PILE STABILIZATION AND GROUNDWATER PROTECTION AT TITLE I AND TITLE II UMTRA PROJECT SITES

Jack A Caldwell and Thomas A. Shepherd

INTRODUCTION

There are at least fifty uranium mill tailings piles in at least ten states that have been, are being, or must be stabilized to protect human health and the environment. The piles at inactive sites that produced uranium primarily for defense are being cleaned up by the U. S. Department of Energy (DOE) as part of the Uranium Mill Tailings Remedial Action (UMTRA) Project. Reflecting the legislation from which the UMTRA Project derives, the inactive sites are often referred to as Title I sites. By contrast the active, or Title II, sites are the responsibility of private industry.

Successful remediation of both Title I and Title II sites, and advanced plans for groundwater restoration and final pile stabilization at many more sites, has highlighted the differences in approaches to and details of Title I and Title II remedial actions.

This paper explains those differences. I set out first to describe the laws and regulations that govern the programs. Then I describe the standards formulated by the U. S. Environmental Protection Agency (EPA) to govern remedial works. Next, I discuss the technical approaches adopted for Title I and Title II sites to compile remedial designs, closure plans, and groundwater protection strategies. Case histories of both Title I and Title II sites are described. I enumerate and discuss the reasons for the differences in the two programs from this discussion.

My reasons for undertaking a study of the differences arise from many discussions with colleagues working in both Title I and Title II arenas, seeking to explain why similar problems are dealt with differently by the DOE on the one hand and private industry on the other. I have variously been accused of excessive or inadequate conservatism, lack of or excessive boldness, inept regulatory interpretation, and unreasonable cost attitudes. I must therefore seek to understand and explain the basis of these opinions.

Objectively, there is no good reason why a Title I site should be treated differently from a Title II site or vice versa. Both contain uranium mill tailings that could blow around, be transported by water erosion, cause groundwater or air contamination, or be misused by humans and animals. Both must be stabilized for 1,000 years to the extent reasonably achievable, or at least for 200 years. And all piles, both Title I and Title II, will be the responsibility of a governmental entity (state or federal) in perpetuity.

In undertaking to explore differences between Title I and Title II approaches, I hope to:

- Identify unwarranted differences and seek to eliminate those that result in inappropriate expenditures.
- Explain justifiable differences.
- Identify technical approaches on one program that may be shown later by experience on one or the other of the programs to be inadequate or inappropriate.
- Establish that, as a consultant, I am serving the needs of my client in a professional manner.

It is not my theme or intention to suggest that what is being done on one program or the other is wrong. I accept that in a free society, the essence of which is mutual and professional checks and balances, there is room for equally correct but different approaches. I accept that in a free society somebody must judge and make a final decision if we are to accomplish anything and advance. In uranium mill tailings remediation, the role of judge has been assigned to the U. S. Nuclear Regulatory Commission (NRC). They have the difficult and unenviable task of reviewing the varying submissions from different designers and of deciding what engineering works lead to compliance with the relevant laws and regulations. Finally, I accept the basic concept of law, "stare decisis" - the decision stands. Once the NRC has decided that a certain approach complies with 40CFR192 or 10 CFR 40, this decision, as it were, must remain binding on future generations, all public parties concerned, and the different government agencies affected.

The perspective I provide in this paper is one of a moving scene. The technology of uranium mill site reclamation is not now what it was a decade ago, when work began. I entreat my reader to keep in mind that differences in technical approaches may be simply the result of advancing technical knowledge and understanding, and not of any personal perspectives or prejudices. If, indeed, the differences I highlight stem only from technology advances, then I rejoice, and believe this paper will be another stepping stone in that technology advance leading to cost-effective, prudent, and appropriate long-term stabilization of wastes that, left unattended, could adversely impact human health and the environment.

PILE STABILIZATION AND GROUNDWATER PROTECTION AT TITLE I AND TITLE II URANIUM MILL TAILINGS SITES

REGULATORY BACKGROUND

The Uranium Mill Tailings Radiation Control Act of 1978 as amended (UMTRCA) notes that uranium mill tailings may pose a potentially significant radiation health hazard to the public. Accordingly, Title I (covering inactive sites) of the UMTRCA directs the DOE to conduct remedial actions at the inactive sites to ensure compliance with standards established by the EPA. The remedial actions are to be selected and performed with the concurrence of the NRC. Upon completion of the remedial action, the NRC is empowered to issue to the DOE a license to care for the remediated site in accordance with an approved Long-Term Surveillance Plan (LTSP). The EPA standards for Title I sites are published as 40 CFR 192 Subparts A, B, and C.

Title II of the UMTRCA deals with active uranium mill sites, which are the responsibility of the commercial companies operating the associated mine or mill. Closure plans for Title II sites are prepared and implemented by the private companies that own or are responsible for the sites. Upon closure of the Title II site, responsibility for the site will be transferred to the state in which the pile is located, if the state elects. If the state elects not to take title to the site, the federal government, probably the DOE, will take ultimate long-term responsibility for the site.

The design, operation, and closure of Title II uranium mill sites are governed by 10 CFR 20 and 10 CFR 40. (Note that the term "remedial action" applies only to Title I sites, and the term "closure" applies to Title II sites.) Appendix A of 10 CFR 40 and Subparts D and E of 40 CFR 192 set out standards that are equivalent in intention and technical approach to the EPA standards of 40 CFR 192 Subparts A, B, and C, which govern Title I remedial actions. The NRC is required to approve closure plans for Title II sites in states under NRC licensing control or to concur that closure has been completed in accordance with 10 CFR 40 for Title II sites in states where state agencies provide regulatory control and if the site is to be transferred to federal control. In either case, the NRC is to issue to the DOE (or the state), upon transfer of the site, a license for long-term post-closure care.

