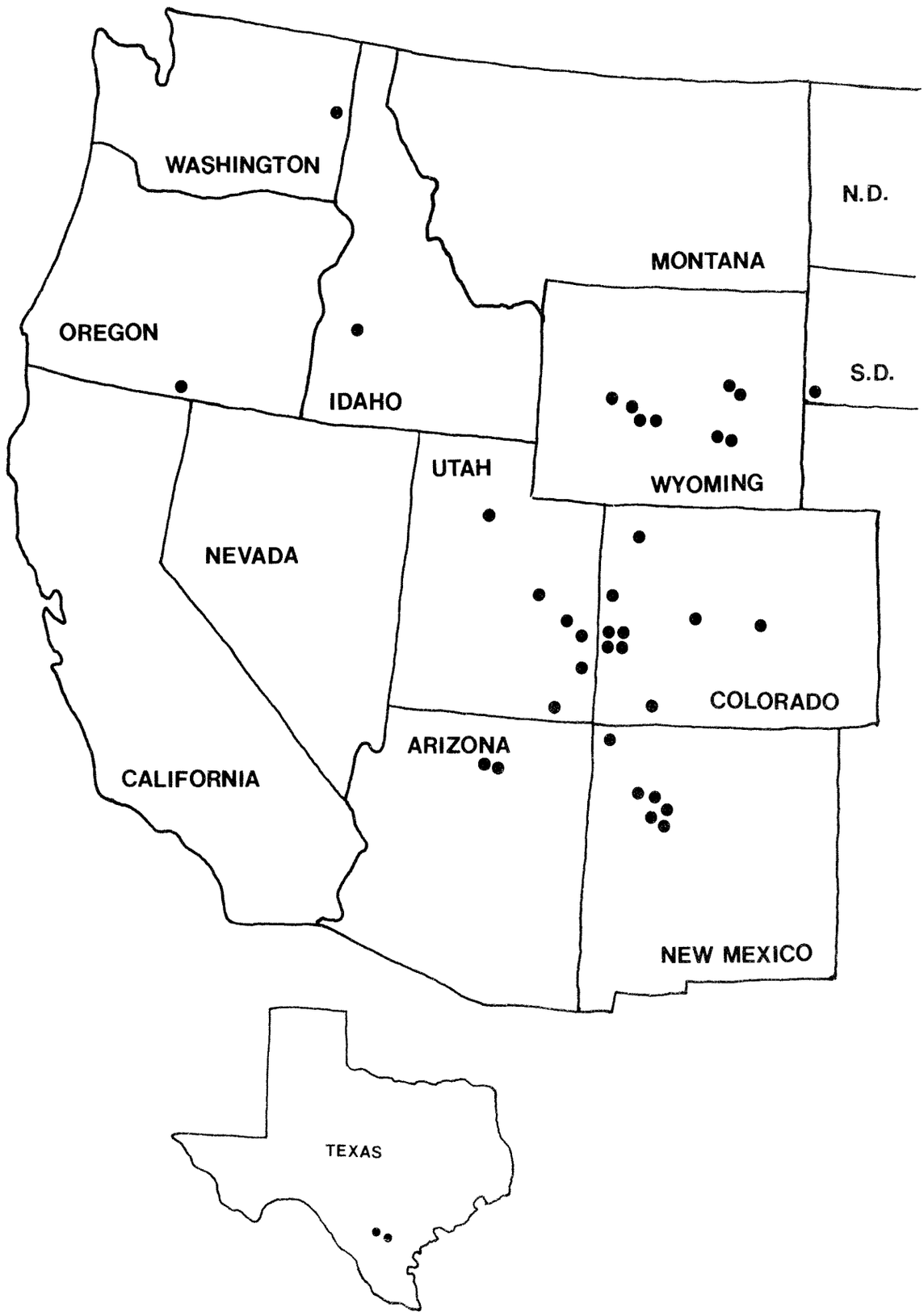
Policy Recommendations on Financing Stabilization, Perpetual Surveillance and Maintenance of Uranium Mill Tailings

APRIL 1977

WESTERN INTERSTATE NUCLEAR BOARD
Committee on Mining and Milling
of Nuclear Fuels

UNITED STATES
URANIUM MILL SITES



POLICY RECOMMENDATIONS RELATED TO THE FINANCING OF STABILIZATION AND PERPETUAL SURVEILLANCE AND MAINTENANCE OF URANIUM MILL TAILINGS

APRIL 1977

Western Interstate Nuclear Board
P.O. Box 15038
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WINB
Committee on Mining and Milling of Nuclear Fuels

FOREWORD

This report and its recommendations are the result of a one year study of alternatives for assuring financial responsibility on remedial actions for stabilizing and monitoring uranium mill tailings piles in the West.

The Western Interstate Nuclear Board Committee on Mining and Milling of Nuclear Fuels benefited significantly from the advice and suggestions of representatives of state governments, federal agencies, uranium milling firms, academic institutions and environmental organizations.

The committee gratefully acknowledges the assistance of many persons including attendees at the two day conference on the subject at Snowbird, Utah, in November, 1975. The assistance of the Rocky Mountain Institute for Policy Research, co-sponsor of the conference, is appreciated.

This report was prepared to help develop appropriate arrangements for financing the stabilization, maintenance and other remedial actions for uranium mill tailings control. It is respectfully submitted.

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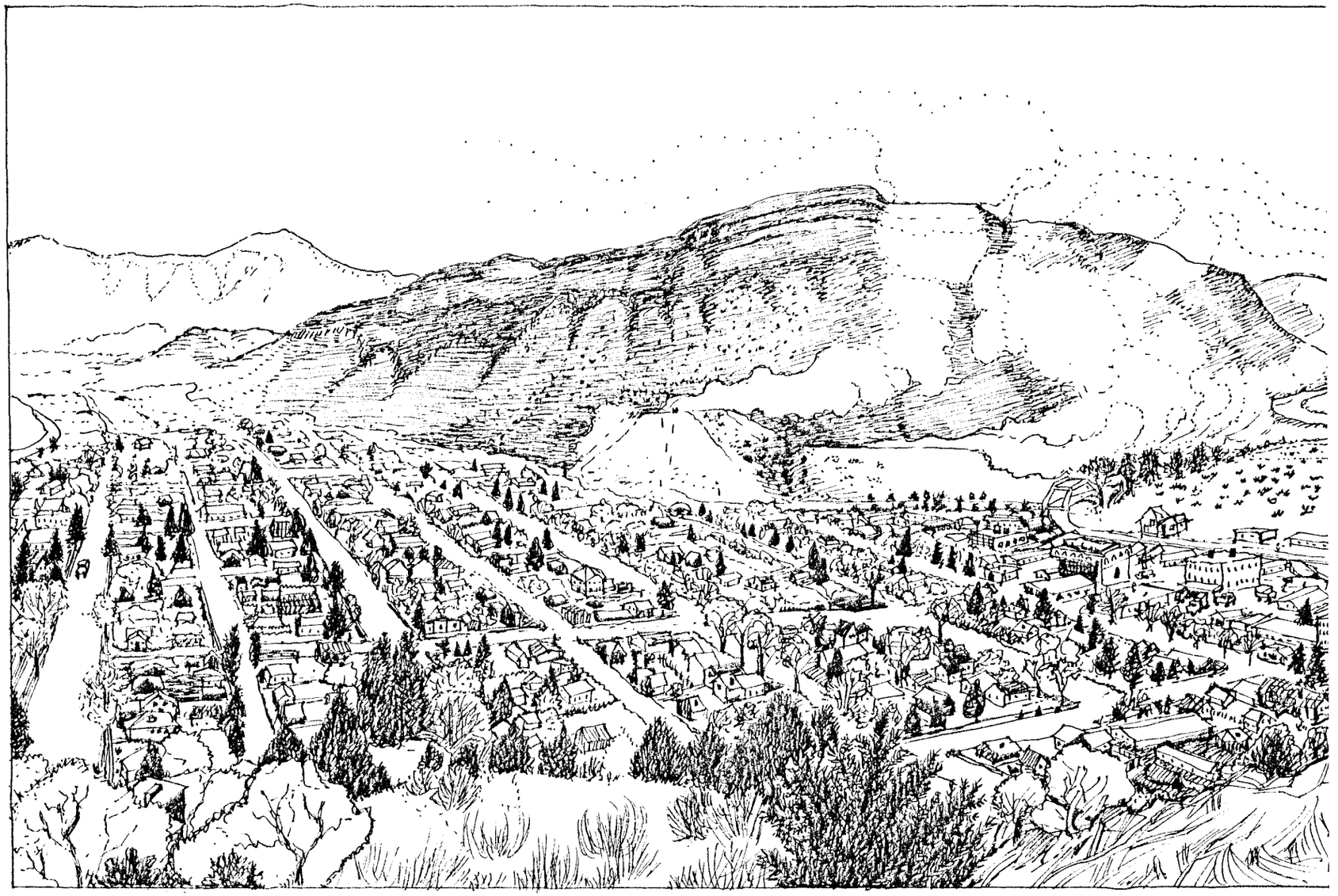

