps, springs, ponds, lakes and streams relative to the site. Climatologic data will be obtained from the National Oceanic and Atmospheric Administration (NOAA) or the National Weather Service (NWS). These data will be used in the hydrogeochemical characterization of the impacted area.

Surface water samples will be collected from all rivers/streams and ponds within the immediate vicinity of the waste site. Grab samples of ~~streams~~^{streams} will be collected downgradient from known sources of contamination. Sampling locations will be along the stream bank nearest any tailings accumulations. Routine samples will be filtered through 0.45 micrometer membrane filters, and analyzed for the constituents in Table 1. Where appropriate, unfiltered samples will also be collected and analyzed.

Flow measurement for streams should be conducted with flow meters or weirs

If significant concentrations of Priority Pollutant Organic Compounds are detected in site ground waters, a program to monitor similar compounds in surface waters would be developed.

The presence of significant concentrations of any contaminant constituents would indicate that future surface water sampling should involve depth-integrating procedures to better quantify the constituents.

Surface water quality data will be synthesized into graphs showing downstream concentration patterns of contaminant indicator constituents. Relative locations of tailings piles will be noted on these graphs. In addition, tables and/or graphs will be constructed comparing the contaminant concentrations, if present, to appropriate state and EPA water standards and criteria.

3.3.1.3 Movement of contaminated ground water

Uranium mill tailings are a potential source of ground water contamination. The contamination may move from the tailings to the ground water by gravity-driven saturated or unsaturated flow, and then transported laterally within the ground water. Thus in order to assess the rate and direction of contaminant movement it is first necessary to characterize the contaminant source and assess the vertical movement of contamination into the ground water. Then it is necessary to estimate the present rate and direction of ground water flow. Finally, the attenuative properties of the geohydrologic units need to be assessed to estimate the degree to which contaminants are retarded relative to the ground water flow rate.

3.3.1.3.1 Contaminant source

The conceptualization or characterization of a contaminant source is a complicated process. As contamination in an aqueous form moves from the tailings into and through surrounding ground water, it is subject to continuous changes in quantity (by dilution) and quality (by dilution and attenuative processes). Many of the geochemical processes which affect the contaminants, collectively termed attenuation or retardation, are not easily quantified; yet they cause orders of magnitude

changes in the concentrations of key contaminants. With these uncertainties in mind, several approaches for characterizing a contaminant source are presented below.

One approach is to view either the solid phase or the pore water within the tailings as the contaminant source. The ^{solid} chemistry of 12 tailings sites has been determined through assay of residual mineral values (DOE, 1985a), and has been determined at other sites through hydrogeochemical characterization studies (DOE, 1985a). Pore water can be sampled ^{and} analyzed by means of suction lysimeters, however, data from inactive tailings indicate that concentrations of many key contaminants are reduced by several orders of magnitude between the pore water and the ground water. In order to use data on ^{soil} solid chemistry or pore water chemistry as a representation of a contaminant source, it is necessary to use methods which take into account alternative processes:

- o Geochemical models predict attenuation due to solubility controls or other processes, and have been applied to an UMTRA Project site (Narisimhan et al., 1984).

- o Empirical equations describing retardation have been developed for radioactive waste (Gilber et al., 1983) and have been applied at UMTRA Project sites (DOE, 1983).
- o Pore water concentrations could be used as the source concentration for those constituents known to be conservative, e.g., only slightly attenuated.

A second approach to characterizing a contaminant source is to calculate what the apparent source would be based on observed concentrations and distributions of contaminants in the downgradient ground water. This was done for the Salt Lake City inactive uranium tailings (DOE, 1984) using an analytical equation of solute transport. The calculated concentration of the source is then used in concert with predictions of volumetric flux of contaminants to predict movement of contaminated ground water.

A third approach to characterizing a contaminant source is to measure ground water quality directly below the tailings in the existing environment at more than one well, and use the worst quality as representative of the contaminant source.

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The volumetric characterization of the source can be chosen as the predicted ground-water flux through the tailings (if the tailings are to be stabilized partially below the water table).

3.3.1.3.2 * Vertical unsaturated zone movement

The volumetric flux of the pore water into the ground water should be quantified. Most of the UMTRA Project tailings have already drained to near their residual water content, so that throughout the next 1000-year period most of the unsaturated flow out of the tailings will be due to net infiltration of precipitation. Net infiltration may be estimated using one or more of the following methods:

- o By using a numerical model of unsaturated flow with assumed input parameter values, e.g., TRUST (Reisenauer et al., 1982), or an analytical model of infiltration, e.g., the HELP model (Schroeder et al., 1983).
-
- o By assuming saturated flow into the tailings under a unit gradient, using Darcy's Law to calculate an upper-bound flux rate.