The groundwater protection standards originally published by the EPA for Title I sites were set aside by the Tenth Circuit Court, which remanded them back to the EPA "to treat these toxic chemicals that pose a groundwater risk as it did in the active mill site regulations." Proposed new groundwater protection standards were published in the Federal Register Vol. 52 No. 185, September 24, 1987. Final standards have not yet been published.

As required by the Tenth Circuit Court, the proposed Title I groundwater protection standards parallel those applicable to Title II sites. Briefly, both require that the site be remediated and existing groundwater contamination be cleaned up so that specific maximum concentration limits (MCLs) or background concentrations are not exceeded. Alternatively, the responsible organization may propose, and the NRC may concur in, alternate concentration limits (ACLs). As a third alternative, for Title I sites only, and only if specific conditions prevail, supplemental standards may be invoked; for example,

on the basis that the groundwater constitutes a limited use aquifer or because cleanup is not technically practicable.

The Uranium Mill Tailings Remedial Action Amendments Act of 1988 allows the DOE until September 30, 1994, (previously 1990) to perform remedial actions at designated inactive uranium mill tailings sites. The authority to perform groundwater restoration is extended without limitation.

The NRC, in the Federal Register (Vol. 55, No. 25, February 6, 1990), published a proposed rule to issue general licenses that would permit the NRC to license the custody and long-term care of reclaimed (Title I) or closed (Title II) uranium or thorium mill tailings sites after remedial action or closure under the UMTRCA has been completed. As the responsibility for both active and inactive sites will pass to the DOE (or the state), the licenses will in essence be issued to the DOE.

The basic concept of the proposed rules is that the NRC would establish two general licenses, one for Title I sites, and one for Title II sites. (A different license for each type of site is required to deal with minor institutional differences between the two types. From a practical perspective, the technical requirements of the two general licenses are the same.) Once the general licenses are established, specific sites would be brought within the ambit or included in the general license upon completion of the remedial action or closure as documented by a closure plan (with which the NRC must first concur) and formal receipt by the NRC of an acceptable Long-Term Surveillance Plan. The two most significant differences between the licensing of Title I and Title II sites are (a) that the state, at its option, may take over a Title II site, and (b) that Title II licensees must pay a minimum of $250,000 in 1978 dollars to the general treasury of the United States or the appropriate state to cover the costs of long-term surveillance and maintenance.

An additional significant difference between inclusion of a site in the Title I as compared to the Title II general license is that inclusion of a Title I site may be done in two phases. The first phase allows the DOE to do all remedial actions, including complying with the groundwater protection standards, at the disposal site. Thus a Title I site may be included in the general license once the DOE has stabilized the tailings in a suitable disposal cell which will not erode, require active maintenance, or allow seepage that leads to an exceedance of the applicable groundwater constituent limits for that site. This must be done before September 1994. In the second phase, which can go on for a long time (potentially 100 years), the site would be included in the general license when existing groundwater contamination at the processing site is cleaned up or otherwise brought within the scope of the EPA standards for groundwater protection (e.g., by showing that ACLs or supplemental standards are applicable).

The proposed Uranium Revitalization, Tailings Reclamation and Enrichment Act of 1987 was passed by the Senate (but to date not by the House). Among other things, the act proposes to establish a fund to provide for the cleanup of 26 active uranium mill tailings sites (Title II). Contributions to the fund would be as follows: 26 percent federal government; 37 percent electric utilities; and 37 percent uranium mining companies. The total estimated requirements for the closure of the active sites via the fund is $1 to $3 billion. As recently as December 1989, the Uranium Producers of America urged the House of Representatives to follow the lead of the Senate and authorize the $300 million needed from Congress to help pay for reclaiming active mill tailings sites.

In early 1990, the Office of Management and Budget (OMB) suspended review of the EPA's proposed groundwater protection standards. The OMB has requested an

explanation of the difference between the EPA's cost estimate for compliance with the groundwater protection standards by the DOE at Title I sites (about $200 to $300 million) and the DOE's estimate (about $800 million). Furthermore, the OMB considers that the health benefits of aquifer restoration need to be justified relative to the potential costs. Note that the EPA and DOE cost estimates of actual work required to pump and treat contaminated groundwater are similar. The DOE costs for the total program are higher than the EPA's because the DOE includes the cost of factors such as land acquisition, program management, escalation, contingency, and the like. The important point that must be emphasized is that there is no significant difference between the EPA and the DOE in identifying Title I sites where active groundwater cleanup will be required; furthermore, there are no significant differences between the EPA and the DOE in identifying aquifer restoration technologies to be used. It is fair to say that the DOE, as one arm of government, is planning with respect to its proposed groundwater restoration program to implement both the letter and the spirit of the regulations promulgated by another arm of government, the EPA.

THE EPA STANDARDS

The EPA standards for long-term stabilization of active and inactive uranium mill tailings piles (as set out in 40 CFR 192 Subparts A to D and Appendix A of 10 CFR 40) require, briefly, that the remedial or closure works should remain stable to the extent reasonably achievable for 1,000 and at any rate for 200 years; not rely on active maintenance; and reduce the radon flux from the disposal cell to less than 20 picocuries per square meter per second (pCi/m^2s).

The proposed EPA groundwater protection standards for Title I sites are divided into three parts.

Subpart A provides standards that govern the design of the tailings disposal cell. The standards include a list of specific hazardous constituents, a concentration limit for each hazardous constituent, and a definition of the point of compliance. The list of hazardous constituents and MCLs includes the list from the Resource Conservation and Recovery Act (RCRA) plus four additional constituents (molybdenum, radium, uranium, gross alpha and nitrate). The standards require a liner or equivalent if relocated tailings are placed at a moisture content greater than their specific retention. Finally, the standards call for post-remedial-action monitoring to verify design performance and corrective action plans if the standards are exceeded.