WIND CIRCULATES URANIUM MILL TAILINGS AT DURANGO, COLORADO, 1974
DRAWING BY KARA LANG FROM U.S. ENVIRONMENTAL PROTECTION AGENCY PHOTO

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INTRODUCTION

On September 30, 1975, the Western Interstate Nuclear Board (WINB) issued a policy statement concerning uranium mill tailings. It urged, in part:

> "An independent study (should) be conducted, in the immediate future, of alternative methods of financing the costs associated with remedial and perpetual maintenance and surveillance measures for uranium mill tailings piles. Such alternatives may include (but not necessarily be limited to) severance taxes, performance or surety bonds, or various combinations of these. The proposed study would provide guidence to state and federal policy makers."

After discussions with state and federal regulatory agencies, industry representatives and other concerned groups, the WINB Committee on Mining and Milling of Nuclear Fuels initiated a study of feasible alternatives for financing appropriate remedial actions for uranium mill tailings piles.

The committee retained Dr. Gerald J. Boyle, Professor of Economics, University of New Mexico, a fiscal and taxation policy consultant, to assist in evaluating various financing arrangements.

Study Objectives

The principal objective of the study is to determine appropriate methods of financial responsibility for stabilization and perpetual maintenance of uranium mill tailings as a means of reducing potential radiation exposure.

Long term financial responsibility needs to be assured in the event of non compliance or insolvency by a licensed uranium mill operator and the subsequent assumption of responsibilities for remedial actions and monitoring by government agencies.

Policy Recommendations

The committee's work was presented to the Western Interstate Nuclear Board on October 15, 1976. The board recommended it to states which have had or will have uranium milling activity. The policy statement is cited in Appendix I of this report.

SUMMARY

The concern about radioactive uranium mill tailings is two fold: One, the radioactivity itself; and two, the vast volume of material.

There are about 134 million tons of uranium mill tailings in the West. They are at 23 inactive sites, near 16 operating mills and adjacent to three standby facilities. Some projections on existing and anticipated additional milling operations predict the volume of wastes will increase six to eight times the present level by 1990.

The cost of stabilization is estimated to approach $1 billion.

The problem of decommissioning the tailings piles and rehabilitating them has been and remains a serious one with costs ranging from $510 per acre to $14,000 per acre and up. Each site has specific characteristics and requirements. One of the most formidable and pressing challenges is the Vitro site in the midst of metropolitan Salt Lake City. It has an estimated stabilization cost nearing $2 million for some 120 acres.(8)

Since only about five pounds of each 2,000 pounds of ore that is mined becomes uranium concentrate (yellowcake) and the market for it is expected to increase substantially, and the grade of ore may decline in many cases, the sheer volume of material to be managed is in itself a herculean task.

The potentially dangerous nature of long-lived radioactive Thorium-230 and its progeny, notably Radon-222, and other toxic, non radioactive materials, is such that they should not be allowed to be dispersed in the environment.

Under present and future milling license agreements and regulations, the industry is expected to internalize the costs of tailings management. When put on the basis of their relationship to the selling price of a uranium mill's yellowcake product, the costs of stabilizing, rehabilitating and monitoring tailings represent about 1½ per cent to 6 per cent of current contract selling prices ($6 to $40 per pound).

Presently it is uncertain who has the responsibility to perpetually maintain a stabilized uranium mill tailings pile. In the past some firms have

abandoned potentially hazardous waste dumps. Other, more responsible companies have stabilized the tailings and periodically surveyed the sites and maintained their physical integrity.

Inasmuch as the half-lives of the radionuclides in the tailings are on the order of thousands of years, perpetual government ownership, surveillance and maintenance of these waste sites appears to be the most viable approach to protecting the health and welfare of citizens. If this course of action is to be taken, revenues to offset the anticipated government costs should be obtained through some equitable revenue-generating mechanism.

RECOMMENDATIONS

Based on the work of the WINB committee, the following policy recommendations are made. They should be considered for adoption by states with uranium milling operations. It is recommended:

1. An adequate plan for reclamation and disposal of tailings be required as a condition of licensing a uranium mill, with the licensing agency responsible for assuring the compliance by operators during operation of the mill and at shut-down.
2. Short-term decommissioning requirements such as contouring, covering, and stabilizing the pile and fencing site, be the responsibility of the mill operator to be guaranteed by:
   ---a tax or fee per ton of ore processed so as to generate an adequate escrow account over lifetime of the mill; or
   ---a performance bond maintained in the amount necessary to comply with the above criteria.
3. Long-term financial requirements for maintenance and surveillance of the stabilized pile by the responsible agency be assured through accumulation of an annuity by a separate tax, or fee, per ton of ore processed.
4. Provision be made in licensing agreements for transferring ownership of final disposal site, with all mineral rights, to the government agency responsible for maintaing the stabilized tailings pile. This is necessary because of the long-lived radionuclides in uranium tailings piles.

5. A price index be established suitable for adjusting the taxes, fees or bonds in order to maintain the purchasing power parity of the financial requirements identified in the above recommendations.

DERIVATION OF URANIUM MILL TAILINGS

Uranium's Role in the Nuclear Fuel Cycle

The sequential steps in processing uranium ore into uranium fuel, and the recycling steps in extracting useable uranium and plutonium from irradiate reactor fuel are shown in "The Nuclear Fuel Cycle", Figure 1. Uranium ore is beneficiated into "yellowcake" (equivalent U_3O_8), in which impurities are removed. "Yellowcake" is shipped to a uranium conversion plant to be converted into uranium hexafluoride (UF_6). This step is a prerequisite to enriching the fuel into fissionable isotope U-235.

The UF_6 is transported to a uranium enrichment facility in which the U-235 and U-238 isotopes are separated using the gaseous diffusion process. Natural uranium contains only 0.7 per cent U-235. The remaining 99.3 per cent is primarily U-238. Light water nuclear power plants require enriched fuel with at least 2 per cent to 4 per cent U-235. (By contrast, nuclear weapons require U-235 content to be well above 90 per cent.)