* may consider "partially-saturated" rather than "unsaturated"

*This may be
combined
with the
preceding •*

o By assuming that saturated flow occurs only some fraction of the year and making calculations based on Darcy's Law (DOE, 1985b). The fraction of the year during which saturated flow occurs will be based on experimental data or meteorological data.

o By measuring spatial variations in concentrations of isotopic tracers (e.g., tritium), assuming that infiltration through a low-permeability cover will be less than or equal to the existing estimated infiltration rate.

o By using Darcy's Law modified for unsaturated flow (Hillel, 1971), based on in-situ measurements of matric potential and on measurements of unsaturated hydraulic conductivity. Infiltration through a low-permeability cover will be assumed to be less than or equal to the existing infiltration rate.

*This model is similar
to HLP
described earlier*

o By using a water balance model. Infiltration through a low-permeability cover will assumed to be less than or equal to the existing infiltration rate.

** see pg. 16*

3.3.1,3.3. Saturated ground water flow

The saturated ground water flow rate (average linear velocity) and flow directions in the site vicinity will be characterized by obtaining site-specific hydrologic data from monitoring wells and aquifer tests. Data will be obtained to provide values for hydraulic conductivity, effective porosity, and hydraulic gradient for each hydrogeologic unit of concern at each processing and disposal site. These data will be used to calculate estimates of ground-water velocity from the Darcian flow equation:

$$V = \frac{K i}{\theta}$$

where

*

V = average linear velocity

K = hydraulic conductivity

i = hydraulic gradient

θ = effective porosity

* may consider "seepage velocity" (interstitial velocity) rather than "average linear velocity"

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Hydraulic conductivity values will be estimated from aquifers pumping tests or slug tests using well-established techniques (Bouwer, 1978; Kruseman and DeRidder, 1983). The hydraulic gradient values will be estimated from potentiometric surface maps or flow maps constructed based on ground water level measurements in all monitoring wells in the vicinity of a site. Effective porosity values will be estimated based on lab tests on core, aquifer tests, or conservatively low values obtained from literature by previous investigators of similar geohydrologic units.

3.3.1.4 ~~8.~~ Attenuation of contaminants

The processing of uranium ore results in a tailings byproduct that is not in chemical equilibrium with normal or aquifer systems. Because of this, the movement of tailings solution into the soil and ground-water zones beneath and downgradient from the pile will initiate chemical interactions that will establish a new equilibrium for rock/water interactions. Adsorption and mineral precipitation processes will tend to lower the solution concentration of contaminants moving out of the tailings pile into the surrounding environment. In effect, the rate of movement of contaminants will be attenuated relative to the ground-water flow rate. In order to understand and predict movement of a contaminant plume it is necessary to identify the attenuative

Note:

[Hydrodynamic dispersion and molecular diffusion tend to shorten the arrival time of solutes.]

processes and measure the attenuative capacity of the natural environment affected by the plume. This discussion focuses on the UMTRA approach to identifying and quantifying this attenuative capacity and stresses the expected chemical interactions between the tailings solution and the soil and sediment.

The neutralization capacity of the soil and sediment beneath an acid mill tailings pile has been identified as the single most important chemical factor in determining the ability of geologic material to attenuate the movement of contaminants (Shepard and Cherry, 1980). Neutralization is the main driving mechanism for mineral precipitation and adsorption in these systems. The rise in solution pH that characterizes neutralization produces a condition in which the solubility of Fe and Al oxyhydroxides decreases. These solids precipitate and scavenge several other contaminant metals (Mn, As, Se and Mo) from solution. Because carbonate minerals are the primary source of neutralization in the soil and sediment, determination of the carbonate content of the solid phase can be used to substantiate measurements of the neutralization capacity. The presence of even a small fraction of 1 percent of carbonate minerals is sufficient to provide considerable neutralization capacity. For this reason an analytical method that has a low detection limit will be chosen for determining carbonate content of the soil and sediment.

Concentrations of some of the ~~so~~ constituents (SO_4 , U, As, Se, and Mo) often persist at contaminant level in the aquifer downgradient from the zone of neutralization. Chemical attenuation processes affecting these constituents in this environment are basically the same as those near the pile (i.e., mineral precipitation and adsorption), but soil parameters other than neutralization capacity must be measured to estimate attenuation in this regime.