Subpart B provides standards for cleanup of existing contamination at processing sites. This involves cleanup by means of active restoration (for example, pump and treat systems) to the levels specified in Subpart A. Alternatively, remediation of the groundwater may be achieved by natural flushing if no public drinking water use exists or is projected; institutional controls will effectively protect human health and the environment; and the standards will be met in 100 years. Finally, supplemental standards may be invoked to justify no action if the requirements of Subpart C are met.

Subpart C provides for the use of supplemental standards if the harm involved in an action clearly exceeds the benefits of the action; restoration is technically impracticable from an engineering perspective; or the groundwater is a limited use aquifer (i.e., Class III); in addition, however, the concentration levels must be as close as reasonable to the otherwise prevailing limits.

The differences between the Title I and Title II groundwater protection standards are:

- o MCLs for molybdenum, uranium, and nitrate are added for Title I sites.
- o For new facilities, the Title II standards call for a liner regardless of the tailings' placement moisture content.
- o Title II standards do not explicitly provide for natural flushing under institutional controls.
- o Title II standards do not provide for supplemental standards.

ALTERNATE CONCENTRATION LIMITS

ACLs for groundwater may be proposed and justified at Title I or Title II sites. The critical requirement of an ACL proposal is that the proponent must demonstrate that the alternate concentrations will not adversely affect human health or the environment. In addition, the proponent must demonstrate that the design results in concentrations as low as reasonably achievable (ALARA).

The DOE has compiled a draft guidance document for the compilation of ACL applications on the UMTRA Project. The proposed ACL procedure reflects EPA requirements and practices. Furthermore, the DOE ACL guidance document essentially follows guidance paths developed by the NRC for applying ACLs at Title II sites (NRC, 1988).

ACL applications considered by the EPA under the RCRA program for Superfund sites have been time-consuming and expensive. Very few have been granted. The DOE is concerned that the same may occur for ACL applications attempted for the UMTRA Project. Certainly estimates of the time and cost to do the work laid down in the DOE ACL guidance document indicate a long and expensive process: at the very least, for Title I sites the local community and the affected state must support any proposed ACL higher than a specified MCL.

The NRC believes ACL applications for both Title I and Title II facilities should and will be simple and speedy. The NRC considers that the DOE is unduly pessimistic in its evaluation of the difficulty, complexity, and cost of invoking ACLs. There is, to date, no actual case history by which to decide which opinion is correct.

The Title II industry believes, on the basis of their reading of the regulations and indications from the NRC, that ACLs can be, and should be, approved at many Title II sites. For this reason, ACL applications are planned or envisaged as the means by which groundwater standards will be achieved at many Title II sites.

COMPLIANCE WITH THE STANDARDS

PILE STABILIZATION

Various approaches to stabilizing a uranium mill tailings pile have been and will be adopted. The most extreme approach to the design of a Title I disposal cell in terms of infiltration control involves a multi-component (or full component) cover that incorporates numerous redundant and dual-purpose components such as vegetation, biobarriers, filters, low-permeability infiltration barriers, and radon barriers. The cover probably reduces the overall average water flux to the cell to between 1E-9 and 5E-8 $cm^3/cm^2/sec$. The sides of the pile are formed of clean fill dikes in which vegetation

growth is permissible and through which the water flux is of no consequence. This design is proposed at five UMTRA Project sites. The multi-component cover without the clean fill dikes is proposed at an additional two sites. The remaining piles will be covered with a clay radon barrier and erosion-resistant riprap. To date, Title II site cover designs have not required such extreme measures to achieve regulatory acceptance.

The approach more common for Title II sites is to place a cover of compacted soil from 300 mm to as much as 3 meters thick over the reshaped tailings. This cover is designed to control radon emanations and provide long-term surface stability, but does not have infiltration control as a primary design objective. However, acceptable groundwater protection has been achieved by these cover designs based on site-specific conditions and the NRC's interpretation of their groundwater protection regulations. Why cover designs differ so greatly between Title I and Title II sites may to some extent be based on site-specific conditions, but must also be attributed to different philosophical approaches taken by the DOE and industry as well as possible differences in the interpretation of the requirements of the regulations by the DOE and private industry, and application of the regulations by the NRC to Title I and Title II sites. An examination of these possible or suggested reasons for perceived differences is the primary focus of this paper.

Regardless of the details of the disposal cell, the following design criteria and approaches are used at both Title I and Title II sites:

- Performance of the remediated site for 1,000 years to meet the 10 CFR 40 criteria: Use only natural materials that have proven long-term durability and integrity. Design for extreme events such as the probable maximum precipitation or maximum credible earthquake.
- Protect groundwater: Achievement of groundwater protection criteria by active remediation, closure design, ACLs, supplemental standards, and natural flushing. Shed water by causing it to run off top and side slopes. Use low permeability layers to impede infiltration (for Title I sites only). Establish vegetation to cause evapotranspiration.
- Minimize long-term maintenance: Reduce the potential for the establishment of unplanned vegetation. Provide for the establishment of a stable vegetation community in appropriate soil layers.
- Control dispersion of the tailings: Construct covers that will not erode by using either riprap covers or vegetative covers with very gentle slopes.
- Prevent human misuse and detrimental intrusion to the pile by animals and plants. (This is generally a criterion adopted for Title I sites, but not Title II sites, which, for example, do not use biointrusion barriers. This criterion is not directly derivable from the EPA standards, although avoidance of human misuse and dispersion by animals was one of the reasons for promulgating the standards in the first place.)
- Limit radon gas flux from the pile: Provide radon barriers of natural soil.

GROUNDWATER PROTECTION

Compliance with the EPA groundwater standards at either Title I or Title II sites may involve one or more of the following:

- Demonstrate that existing concentration levels do not exceed MCLs or background. In such a case, all that is required is the production of documents that meet the requirements of the National Environmental Policy Act (NEPA) and the NRC to demonstrate that further action is not required.