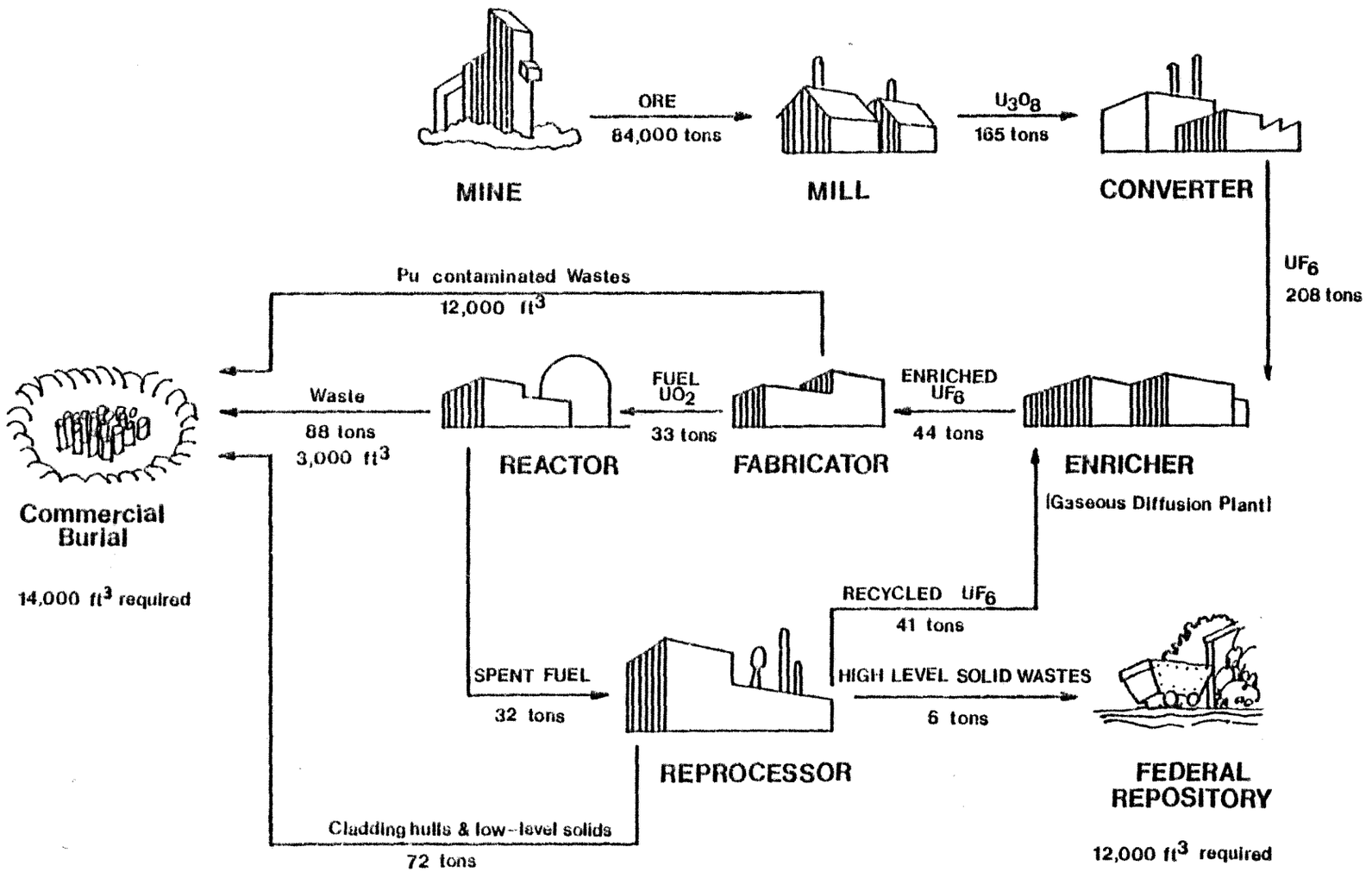
The enriched material is converted into the metallic oxide form, UO_2, from which it is fabricated into the hundreds of fuel rods and assemblies which, with various control mechanisms, comprise the "core" of a nuclear reactor.

After irradiation in the reactor for periods of one to three years, the "spent" nuclear fuel is removed. After temporary storage in the reactor's spent fuel pool to allow heat and radioactivity to decay to lower levels, the fuel rods are shipped to a nuclear spent fuels reprocessing plant.

Reprocessing extracts and separates uranium, "bred" plutonium, and other useable isotopes for recycling into replacement fuel and other uses. Other radioactive fission products --"radwastes"-- are extracted for storage and disposal. (1)

FIGURE 1

NUCLEAR FUEL CYCLE



Uranium Milling

Most uranium mines produce an ore which is from 0.1 to 2 per cent uranium (U_3O_8). Future operations will process ores of much lower grade, possibly as low as 0.05 per cent U_3O_8. Natural uranium is, by weight, 99 percent U-238 which has a decay schedule known as the uranium-radium series. The major radioactive materials (daughter products of uranium and radium) are shown in Figure 2.

Milling Processes

Milling processes vary somewhat, depending upon the nature of the ore. Generally ore received at a mill is crushed in a series of jaw-crushers. Crushing is followed by wet grinding in rod or ball mills until the ore is similar to fine sand. The resulting slurry is pumped into leaching tanks, where, depending on the composition of the ore, either acid or alkaline solutions are added to dissolve the uranium. The uranium, in powder form, is packaged and shipped in large metal drums. The product is referred to as "yellowcake". Figure 3 describes a typical mill process flow diagram.

Mill Tailings

Various procedures are used in the separation and recovery of dissolved uranium, for disposition of the waste liquors and the spent ore residues -- tailings. Common practice is to suspend the tailings in the liquors and to pump the slurry to tailings dumps located alongside the mill.

The liquor ultimately evaporates or seeps into the ground. In a few cases it has been allowed to flow into natural waterways at a controlled rate dictated by applicable regulations. The sand-like material containing the radioactive daughter products of uranium comprises the tailings pile.

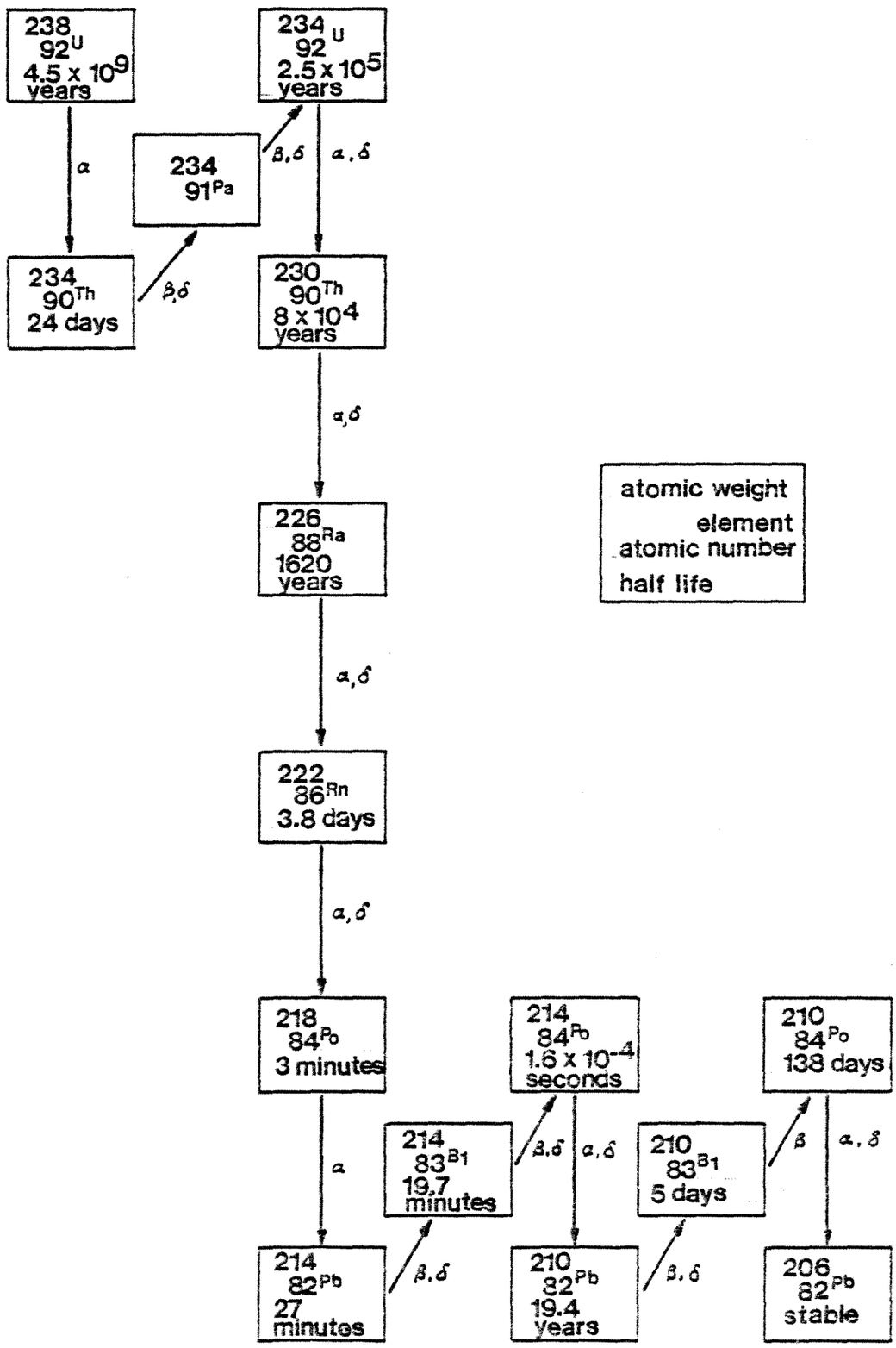
The magnitude of tailings piles can be realized by observing that less than five pounds of uranium, and in some cases a relatively small amount of vanadium, are removed from each ton of ore processed. The remainder becomes a tailings pile.[2]