Most of the aquifers affected by the tailings are probably oxidizing, therefore the higher valence states of the contaminant trace metals predominate. Under these conditions, the primary attenuation mechanism for U, As, Se, and Mo is adsorption onto clay minerals, organic matter, and, especially, onto ferric oxyhydroxides (Henry et al., 1982). Several types of laboratory analyses can be used to produce a qualitative measure of the sediment's ability to attenuate the migration of these metals. The analyses include: cation exchange capacity, identify and type of exchangeable cations, clay content, quantity of metal oxyhydroxides, and amount of organic matter. Some of these analyses are redundant, and provide a check on the reliability of the measurements.

The results of the listed soil analyses give only a qualitative estimate of attenuation capacity because, without extensive additional laboratory experiments to

determine a retardation coefficient for each metal, the expected rate of movement and concentration of the contaminants at a point in the aquifer cannot be predicted. However, the qualitative measures will be sufficient to compare sites and make estimations of concentrations based on the observed movement of contaminants of sites with similar conditions.

At some sites the contaminated ground water may move into zones in which reducing conditions exist due to the presence of pyrite, reactive organic matter, or perhaps H_2S gas. Under these conditions relatively insoluble mineral phases of the elements U, Se, Mo and, perhaps, As will be stable. The precipitation of these phases will lower solution concentration of these elements to below contaminant level, and the metal will remain immobilized as long as the pH/Eh condition is stable. In order to determine if mineral precipitation under reducing conditions is a reasonable attenuation mechanism in an aquifer, the presence of reducing conditions must be established. This can be done most directly by measuring the Ph and Eh of the ground water, ensuring that the solution is not contaminated by atmospheric oxygen during sampling. The presence of noticeable H_2S gas in the ground water or sediment is also a good indication that strongly reducing conditions exist in the aquifer. If reducing conditions are expected to exist, the sediment

may also be analyzed for pyrite (Lord, 19__) and reactive organic matter (Ref _____) to give an indication of the reducing capacity and an indirect measure of the reducing intensity (Eh) of the sediment).

Sulfate is the one constituent of the tailings that will probably not have its concentration lowered below contaminant level by mineral precipitation or adsorption under either oxidizing or reducing conditions. As mentioned previously, the precipitation of gypsum, or perhaps an iron or aluminum sulfate phase, will lower sulfate concentration in the neutralization zone compared to the concentration in the tailings pore solution.

~~Soil~~
~~Solution~~ sampling below the pile for gypsum analysis may be necessary to characterize this potential source of contamination.

Chemical attenuation mechanisms will be ~~elevated~~ ^{evaluated} with regard to long-term impacts on water quality. Attenuation mechanisms decrease ground-water concentrations of contaminants, but a corresponding increase in the amount of contaminants in the solid phase occurs. If the contaminants are immobilized by reaction with the sediment then future ground-water contamination problems may be minimal, but if the solid phases are subject to further long-term reactions (e.g., gypsum) they may maintain contaminant levels well above background and perhaps above water quality standards for

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a considerable period of time. Minerals that precipitated may dissolve and adsorbed species may desorb when normal ground-water conditions are re-established or during aquifer restoration efforts. The response of the entire water/sediment aquifer system to "normal" aquifer conditions established after stabilization or movement of the tailings will be evaluated, just as the response to contamination from the tailings was studied.

3.3.2 Predicted concentrations

Once the contaminant source has been characterized, flow rates estimated and attenuative processes defined, a method can be chosen for predicting the movement and future concentrations of contaminants.

As a conservative upper-bound estimate, it can be assumed that contamination will move in the same direction as and at the same rate as the direction and rate of ground-water flow. However, more realistic methods can be applied to include dispersive and attenuative effects in the aquifer. The chosen method will be proportional in sophistication to the existing and anticipated use of the affected ground water, and the chosen method will be appropriate for the available data.

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- o In a small, well-bounded system, it may be appropriate to assume that all ground water has the same quality as the contaminant source.
 - o Numerical models of contaminant transport including advection and dispersion can be used and have been applied to inactive sites, e.g., the Riverton site (Narasimhan et al., 1984).
 - o Analytical models of contaminant transport have been developed by the Nuclear Regulatory Commission (Codell et al., 1982) or others (Prakash, 1982), and have been applied at UMTRA Project sites (DOE, 1984).
 - o Relatively simple models which include dilution-type processes, e.g., mixing cell models (Bear, 1979), may be appropriate for some sites, especially in view of the fundamental difficulties associated with making measurements of dispersive and attenuative properties for input to models.

In general, methods of describing contaminant transport will be chosen which are appropriate for the given hydrogeologic setting. When using these methods at a processing site, the existing contaminant plume will be considered the best indicator of the dispersive and attenuative properties of the aquifer.