- Undertake active groundwater cleanup.

- Justify ACLs. Documentation to satisfy NEPA requirements and the NRC will be provided in accordance with standards requirements (see NRC, 1988 and DOE, 1989b). In particular, the proponent must demonstrate that the ACLs will not negatively affect human health or the environment and are ALARA.

- Demonstrate that natural flushing will reduce concentration levels to acceptable levels (MCLs or ACLs) within 100 years, and that for that period institutional control can be effected to prevent inadvertent use of the groundwater. (Explicit provision for this approach is made for Title I, but not for Title II, sites.)

Active groundwater restoration may involve a number of approaches, including the following:

- Extract all contaminated groundwater, and treat it via evaporation.

- Extract and treat a limited amount of the contaminated groundwater and allow natural flushing to effect the final cleanup to the ultimate standards.

- Treat contaminated zones in situ by bioremediation or geochemical remediation.

The most significant difference between potential Title I and Title II approaches to compliance with the groundwater protection standards is that Title I sites may justify no active or at least minimal groundwater treatment on the basis of supplemental standards. Supplemental standards at Title I sites may be invoked if:

- The remedial works would present a substantial risk to workers or the public.

- Aquifer restoration would cause excessive environmental harm.

- Aquifer restoration is technically impracticable.

- The groundwater is defined as limited use (i.e., a yield of less than 150 gallons per day, total dissolved solids in excess of 10,000 mg/l, or widespread ambient contamination not due to activities at the site).

- The concept of ALARA is met.

TITLE I REMEDIAL ACTION STATUS

PILE REMEDIATION

In the early phases of the UMTRA Project, the standard cover was simply a clay radon barrier, at least 450 mm thick, a bedding layer of sand, and an erosion-resistant layer of durable rock riprap.

Two significant events caused a reevaluation of this design. The first was the growth of unplanned vegetation on the Shiprock, New Mexico, and the Burrell, Pennsylvania piles. This vegetation may be growing into the radon barrier. Recent studies have shown that vegetation in simple soil covers on uranium mill tailings piles results in significant radon release (Morris and Fraley, 1989). While the methods and results of the studies are controversial and open to different interpretations, the DOE undertook to reevaluate the cover details needed to prevent the potential unacceptable consequences of uncontrolled vegetation growth on piles (i.e., increased radon emanation). The result for sites in wetter climates is a multi-component cover (see below). For drier sites, the DOE now uses a very permeable bedding layer to expedite precipitation shedding, hence reducing the development of a moist zone in the cover that is conducive to vegetation germination and growth.

The second significant event that caused the DOE to reevaluate cover designs was the publication of revised (proposed) groundwater protection standards. Examination of the new standards revealed that to meet the standards it would be necessary to adopt one or more of the following additional design features (the DOE considers that these design approaches are appropriate both if MCLs are to be achieved or ALARA is to be established to support ACLs):

- Covers that resulted in very low infiltration rates.
- Geochemical modification of the tailings or the leachate.
- Placement of the tailings in a very dry condition.
- Relocation of the tailings to sites where supplemental standards are applicable.

The combined effect of these two events is the use of clean fill dikes around the cell and a topslope multi-component cover that includes, from the top down:

- Vegetation for evapotranspiration, erosion protection, and controlled growth.
- Gravel mulch for erosion control.
- Random soil for controlled vegetation growth and as a reservoir for evapotranspiration and reduced infiltration.
- Filter.
- Biointrusion barrier.
- Infiltration barrier of CLAYMAX^{R} or sand amended with a high percentage of bentonite.
- Radon barrier of silt or clay.

These design details have been criticized by many as excessive, redundant, or unnecessarily costly. This may be so, but the DOE has consciously sought to avoid extra cover components which are not absolutely proven to be needed to secure timely NRC concurrence. A design for a cover that incorporates all the above listed elements was submitted to the NRC more than a year ago. To date, no official comment has been received.

Remedial actions, i.e., disposal cell construction, are complete at eight of the 24 UMTRA Project sites. None have been licensed by the NRC. Construction is in progress at six sites, and disposal cell design is well advanced at the remainder.

The designs of the cells have changed in response to the proposed EPA groundwater standards. Hence, cells still to be built may differ from those already completed. The total cost impact of changing the standard disposal cell design to achieve compliance with the EPA groundwater protection standards is on the order of 64 million dollars.

The Green River, Utah, pile remedial works are a good example of the rigors to which UMTRA Project disposal cells are subjected. The DOE believes that geochemical modification of leachate from the cell by foundation materials will result in MCLs or background groundwater concentration levels.

The NRC was not convinced that the DOE had assembled sufficient data to prove the geochemical argument. With a contractor waiting to place tailings, the DOE elected not to pursue the geochemical argument. Instead, it chose to place the tailings very dry (i.e., at seven percent moisture content, a non-standard procedure that often created so much dust that Utah air quality standards were almost violated). Also, the DOE placed a dry buffer layer at the base of the cell. Calculations show that the resulting leachate, unmodified by any geochemical processes, will not reach the groundwater for at least 200 years. Hence, the NRC defined a variant of the MCL approach, now called the travel-time argument. This approach accepts that the EPA groundwater protection standards are met because MCLs will not be exceeded for at least 200 years.

The potential criticism of this travel-time approach to meeting groundwater standards is that it is not envisaged, in fact, by the EPA standards, and is in truth contrary to the spirit of the regulations. If the rock providing erosion protection deteriorates in 200 years, it will be a small matter for a future society to replace the rock. Little or no harm is done to the environment by some deteriorated rock, and the repair cost is small. Conversely, when in 200 years the groundwater is contaminated by leachate newly arrived at the water table, society is faced with an expensive and impossible dilemma. Should it once again relocate the tailings? Should it undertake perpetual aquifer cleanings? Should it refurbish a pile that already has a cover, letting a flux of only 10E-8 $cm^3/cm^2/sec$ infiltrate the cell? I don't know now, and I doubt society, 200 years hence, will know either. Surely groundwater compliance should be based on the steady state performance of the cell, not its transient behavior?