Magnitude of Uranium Tailings Piles [3,4]

For purposes of this study, uranium mill tailings piles are divided int two classes: inactive and active.

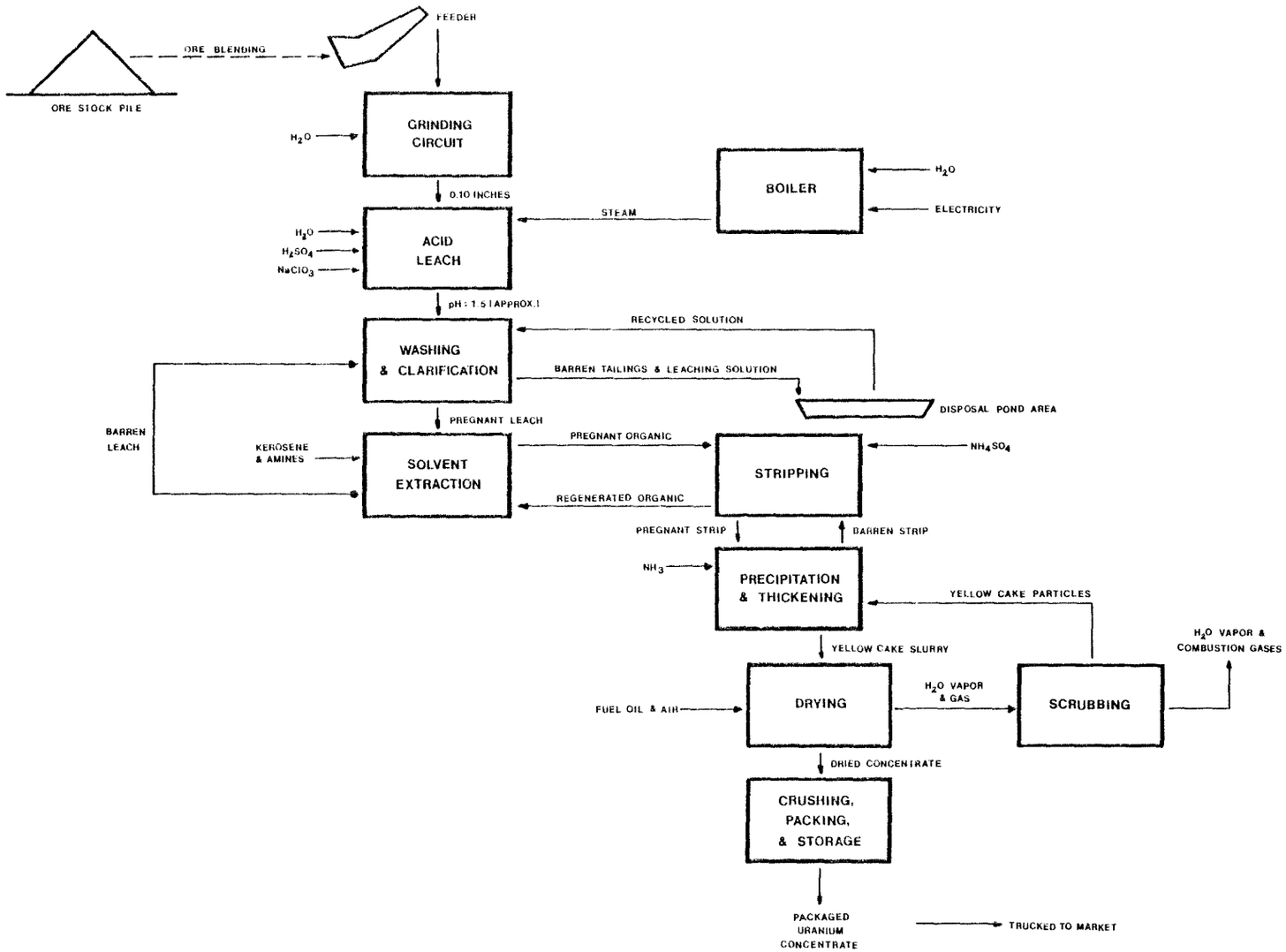
FIGURE 2

URANIUM - 238 DECAY SERIES



MAJOR DECAY PRODUCTS of THE NATURAL URANIUM-RADIUM SERIES

FIGURE 3


ORE BLENDING
FEEDER
ORE STOCK PILE
H_2O
GRINDING CIRCUIT
0.10 INCHES
BOILER
H_2O
ELECTRICITY
STEAM
H_2O
H_2SO_4
$NaClO_3$
ACID LEACH
pH : 1.5 (APPROX.)
RECYCLED SOLUTION
WASHING & CLARIFICATION
BARREN TAILINGS & LEACHING SOLUTION
DISPOSAL POND AREA
PREGNANT LEACH
BARREN LEACH
KEROSENE & AMINES
SOLVENT EXTRACTION
PREGNANT ORGANIC
REGENERATED ORGANIC
STRIPPING
NH_4SO_4
PREGNANT STRIP
BARREN STRIP
NH_3
PRECIPITATION & THICKENING
YELLOW CAKE PARTICLES
YELLOW CAKE SLURRY
H_2O VAPOR & COMBUSTION GASES
FUEL OIL & AIR
DRYING
H_2O VAPOR & GAS
SCRUBBING
DRIED CONCENTRATE
CRUSHING, PACKING, & STORAGE
PACKAGED URANIUM CONCENTRATE
TRUCKED TO MARKET

Inactive Tailings Piles

In January, 1977, at 23 sites in the western United States, the uranium mills have been shut down, decommissioned, or dismantled. At the sites are about 24 million tons of tailings.

A survey is being conducted by the engineering firm of Ford, Bacon and Davis Utah, under the auspices of the federal Energy Research and Development Administration (ERDA), to ascertain the magnitude of the inactive tailings problem and to develop alternative solutions including cost estimates.

Active Tailings Piles

There are 16 conventional uranium mills operating in the U.S. with a combined nominal capacity of 28,450 tons of ore per day. During 1975 these mills operated at about 80 per cent capacity. As of January, 1977, the total amount of tailings at these mills was estimated 100 million tons. A standby mill is functional and can become operational in a short time.

In addition, there are 3 non-operating mills which are on a standby status. Piles at these sites contain about 9.1 million tons of tailings. The anticipated lifetime of currently operating mills ranges from 10 to 30 years. Active and standby mills are listed in Appendix III.

New Mills and Tailings

It is projected that by the year 2000, between 68 and 216 new uranium mills will be required. The volume of tailings accumulated by the year 2000 is estimated to be a billion or more tons (at least 10 times the existing inventory at operating mill sites). This is in addition to the inventory at presently inactive mill sites. Other kinds of uranium wastes can be expected as emerging technologies are perfected. Solution mining, for example, will probably call for reinjection of liquid wastes.

Tailings Acreage

The total area of tailings at active, inactive, and standby sites is about 3021 acres. This calculation does not include surrounding land which is contaminated by wind or water-eroded tailings. The above data and the data for typical active sites is summarized in Table 1.