Concentrations will be given as a range of values rather than single values. If possible, a probabilistic ~~approach~~ instead of a deterministic approach will be used for modeling.

3.3.3 Impact on beneficial use

For each geohydrologic unit in which DOE will evaluate the potential impacts on the quality of the ground water. The present state and existing drinking water and other use classifications will be the basis for evaluating the degree of contamination and determining remedial or protective actions for ground-water supplies. Table 3 lists drinking water standards set by the EPA (40 CFR 141.101) for states which have UMTRA Project sites. Table 3 lists secondary classifications (secondary) set by the EPA (40 CFR 143).

Water quality standards considered applicable are those issued for waters classified for ^{use} ~~use~~ as a source of domestic water supply (i.e., drinking water) are of primary interest. These standards will be compared with contaminant concentration levels in order to qualitatively evaluate the potential health impacts. Maximum concentrations set as allowable limits for other use classifications also are considered. These include limits established for waters used for contact and non-contact recreation, industrial, municipal, and agricultural purposes, and to support aquatic organisms and other wildlife. Where a discrepancy between limits set for different use classifications is found, the lowest, most conservative limit is considered. For states where no distinction between surface and ground water is made, water quality standards for surface water are accepted (EPA, 1976). For key contaminants without legislated water quality

TABLE 2 missing

TABLE 3 MISSING

29
standards (e.g., uranium, molybdenum), water quality criteria established by a widely recognized authority will be considered. For example, maximum permissible concentrations of soluble radionuclides in water released to an unrestricted area (10 CFR 20; 25 FR 10914) (NRC, 1960) will be considered for radioactive contaminants.

Evaluating the availability of alternate supplies of water will include presently used alternate supplies, presently available but unused supplies, and supplies not presently available but which could be developed.

The present value of affected water supplies will be determined through a combination of interaction with state agencies and/or local water companies and a field determination of the nature and extent of contamination. The proximity, withdrawal rates, uses and sources of presently used water will be found in state, county and municipal water administration office files, and may be supplemented by a field survey of the area surrounding the site to gather information on undocumented water users.

The future water value and predicted uses will be developed through consultation with Federal, state, county and local planning commissions. Projections of future water use will be qualified by the accuracy of the assumptions used in the projection. Most projection methods assume continuations of past conditions, present conditions or trended changes in historical

conditions. The two factors of primary concern to water use planners are changes in agricultural productivity and population. The period of accuracy of demographic projection techniques (e.g., cohort-component modeling) is typically limited to 30 years (Pittenger, 1976). Although the rules and regulations guiding the UMTRA Project require stabilization of the contaminated materials for 1000 years or at least 200 years, it is felt that water use and resource value projections beyond 50 years may be of limited usefulness.

3.3.4 Control alternatives

Once the need for remedial or protective actions has been established, the following steps will be initiated:

- o Develop a list of potential remedial/protective alternatives.
- o Evaluate the technical feasibility of the alternatives.
- o Perform a cost-benefit analysis of the alternatives.

The technical feasibility of a wide range of possible actions to protect the ground water resource will be considered for each site. Some of these options are listed in Table 4. This list is not considered to be comprehensive, and several combination of individual protective actions may be feasible.

Table 4 Potential protective actions water resources

Stabilization of tailings in place or on-site:

- Stabilize and cover with low permeability sediment.
- Construct diversion structures or drains to intercept surface and shallow ground water.
- Construct slurry walls/grout curtains.
- Move tailings locally onto a low-permeability sediment layer with capillary breaks.
- Move tailings locally into a lined impoundment.

Move to alternate site: cap, stabilize:

- Stabilize and cover with low-permeability sediment.
 - Construct low-permeability sediment under-layer/capillary breaks.
-

3.3.5 Restoration of ground water

In addition to the options in Table 4, DOE will evaluate the feasibility of aquifer restoration and providing alternative sources of water for existing or future uses. Strategies for reducing contaminant concentrations in the ground water may include water extraction and treatment or other schemes such as those involving the mixing of "clean" alternative sources with contaminated waters.

Cost-benefit analyses of all reasonable technical approaches will be performed to aid in the ranking and selection of an appropriate alternative.

Assuming that an acceptable method of evaluating potential resource damages could be agreed upon, DOE may consider various options of minimal protective actions coupled with monetary compensation to local populations could decide how they would wish to use compensation funds. Such options would provide greater flexibility in dealing with the uncertainties of future water use, water valuation, and changes in technical capabilities.

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