GROUNDWATER STANDARDS COMPLIANCE

The DOE adopted the following policy when the proposed EPA groundwater protection standards were first published (DOE, 1989a):

> During the period prior to promulgation of the final standards, the DOE intends to comply with Subparts A and C of the proposed standards as they apply to disposal sites and the design and construction of disposal cells. The provisions of Subparts B and C, as they apply to groundwater remediation, will be complied with following promulgation of the final standards.

In anticipation of promulgation of the final groundwater protection standards in 1990, the DOE has proposed a budget for a new program leading to compliance with the standards. Congressional funding has not yet, however, been provided. The anticipated budget for demonstrating and achieving compliance with the groundwater standards is about $800 million.

When Congressional funding is provided and the new UMTRA Project groundwater compliance program undertaken, detailed site planning may begin. The normal flow of activities will probably be:

- o One to five years of site characterization, including field and bench-scale testing of potential contaminated water treatment processes.
- o Preparation of NEPA documents.
- o Preparation of groundwater compliance plans and/or demonstration documents for submission to the NRC to obtain their concurrence.
- o If active restoration is not to be done at a site, inclusion of the site in the general NRC license after concurrence by the NRC on appropriate documents such as the compliance demonstration report and the LTSP.
- o Allowance of sufficient time to pass for natural flushing to restore groundwater quality to acceptable regulatory limits.
- o If active restoration is to be done, preparation of a detailed plan and implementation of active restoration activities.
- o When active restoration is complete, inclusion of the site in the general NRC license after they have concurred in the appropriate documentation.

Because of the need for detailed programmatic and site planning, including prioritizing sites, preparing NEPA documents, characterizing sites, preparing detailed remedial action plans, and obtaining NRC concurrence, the start of actual active groundwater cleanup may not begin until at least five to seven years after the start of the program by the DOE. Completion of all activities at the 24 UMTRA Project sites may take between 30 and 100 years. Certainly it is not improbable that the last UMTRA Project site will be brought under the general NRC license in the year 2090.

TITLE II REMEDIAL ACTION STATUS

TAILINGS STABILIZATION

Construction of surface reclamation has been essentially completed at three Title II sites and is in various stages of completion at other sites. Range (1989) describes the cover for the Exxon Wyoming uranium mill tailings pile. The tailings at that site will be covered with 1 meter of sandy clay compacted to 95 percent of standard proctor density and 150 mm of topsoil. The thickness and configuration of the soil cover was established to control radon flux from the pile and to provide long-term stabilization. Groundwater protection standards will be achieved through the submission of an ACL application.

At Ray Point, Texas, the Title II uranium mill tailings pile has been covered with 1.2 meters of soil and vegetation (Miller, 1986). Runoff and erosion control is achieved with a gentle, half percent topslope that directs water to a broad swale down the central part of the pile.

The Quivira Mining Company pile near Ambrosia Lake, New Mexico, covers 200 hectares, is 30 meters thick, and contains 30 million tons of tailings. Reclamation involves a 300 mm thick soil cover and rock riprap on the sides. To quote the source of this information (Albuquerque Tribune, 1990), "Quivira is following a reclamation plan it submitted in 1986. The NRC has given Quivira oral approval but not written approval."

The Atlas pile in Utah is in the floodplain of the Colorado River. Groundwater contamination of the alluvial aquifer beneath the pile has been detected to 40 meters in depth. The proposed closure plan involves stabilization in place with a soil cover. The state considers such remedial works inadequate for environmental protection, and has declined to accept this remediation proposal (Anderson, 1990).

Shepherd and Abt (1988) compare remedial action plans for two adjacent sites in Texas. One is a Title I facility, the other is a Title II facility. At the Title II Conquista site, construction of which is partly complete, the proposed closure plan involves the placement of fill material over the tailings to create a very gently sloping domed surface. The resulting soil cover and radon barrier will be stabilized with vegetation. The outer slopes will be five to one, and will be stabilized against erosion with vegetation. Analyses according to procedures recommended by the NRC (1989) show that the existing earthen embankment that surrounds the Conquista tailings impoundment is sufficiently thick to isolate the tailings from predicted gully intrusion, and that the vegetation-stabilized soil will provide acceptable erosion control. The surface remediation for the Conquista site has been approved by the state of Texas Department of Health, but not by the NRC, and is under construction.

The reader may note differences between the degree of conservatism in the remediation of Title I and Title II sites. One reason for this may be that the designs of Title I disposal cells, for the most part, are being compiled to achieve compliance with the groundwater standards, primarily MCLs. To date, ACLs have not been used as an integral part of the groundwater compliance strategy for the design of any disposal cells on the UMTRA Project as a matter of DOE policy. This is not the case for most Title II sites, where disposal cell designs have been formulated to achieve the stability criteria and groundwater protection standards with the application of ACLs after proof has been provided that MCLs cannot be met with reasonable active remediation and that an ALARA approval to close has been accomplished.

It is certainly the case for Title II sites that economic considerations, a realistic evaluation of public health risks and environmental quality, and the industry's interpretation of 10 CFR 40, Appendix A, criterion 5, leads the industry to assume that ACLs can be approved to achieve groundwater protection standards on the basis of the surface designs. It is also the case that active groundwater remediation is in progress or planned at most Title II sites. This groundwater remediation has been required by the NRC as part of the ultimate application of ACLs as a demonstration of the effect of active remediation on MCLs and to show that an ALARA approach to remediation has been taken.

RELOCATION AND COLOCATION

The Title II regulations call for the avoidance of multiple, separate disposal facilities. Colocation of tailings impoundments is considered desirable. To my knowledge, no Title II facilities are being relocated or colocated as part of the closure program.