TABLE 1

URANIUM MILL TAILINGS

January 1977

Acres of tailings (Total U. S.)

Active	2035
Standby	180
Inactive	806
	3021

Inactive $\frac{2.4 \times 10^7 \text{ tons}}{806 \text{ acres}} = 2.98 \times 10^4$ tons/acres (average)

Active $\frac{1.00 \times 10^8 \text{ tons}}{2035} = 4.91 \times 10^4$ tons/acres (average)

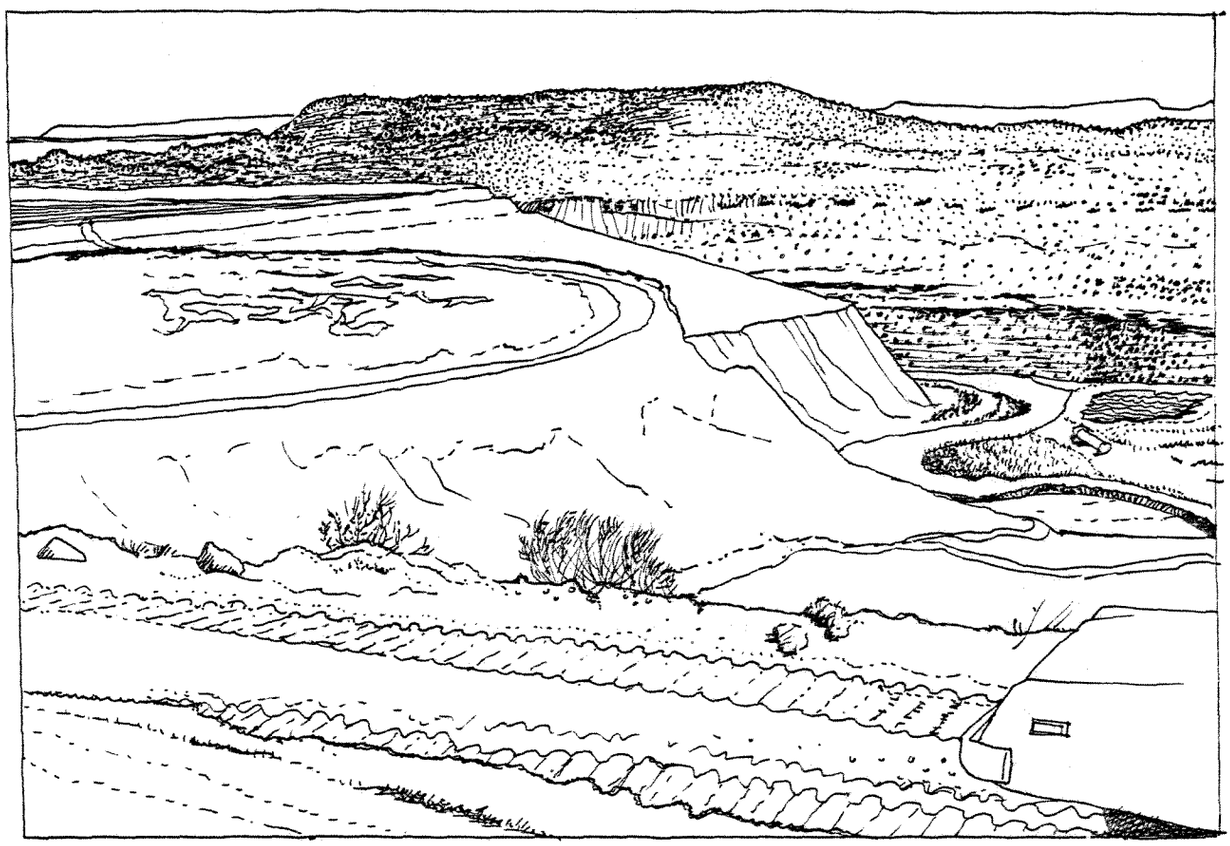
Standby $\frac{9.1 \times 10^6 \text{ tons}}{180} = 5.06 \times 10^4$ tons/acres (average)

4.41×10^4 tons/acres (average)

Typical Active Sites:

Kerr McGee
Grants, New Mexico
$\frac{25 \times 10^6 \text{ tons}}{200 \text{ acres}} = 1.25 \times 10^5$ tons/acre

Homestake
& United Nuclear
Grants, New Mexico
(75 ft. high)
$\frac{19 \times 10^6 \text{ tons}}{150 \text{ acres}} = 1.27 \times 10^5$ tons/acre



Uranium mill tailings near Uravan, Colorado, provide an indication of the volume of material to be stabilized. Drawing by Kara Lang from photograph provided by U.S. Environmental Protection Agency.

PROBLEMS ASSOCIATED WITH IMPROPER HANDLING AND DISPOSITION OF URANIUM MILL TAILINGS PILES

Principal Radionuclides

Uranium mill tailings piles contain a small amount of residual uranium and most of the products of the radioactive decay of the element. The principal radionuclides of concern, in order of their appearance in the decay chain, are Thorium-230, Radium-226, Radon-222, Polonium-218, Lead-214, Bismuth-214, Polonium-214 and Polonium-210.

Tailings contain elevated levels of some non-radioactive toxic metals, such as selenium, and chemical contaminants such as nitrates and sulfates.

Potential Contaminants

Uranium mill tailings piles release radioactivity into the air as radon gas and as particulates when winds blowing over the pile lift the material into the air. Radioactivity may be leached from the pile into surface and ground water.

Sufficient radioactivity is in the tailings to create a field of gamma radiation in the vicinity of the tailings. Because of the presence of Thorium-230 in the tailings, which by its decay maintains the radium inventory, the radioactivity in the pile can remain almost constant for thousands of years.

Toxic metals and chemicals from the piles can be transported by wind and water. The scope of these problems and remedial actions required for their control vary with each site.

Most Significant Exposure Pathway

The most significant radiation exposure pathway is believed to be Radon-222. Radium-226 in the pile decays by alpha particle emission and becomes Radon-222, a radioactive noble gas. The Radon-222 gas which is released into the spaces between the grains of tailings material diffuses toward the tailings pile surface; some reaches the surface and some undergoes radioactive decay enroute. Radon-222 which reaches the surface escapes into the ambient air.

The wind dilutes Radon-222 concentrations. Persons within about one

mile downwind of the tailings pile are exposed to some level of Radon-222 (half life, 3.8 days) and its particulate radioactive decay products. The air that enters a building downwind remains inside it for a period of time, depending on the ventilation rate, i.e., on the rate at which air enters and leaves the building. Radon-222 in the air undergoes its normal rate of radioactive decay, forming a series of decay products which may be inhaled by persons in the building. Some of the radioactive daughters of Radon-222 are retained in the tracheo-bronchial region and lungs, irradiating the fluids and tissues, increasing the risk of cancer there.

In contrast, persons outdoors who are exposed to the same Radon-222 concentration from a nearby tailings pile may receive an exposure to the lungs from the radon decay products which is appreciably smaller (e.g., a factor of 10) than that received indoors, due to the lack of a delay time which permits daughter product build-up in a confined area.

Other Exposure Pathways

Another pathway for exposure to radiation and toxic materials results when the wind lifts particles from the tailings pile and carries them downwind. Inhalation of the particles leads to radiation exposure in several ways, but it is believed that the principal effect occurs indirectly in the lymph nodes.

This results after the radioactive materials are inhaled and deposited in the alveoli (smallest air sacs of the lung). The submicron sized particles can be removed by solution and phagocytosis -- white blood cells move into the alveoli; absorb the particles and move into the lymph. The particles are deposited primarily in the lumph nodes.

The maximum dose and effect probably stems from lymph-node sites. Some particles may be ingested with mucus, and some may be absorbed into the blood stream with subsequent deposition in the liver and bone.

It is possible that indoor exposures by this pathway are smaller than those outdoors because filtration and sedimentation processes reduce the particle concentrations.