By comparison, twelve of the 24 Title I sites are being relocated, either to remove them from urban centers (such as Salt Lake City, Utah, and Grand Junction, Colorado) or to take them out of floodplains (such as Gunnison and Slick Rock, Colorado). Community pressure to relocate piles from areas considered vulnerable by the community has been intense at sites such as Gunnison. The Riverton, Wyoming, pile has been removed from Native American tribal lands and relocated with a Title II facility at Gas Hills. Here also community concerns were a significant factor in the decision to relocate the pile.

The possibility of colocating the Ambrosia Lake, New Mexico, and the Falls City, Texas, piles with Title II facilities has often been discussed. To date, short-term (25 years) cost considerations and institutional constraints have precluded this.

The Monticello, Utah, uranium mill tailings pile, which is neither a Title I nor a Title II facility, but which is a National Priority List Superfund site to be remediated by the DOE, will be moved out of a floodplain to high ground. Current plans call for encapsulating the tailings within a clean fill dike, and covering them with a multi-component cover.

A reason for relocating so many Title I facilities may be their current undesirable locations in floodplains and urban areas. Certainly the DOE has tried, without success, to argue against the excessive relocation costs for piles in floodplains by appealing for lesser design floods than the probable maximum. Such appeals have not been successful. Generally, community concerns and desires have been considered and met.

Another reason for large-scale relocation of Title I piles from floodplains is that the alluvium found beside rivers is usually permeable, and such permeable deposits often contain groundwater that contains leachate from the piles with concentrations in excess of those of the EPA standards. To demonstrate that stabilizing a pile in place in a floodplain will result in a stable facility that protects groundwater has generally not been possible for the DOE.

Moreover, community concerns about pile stabilization in floodplains at Grand Junction, Gunnison, Naturita, and Slick Rock, Colorado, have played a part in the DOE's decision to relocate such piles. The public nature of the Title I program, with individual site Environmental Assessments (EAs) or Environmental Impact Statements (EISs), has resulted in the public sensitivity and responsiveness the DOE has displayed in relocating piles.

DIFFERENCES BETWEEN TITLE I AND TITLE II APPROACHES

I may compare some obvious differences between Title I and Title II design approaches by considering specific design components, as follows:

- Radon Barrier: The Title II Quivira pile radon barrier is reported to be 300 mm thick. The minimum thickness the NRC will accept for Title I facilities is 450 mm. This is because of concern for contamination of the first lift by the tailings, on which it is placed. Moreover, a cover of only 300 mm thickness can be placed in two lifts, each of 150 mm. The statistical probability of overlapping or coincident defects is high with only two layers. Hence, a three-layer, 450 mm thick barrier is considered the minimum. The DOE generally accepts and concurs with the NRC concerns in this regard.

- Infiltration Barrier: Title I sites have placed infiltration barriers (doubling as the radon barrier) to hydraulic conductivities as low as 10E-8 $cm^3/cm^2/sec$. A bentonite amendment to achieve this permeability has been required. Low-permeability infiltration barriers are required on Title I sites because, generally, the approach to groundwater protection is to limit infiltration into, and hence seepage from, the disposal cell.

  In order to reduce infiltration further at certain Title I sites, the DOE is using or proposing to use CLAYMAX or sand amended with up to 25 percent bentonite. This could conceivably, in conjunction with other cover components, reduce hydraulic conductivities to as low as 10E-9 $cm^3/cm^2/sec$.

  Low-permeability infiltration covers have not been used at Title II sites The reasons for this are as follows. Generally, only the issue of surface stabilization has been formally addressed on Title II sites. To expand and explain: There are two main parts to the EPA standards applicable to all uranium mill tailings piles. The first is the surface stabilization requirement; the second is the groundwater protection standard. To date the Title II sites, where remedial work has been done, have addressed only surface stabilization. Groundwater protection has been postponed until sometime in the future. The Title II operators consider that in many instances ACLs will be the basis for establishing compliance with the groundwater protection standards. Freed of the immediate need to consider groundwater protection standards, the Title II pile remediators have not had to consider seepage reduction or the use of low-permeability components in the cover. The Title II pile remediators moreover consider their current covers ALARA. If, in the future, the NRC declines to concur that current surface stabilization works constitute ALARA for groundwater protection, some in the industry have indicated a willingness to consider the matter in court.

- Biointrusion Barriers: In order to control, prevent, or at least inhibit animal and root penetration of the cover, Title I sites generally incorporate a biointrusion barrier. In a simple cover, the erosion control riprap doubles as the animal intrusion barrier. For vegetated covers, a distinct rock or cobble layer is used. While there is considerable controversy about the efficacy of such biointrusion barriers, the DOE considers them a prudent design feature. Recent literature showing the potential negative impact of vegetation growth into uranium mill tailings piles supports the reasonableness of the DOE position.

  By contrast, biointrusion barriers are not generally used on Title II facilities. This is because the Title II remediators believe that biointrusion barriers are not

required by the EPA standards, and do not, in fact, work to preclude vegetation growth from the soil layer to the radon barrier. The NRC, one may assume, concurs with this technical approach, for the NRC has approved Title II pile closure plans that have no biointrusion barriers.

Because of the high cost of biointrusion barriers, the criticism leveled at their functionality, and the presumed NRC technical position, recommendations have been made to the DOE to consider not incorporating biointrusion barriers in future disposal cell covers.

- Vegetation: Where vegetation is specifically provided for on Title I sites, a distinct soil layer is constructed. This may be as thick as 1 meter or more. This provides ample depth for roots. The biointrusion barrier underlies the soil and rooting zone.

  At the Title II sites, a 150 mm soil layer is generally provided for vegetation. Roots may grow into the underlying radon barrier, which could be up to 1 meter thick.