The third principal pathway for exposure to radiation from the tailings piles is that in which the radionuclides in the pile emit gamma radiation which may penetrate the overlying material and air to interact with the body tissues of persons on or near the tailings piles.

Depending on the availability and potability of ground or surface water at a particular site, the use of contaminated water may also become an exposure pathway for both radioactive and toxic materials.

Consumption of food crops grown on land contaminated by tailings, or consumption of animals grazing on such land can lead to indirect intake of radionuclides and toxic materials.

Control of Exposure

To minimize exposures to radioactive and toxic materials, access to the site and tailings piles should be controlled at all times, both before and after stabilization. Removal of tailings for general use by the public as was permitted at some sites in earlier years should be prohibited.

The site should be fenced and posted. After stabilization the site should be periodically inspected for erosion and breaks in its environmental protection barriers. Any damage (such as from wind or water erosion) should be promptly repaired.

COSTS OF CONTROLS

Costs associated with proper handling of uranium mill tailings fall into two categories:

1. Costs incurred during normal plant operation, such as the construction of a clay core dam retention system, chemical or other methods for control of windblown dust from the tailings pond beach, liners for tailings pond, etc.;
2. Costs incurred after plant shutdown, such as stabilization and long-term surveillance and maintenance.

It is expected the mill operator will absorb costs incurred after shutdown, which are the only costs considered here.

After mill shutdown, costs to be incurred fall into two categories: namely:

1. Short-term costs associated with tailings site decommissioning requirements, such as contouring, covering, and stabilizing the pile and fencing the site; and
2. Long term costs incident to the perpetual maintenance and surveillance of the stabilized pile.

Short-Term Costs

Several estimates have been made of the short-term costs associated with stabilization of tailings piles. For example, at the site at Monticello, Utah, the tailings pile involved considerable moving and contouring adding 12" to 24" of soil, and vegetative planting at a reported cost of $7,300 per acre.

Union Carbide has calculated its stabilization costs at $1,300 to $5,100 per acre for minimum soil cover of 6". Costs depend on contouring and grading, distance that soil, rock and rip rap must be hauled and other factors.

The "as low as possible" guides for milling of uranium ores prepared by Oak Ridge National Laboratory ORNL) for the Nuclear Regulatory Commission (NRC)[6] estimate tailings management costs of $510 per acre per foot of earth cover. A $3,000 per acre cost was given for a 12" layer of rock topping.

Arizona copper producers estimate a 12" cover costs about $1,600 per acre.[7]

Ford, Bacon and Davis Utah recently reported the 2.5 million tons of tailings at the 128 acre Vitro site in metropolitan Salt Lake City would cost $1.4 million to adequately stabilize.[8] The calculation includes about 200,000 tons of contaminated soils as well as tailings.

Several stabilization and/or disposal methods were considered. The costs ranged upward to nearly $40 million.

TABLE 2

ESTIMATED STABILIZATION COSTS FOR
URANIUM TAILINGS PILES

Estimator or Location of Tailings Pile	Cost per Acre	Cost per 100 acres
Union Carbide	$1,300 - 5,100	$130,000 - 510,000
N.R.D.C.[9]	3,000	300,000
Monticello, Utah	7,300	730,000
Ford, Bacon and Davis Utah (Vitro site)	11,406	1,140,000

Note: Existing stabilization techniques can be considered as only an interim control in view of the long half life of the radionuclides. (ANSI Standard N313-1974).

Long-Term Costs

The long-term costs associated with uranium tailings piles are related to the perpetual surveillance and maintenance of the pile. The long lived radionuclides require that such maintenance and surveillance continue indefinitely.

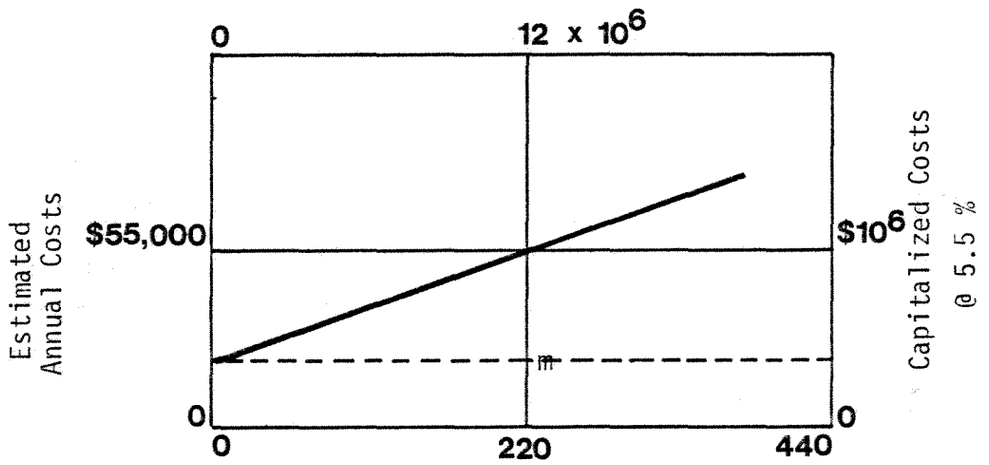
Monitoring of ground waters may be required three or four times per year along with surveillance for wind and water erosion. Maintenance to assure the integrity of the pile cover may include additional fill for eroded sections. Recontouring, reseeding, planting, repair to fences, signs, and other work may be necessary.

The combined annual costs for surveillance and maintenance would be about $55,000 per year (1976 dollars) for the tailings pile of a uranium mill which processed 2,000 tons of ore/day, 300 days per year, for 20 years, i.e., 12×10^6 tons (10.9×10^6 metric tons). This would require about $1,000,000 in an endowment fund at 5½ per cent interest to yield an annuity of $55,000 annually.

It is expected that the long-term costs would be made up of certain fixed and variable elements as shown in Figure 3 which is an illustration of the costs as estimated above.

FIGURE 3

Cost of Long Term Maintenance and Surveillance of Inactive Stabilized Uranium Mill Tailings Versus Size of Pile



FISCAL RESPONSIBILITIES ASSOCIATED WITH SHORT AND LONG-TERM COSTS

Short-Term Costs

The costs associated with short-term decommissioning requirements such as contouring, covering, and stabilizing the pile and fencing the site, have been estimated on page . Costs are expected to be borne by the uranium processor. To assure necessary financial resources are available upon plant shutdown, a guarantee performance bond or other appropriate financing mechanism should be a part of the mill operating license.

Several Options

If the performance bond option is preferred, then such a bond should be maintained in the amount necessary to complete prescribed decommissioning tasks.

One possible option other than a performance bond would be a tax or fee per ton of ore processed. This would be designed to generate an adequate escrow account over the lifetime of the mill. The accumulated amount would have to be equal to or greater than that required for decommissioning.

It may be feasible for the processor to select a mechanism compatible with his corporate income tax status.

Another alternative would be a mix of processing tax and performance bonding for new mills as well as active mills with large amounts of tailings. The tax or fee might be more appropriate for a new mill whereas a performance bond would be set at a level appropriate to each particular case.

Long-Term Costs

After plant shutdown and decommissioning, the mill operator/owner may wish to relinquish interest and responsibility for the mill tailings property. Past examples, such as we have with many of the 23 inactive tailings piles in the West, show this to be true.

The federal government disclaims any responsibility for long-term perpetual surveillance and maintenance of these piles, thus leaving it to the states.

The state has primary responsibility for the health and welfare of its

citizens. Therefore, the failure of the federal government to step in and assume such responsibility should not surprise the states. A recent survey of states with uranium mill tailings revealed some states have much to do.

The long-term financial requirements for maintenance and surveillance of the stabilized tailings pile were outlined on page . The uncertainty with financial estimates associated with stabilization is reflected in the fiscal recommendations associated with long-term surveillance and maintenance problems.

Transfer of Site Ownership

There are at least two alternatives relative to perpetual title to a privately-owned tailings pile site. One alternative is that it remain in private hands with the expectation that title to the property over a long period of time could possibly be transferred. This option lacks the required longevity of ownership for the assumed time span of "thousands of years". Few, if any, private entities would be expected to be in existence for such very long time periods.