- Erosion Control: On Title I sites, erosion control is provided either by the rock riprap or by a gravel mulch over the soil and vegetation growth medium.

  On some Title II sites, such as Quivira, a similar approach is used. Generally, however, the preferred approach is to use very flat slopes (i.e., less than one-half percent) on the top.

  Often at Title II sites the sideslopes are underlain by clean fill embankments that were part of the original impoundment construction (Shepherd and Abt, 1988). As part of the philosophy that accepts that erosion may occur provided it does not, for at least 200 years, intercept the tailings, such sideslopes are incorporated as part of the final reclamation plan.

  Using procedures documented by the NRC (1989), the Title II industry prefers to demonstrate that the 200-year gully development in such dikes will not intersect the tailings.

  Conversely, the DOE, which is generally held to the 1,000-year requirement (and not the 200-year default value of the EPA standards), places rock erosion protection over even clean fill sideslope dikes.

- Costs: The total cost of the Title I program for pile stabilization and vicinity property cleanup will approach $1.0 billion. Of that, about one-third to one-half will be for pile stabilization (the remainder is for cleanup of vicinity properties). The cost of aquifer restoration is currently estimated to be about $800 million. As previously noted in this paper, Congressional funding is currently being sought to assist with the estimated $1 to $3 billion cost of Title II remediation.

  The only direct, site-by-site, Title I versus Title II cost comparison available to us is for Ambrosia Lake (Albuquerque Tribune, 1990). The 3 million tons of Title I tailings will cost up to $25 million to remediate. The 33 million tons of Title II tailings will cost $14 million to remediate. It is difficult, and probably unfair, to compare these costs directly. The Title II work is being done by the private mining company involved. The cost quoted may not account for all overhead and the fact that existing employees are involved. By comparison, the

Title I work will be done by contractors subject to all the requirements and public scrutiny that currently attend DOE cleanup activities. The Title I cost also includes the cost of mill demolition; hence, these costs are not directly comparable.

- Time: The Quivira Mining Company submitted their reclamation plan to the NRC in 1986. To date they still have no written approval of the plan. This is not serious, as there is no legally mandated end date to the Title II program. However, the Title I program must, by law, be completed by 1994. It simply is not possible to accommodate four-year NRC review delays. At Quivira they are proceeding without official NRC concurrence. This option is not open to the DOE; tailings stabilization simply cannot begin until the NRC concurrence has been obtained. Hence, the DOE often adopts conservative design details that expedite NRC concurrence. Conversely, the Title II industry can accommodate the longer NRC review of less costly, less conservative design details.

- Groundwater Protection: Since publication of the proposed EPA groundwater protection standards applicable to Title I sites, the NRC has concurred on the following groundwater compliance strategies: supplemental standards for Spook, Wyoming, and Ambrosia Lake, New Mexico; and the so-called "travel-time argument" for Green River, Utah. The travel-time argument is a variant of the MCL/background approach. In essence, it says that MCLs will not be exceeded for at least 200 years, when the first wave of contaminated leachate will reach the groundwater table. The groundwater strategy for other sites yet in the works is primarily MCLs or supplemental standards.

  The DOE is considering an ACL application for Durango, Colorado. Generally the DOE does not prefer the ACL approach because of the time and cost potentially involved. In particular, the general argument against ACLs for piles to be relocated to a new site (50 percent of the Title I facilities) is that if ACLs are required, a better site might have been chosen.

Shepherd and Abt (1988) conclude that, with regard to surface stability, while the cover options employed for Title I sites are generally quite different from those commonly proposed for Title II sites, the differences are primarily due to differing site conditions, such as the presence or absence of earthen embankments. They conclude that differences also result from the confidence level provided by the available technology and the application of sound engineering to address the site-specific conditions that exist at the different sites and the different levels of risk (and reward) the two different entities, public and private, are willing to take. They further conclude that differences cannot be attributed to any basic difference in the technical criteria or engineering philosophies used to develop remediation and closure plans, or to the political or economic constraints that could influence decisions. Shepherd and Abt, however, did not address groundwater issues or recent DOE cover designs.

With regard to the differences in approach to groundwater protection, the basic cause may be the fact that there is a legally mandated date of 1994 for completion of Title I remediation, as compared to the indefinite future for Title II sites. Because of this, there is clearly a managerial imperative to complete work at Title I sites in the time allowed. This binding time constraint, and the DOE's prediction of a protracted procedure required for the approval of ACLs, yields a situation where the DOE has decided to attempt to meet the EPA groundwater standards through engineering designs. In contrast, the Title II operators, who are not constrained by a mandated completion date and have determined that ACLs can be approved as provided in 10 CFR 40, can and are proceeding in

reclamation design with more cost-effective closure plans that will, in most cases, achieve groundwater protection via ACLs after demonstration that MCLs cannot be met and that an ALARA closure has been accomplished.

The NRC does not believe there are any significant differences between Title I and Title II sites. To the extent there are differences, if any, the NRC staff appear to consider that the differences may arise from the following perspectives I have heard expressed at various times in informal conversations:

- Differences in the laws and regulations governing the two programs.
- The DOE's policy decision not to pursue ACLs as an option to achieve groundwater compliance.
- The significant body of data at Title II sites that indicates that even for unremediated piles, groundwater contaminant concentrations are decreasing and not increasing with time.
- The DOE likes all plans submitted to be perfect; Title II installations are prepared to negotiate design details.
- The DOE has more money than the Title II industry.
- The DOE is motivated more by schedules than by cost.

One final possible reason for perceived differences between Title I and Title II sites is that most of the Title II sites are dealt with by the NRC Denver office, whereas many Title I sites are dealt with by the Washington group of the NRC. It is generally acknowledged on the UMTRA Project that there are differences in approach and perspective between the Denver and Washington NRC offices. The latter is best described as conservative but innovative, with an Eastern perspective; the former is traditional but bold, with a Western perspective.

In theory and in practice there should be no differences. The problems are the same, the regulations that affect technical approaches are essentially similar, and responsibility for all sites may ultimately pass to the federal government.

The inconsistencies that are apparent result in what appears to Title II owners as excessive and inefficient closure plans at Title I sites. While specific conditions differ at all sites and require different technical approaches, I believe that site conditions alone cannot account for all the perceived and actual differences in remediation approaches.

I believe that the differences arise from a blending of many factors: regulations, government versus private sector perspectives, perceived regulatory treatment, permissible schedules, available funding, consultant initiatives, and general public perception, demands, and involvement.

I acknowledge that there may indeed be no such thing as a single objective reality in remediating or closing uranium mill tailings piles. It may be that it is all in the frame of reference--the particular client, the understanding and interpretation of regulatory requirements, and the implications for final site licensing and transfer.

To avoid future problems, expense, and possible legal action, I believe that the causes of the differences should be fully explored and documented, and those that are not justified

should be removed, avoided, or alleviated. This paper has done no more than point to the situation. I have not fully defined it, and I certainly have not solved it. I hope, however, that this first attempt will lead to productive discussion and a serious effort to clarify and avoid future difficulties.

CONCLUSIONS

Both the Title I and the Title II programs are moving to stabilize uranium mill tailings piles and clean up groundwater contaminated by past activities. Both programs can point proudly to progress and success: piles have been and are being stabilized and groundwater protection is being addressed.

The very act of successful pile remediation has brought into clearer focus the similarities and the differences in technical approaches adopted in the two programs. All concerned agree that there are differences; none concur on the source or cause of the differences.

This paper has attempted to document aspects of the current state of uranium mill tailings pile remediation. I have tried to establish a basis for further discussion and elucidation of questions that arise. I hope that my attempt is viewed for what it is: a bona fide attempt to improve and progress through fact and understanding.

Reviewing the aims I set myself in the introduction, I may conclude thus:

- Those in the Title II industry believe the extreme conservatism and expense of Title I designs are unnecessary and unwarranted.
- The Title I program believes that its conservative designs are a direct result of the governing standards and the demands of the regulations, and the realities of a program with a legally mandated end date.
- The major justifiable design difference is the approach to erosion control based on site-specific conditions. The justification is the presence of clean fill dikes and a greater reliance on vegetation control. (The NRC's recently published Staff Technical Position on surface stabilization provides specific guidance for determining acceptable surface stability.)
- One major reason for differences may be that 50 percent of Title I piles are to be relocated, while no Title II piles are being relocated.
- Another major reason for differences may be that Title I remediation involves demonstration of simultaneous compliance with stability and groundwater protection standards, whereas to date the Title II facilities have been designed only for surface stability; consideration of groundwater protection has been postponed to the future, and hence infiltration control is not a cover requirement for Title II piles.

I happily acknowledge that consultants, such as myself and those who work for the Title II owners, may have differences in our philosophies, attitudes, and approaches. While different, I believe all are professional in their honest, competent advice to clients who are attempting to comply with regulations and regulators who are as human as we are, and who all are genuine in their desire to protect human health and the environment.

ACKNOWLEDGEMENTS

First, I wish to acknowledge the capable way Susan Hammermeister has compiled this paper from many untidy and conflicting manuscripts. Her patience as I edited and re-edited in an attempt to produce text acceptable to the different perspectives of the many who reviewed and commented on this paper was admirable. Denise Bierley has provided insightful and helpful ideas and comments on the many versions of this paper, and I thank her for her enthusiastic input. Finally, I must acknowledge my many colleagues in the DOE, the NRC, the TAC, and the RAC, who have helped me frame and understand the issues. We are all working towards a common (but disputed) goal of environmental protection and improvement, and their input to this paper is further proof of their ideals.

REFERENCES

Albuquerque Tribune, 1990. "Push Turns to Shove," Page 1, Section D, Sunday, April 8, Albuquerque, New Mexico.

Anderson, L., 1990. Utah Department of Health, personal communication with J. Caldwell, Jacobs Engineering Group Inc.

DOE (U.S. Department of Energy), 1989a. "Technical Approach Document - Revision II," UMTRA-DOE/AL-050425.0002, prepared by the DOE UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1989b. "Regulatory Alternatives for Groundwater Compliance for the Department of Energy's UMTRA Project - Alternative Concentration Limits, Supplemental Standards, and Institutional Controls," prepared by the DOE UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

Miller, L.L. and L.A. Davis, 1986. "Hydrogeologic Aspects of Reclamation of the Ray Point Tailings Facility: A Case Study," Geotechnical and Geohydrological Aspects of Waste Management, Lewis Publishers, Inc., Michigan, pp. 299-310.

Morris, R.C. and L. Fraley, Jr., 1989. "Effects of Vegetation, a Clay Cap and Environmental Vegetables on ^{222}Rn Fluence Rate From Reclaimed U Mill Tailings, Health Physics, Vol. 56, No. 4, p. 431-440.

NRC (Nuclear Regulatory Commission), 1988. "Technical Position on Alternate Concentration Limits for Uranium Mills: Standard Format and Content Guide and Standard Review Plan for Alternate Concentration Limit Applications," Technical Branch Division of Low-Level Waste Management and Decommissioning Office of Nuclear Material Safety and Safeguards, June.

NRC (Nuclear Regulatory Commission), 1989. "Staff Technical Position: Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites," August.

Range, D.M., 1989. "Exxon Relocates Its Highland Uranium Tailings Basin in Wyoming," Mining Engineering, p. 831.

Shepherd and Abt, 1988. "A Comparison of Reclamation Plans at Title I and Title II Uranium Mill Tailings Sites," DOE Model Conference, Oak Ridge, Tennessee, October 3-7.