The other alternative is to transfer title of the property, including all mineral rights, to the state, which has a greater expected longevity. Transfer of title to the state could occur before commencement of plant operations as well as later. Three of the states surveyed have land title transfer provisions.

Mechanisms for Funding

There are several options for paying long-term maintenance and surveillance costs. One option would be a state's general fund. This option could be the simplest administratively.

However the question of relative costs and benefits emerges. If it is possible to identify specific social costs related to a specific private or public entity, then those costs should be internalized by that entity. The costs would be passed on to the entity's direct beneficiaries.

Another option would be to establish a perpetual fund or endowment through the accumulation of an annuity from a tax or fee per ton of ore processed. This option addresse the issue of internalization of identifiable social costs. The perpetual fund would be expected to grow to the level

where, after all uranium in a state had been mined and milled, the fund would generate adequate interest to perpetually finance the expected long-term surveillance and maintenance costs associated with all of the uranium tailings in the state.

What about a mill which has operated fifteen or twenty years and soon will cease operations? A tax or fee based on production will not accumulate sufficient funds. This is not any different, however, from other production tax situations. Accumulated revenues have to be pooled and not designated to a particular site. Recognition that a mill might shutdown relatively soon would, however, have an influence on the overall tax or fee mill levy assessed.

What effect will such a tax or fee have on mill management operating under fixed price contracts? Can this assigned social cost be added to a contract price to pass it on to the ultimate primary beneficiary?

There is no pat answer to these questions; i.e., it depends upon many factors including whether or not the state will subsidize the industry. That, in effect, is what happens if tailings management costs are not internalized by the firm.

Allowance for Inflation

To offset inflation a price index is needed to adjust the taxes, fees, or bonds in order to maintain the purchasing power parity of the financial requirements previously identified.

STATE SUMMARIES

A telephone survey was conducted of the states with active and inactive uranium mills. The results of this survey are shown in Table 3. Several of the surveyed states are revising rules and regulations pertaining to uranium mills and mill tailings. That there are no regulations in a given state does not necessarily imply that the problem is being ignored. Most states indicated that regulations and policies are being studied. In some cases states are awaiting the results and recommendations of this WINB study.

TABLE 3

EXISTING STATE MILL TAILINGS REGULATIONS/POLICIES

State	Agreement State [a]	Mill Tailings Regulations	Stabilization Guarantees	Land Title Transfer Mechanism	Perpetua Maintenanc Provisions
Arizona	Yes	Yes	No	No	No
Colorado	Yes	Yes	Yes	Yes	Yes
Idaho	Yes	No	No	No	No
New Mexico	Yes	Yes	Yes	Yes	No
Oregon	Yes	Yes	No	Yes	Yes
South Dakota	No	Yes	No	No	No
Texas	Yes	No	Yes	No	No
Utah	No	Yes	Yes	No	No
Washington	Yes	Yes	No	No	No
Wyoming	No	Yes	Yes	No	No

[a] An agreement state has authority to issue uranium mill licenses. Mills in non agreement states are licensed by the Nuclear Regulatory Commission.

ARIZONA

A. Regulations: Regulations pertaining to mill tailings are in Chapter 4, Title 30, Arizona Revised Statutes. They require mill tailings must meet Arizona Atomic Energy Commission standards.

B. Stabilization Guarantees: None.

C. Land Title Transfer: No regulations.

D. Perpetual Maintenance: No regulations.

E. Mills and Tailings: There are no active uranium mills in Arizona. There are two abandoned mill tailings piles on the Navajo Indian Reservation. The state does not have jurisdiction over them.

COLORADO

A. Regulations: Regulations are Colorado Revised Statutes (1973) 25-11-104(2) and C.R.S. 25-11-103(7). They address commercial waste disposal sites. They are being reviewed for use in the uranium tailings pile situation. Parts 3 and 8 of the Colorado State Department of Health Radiation Control Regulations apply.

B. Stabilization Guarantees: Part VIII of rules and regulations pertaining to radiation control are in effect. They are being rewritten to comply with the American National Standard, ANSI, N313-1974, for "Stabilizations of Uranium-Thorium Milling Waste-Retention Systems".

C. Land Title Transfer: Colorado intends to adopt the regulatory language provided in Appendix C of the Task Force report on "Bonding and Perpetual Care of Licensed Nuclear Activities". The report was sponsored by the Executive Committee of the National Conference of Radiation Control Program Directors and the Nuclear Regulatory Commission NRC) and the Environmental Protection Agency (EPA).

D. Perpetual Maintenance: Same as C.

E. Mills and Tailings: Colorado has two active, eight inactive and one standby uranium mills.

NEW MEXICO

A. Regulations: Regulations for "Governing the Health and Environmental Aspects of Radiation," are enforced by the New Mexico Environmental Improvement Agency. Generally Parts 3-320j and 4-310 relate to commercial waste disposal and maintenance applicable to uranium mills and tailings.

B. Stabilization Guarantees: Part 3-320j specifies a performance bond be posted; the sum to be decided by the agency. The bond based on the half-life and activity of the radioactive material involved.

C. Land Title Transfer: Part 3-320j requires the process by which ownership will be ceded to the state or federal government after shutdown be specified when the mill is licensed.

D. Perpetual Maintenance: New regulations covering perpetual maintenance provisions are being formulated.

E. Mills and Tailings: New Mexico has four active and two inactive mills.

OREGON

A. Regulations: Regulations under Part I, Radiation Safety Requirements for Uranium and Thorium Mill Tailings are monitored and enforced by the Oregon Department of Human Resources Health Division, Radiation Control Section. They set requirements for maintenance and stabilization of mill tailings.

B. Stabilization Guarantees: None.

C. Land Title Transfer: The state agrees with the mill operator for the transfer of land title when the mill is shutdown. Oregon's only uranium mill is shutdown and the land title transfer is being processed.

D. Perpetual Maintenance: The state will have perpetual maintenance responsibilities as a result of the agreement with the mill operator.

E. Mills and Tailings: Same as D.

SOUTH DAKOTA

A. Regulations: State Radiation Safety regulations require approval from the State Department of Health prior to disposal of radioactive materials.

B. Stabilization Guarantees: Stabilization is required, but there are performance guarantees.

C. Land Title Transfer: No regulations.

D. Perpetual Maintenance: No regulations.

E. Mills and Tailings: One non operating mill recently was purchased by the Tennessee Valley Authority (TVA). The mill is to be operable at an undetermined date. The mill is about a half mile from Edgemont.

TEXAS

A. Regulations: None.

B. Stabilization Guarantees: A tailings stabilization performance bond is necessary to obtain a mill operating license from the State Water Quality Board and the State Radiation Control Agency. The Radiation Control Agency periodically inspects mill tailings ponds to assure proper maintenance.

C. Land Title Transfer: No regulations.

D. Perpetual Maintenance: No regulations.

E. Mills and Tailings: There are one active and two inactive mill sites in Texas.

UTAH

A. Regulations: The only regulation governing uranium mill tailings is the Mined Land Reclamation Act which applies only to Mine-Mill Complexes and not to independent mills.

B. Stabilization Guarantees: A surety or performance bond is posted by the mill operator to guarantee stabilization of the tailings when a mill is shutdown. NRC requires new mills to write an environmental impact statement (EIS) before startup. It includes a plan for tailings stabilization when the mill shuts down. The EIS is applicable when an existing mill undergoes a major overhaul. An EIS was prepared for the recently renovated Atlas mill. At the urging of the state a tailings stabilization plan was prepared for when the mill will be shutdown permanently.

C. Land Title Transfer: No regulations.

D. Perpetual Maintenance: No regulations.

E. Mills and Tailings: There are two active mills and five inactive mill sites. The old Vitro Uranium Mill site in Salt Lake City has been chosen to establish a mechanism by which all abandoned tailings ponds will be reclaimed.

WASHINGTON

A. Regulations: New regulations are in effect governing the operations of active mills and for stabilization of mill tailings before and after shutdown.

B. Stabilization Guarantees: Provisions are in the process of being adopted and will be in effect soon. The State Radiation Control Unit has determined specific requirements to be met by a mill operator and makes them part of the licensing requirements.

C. Lane Title Transfer: No regulations

D. Perpetual Maintenance: No regulations.

E. Mills and Tailings: There are two mills operating. One mill planned.

WYOMING

A. Regulations: The State Department of Environmental Quality, under the Environmental Quality Act of 1973 and a 1975 amendment, is the principal state agency with administrative responsibilities in uranium mill operations.

B. Stabilization Guarantees: The Department requires a stabilization bond from a mill operator for licensing by the NRC. This is handled on a case by case basis because there are no specific state regulations. The NRC has responsibilities for all control activities involving uranium mills in Wyoming.

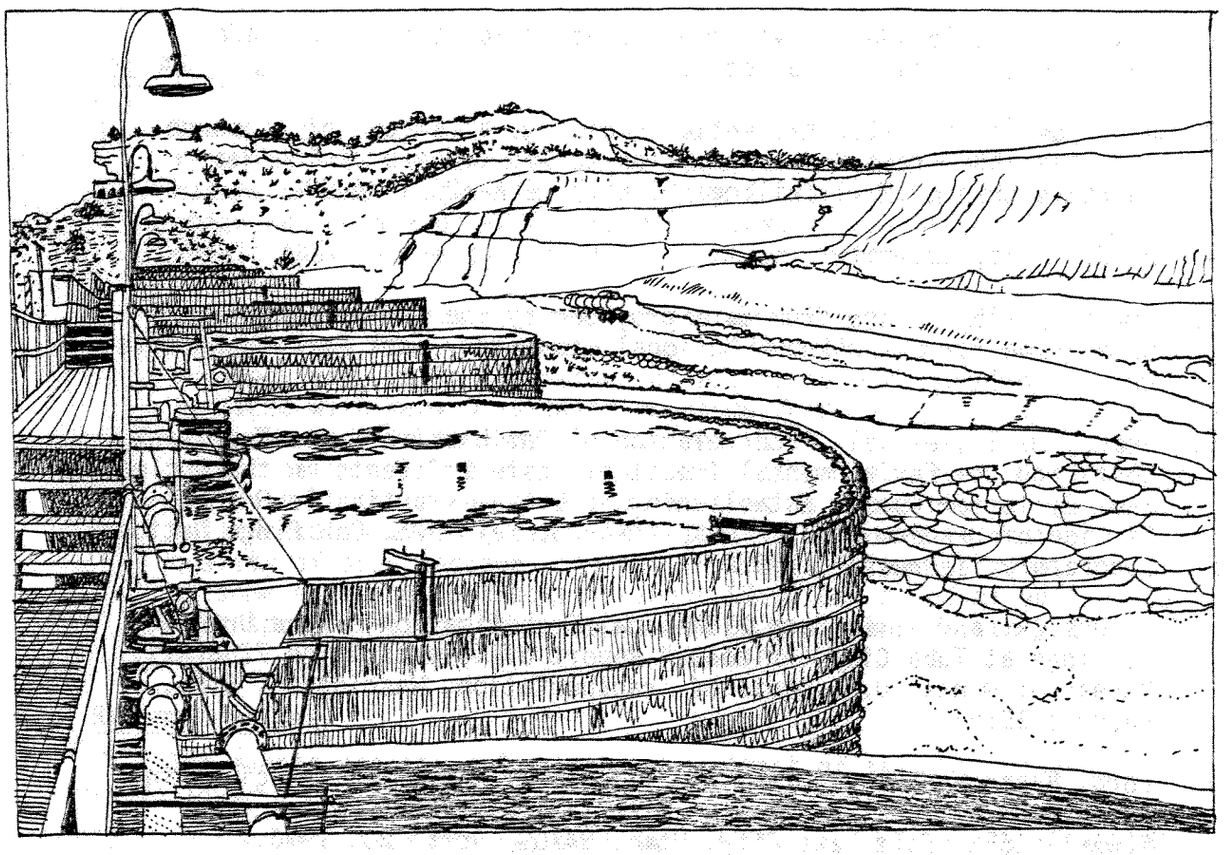
C. Land Title Transfer: No regulations.

D. Perpetual Maintenance: No regulations. It is assumed the mill operator has responsibility for perpetual maintenance.

E. Mills and Tailings: There are six active, two inactive and one standby mills.

FUTURE REGULATIONS

Most states, with the possible exception of Colorado, are in need of additional regulations governing the operation and maintenance of uranium-thorium mills and the stabilization and perpetual maintenance of mill tailings. It is hoped most states are cognizant of the need and are actively engaged in formulating regulations which meet existing and foreseeable needs.



Uranium mill tailings (center, right background) adjacent to a mill near Uravan, Colorado, remain to be stabilized. Drawing by Kara Lang from 1976 U.S. Environmental Protection Agency photo.

REFERENCES

1. Nuclear Power & Uranium Fuel Requirements in the Western U.S.- WINB, October, 1975.

2. N-Wastes & Colorado's Environment (Second Edition) - Colorado Department of Health, August 1971.

3. J. J. Swift, et. al., "Potential Radiological Impact of Airborne Releases and Direct Gamma Radiation to Individuals Living Near Inactive Uranium Mill Tailings Piles." EPA-520/1-76-001.

4. J. J. Swift, op. cit.

5. EPA-520/1-76-001 and from data provided by the Nuclear Regulatory Commission for the Argonne National Laboratory Task Force on Active Uranium Mills.

6. Sears, M. B., et. al., "Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing As Law as Practicable Guides - Milling of Uranium Ores," ORNL-TM-4903, May 1975, Oak Ridge National Laboratory, Tennessee, 37830.

7. Havens, R. and K. C. Dean, "Chemical Stabilization of the Uranium Tailings at Tuba City, Arizona," Report of Investigation 7288(RI). Bureau of Mines, U.S. Dept. of Transportation, Washington, D.C., (August 1969).

8. Ford, Bacon and Davis Utah, Inc., "Phase II - Title I, Engineering Assessment of Inactive Uranium Mill Tailings, ERDA Contract No. E(05-1)-1658, Salt Lake City, Utah, 84108, April 30, 1976.

9. Havens, R. and K. C. Dean, op. cit.

10. Ford, Bacon and Davis Utah, Inc., op. cit.

11. "Task Force Report on Bonding and Perpetual Care of Licensed Nuclear Activities," April 5, 1976, Conference of Radiation Control Program Directors.

APPENDIX I

SUGGESTED METHODS FOR FINANCING THE STABILIZATION AND MAINTENANCE OF URANIUM MILL TAILINGS

A. The Problem

1. The concern with tailings from the uranium milling industry stems from the large amounts of these wastes, the potentially hazardous nature of the long-lived radioactive Thorium-230 and its progeny which includes Radon-222, and other toxic, non-radioactive materials should they become distributed in the environment.

2. The problem of decommissioning uranium mill sites has been and will be a serious one. Currently, about 125 million tons have been accumulated, and, while the future of nuclear electric power generation is faced with many uncertainties, some forecasts indicate a 6 to 8 fold increase in tailings by the year 1990. Cost estimates for stabilization and rehabilitation will be on the order of $1 billion. The cost of the recommended reclamation is about 60¢ per pound of yellowcake in 1975 prices. This cost is expected to increase as the quality of ores decline. To put this cost in perspective, the price on some existing contracts is about $9.00 per pound of yellowcake with spot prices reaching about $40.00 per pound in early 1976.

B. Recommendations

The events necessary for proper treatment of tailings piles are as follows:

1. An adequate plan for reclamation and disposal of tailings should be required as a condition of licensing the mill, with the licensing agency responsible for assuring the compliance by operators during the lifetime of the mill and at shut-down.

2. Short-term decommissioning requirements such as contouring, covering, and stabilizing the pile and fencing site, are the responsibility of the mill operator and should be guaranteed by:

   - tax or fee per ton of ore processed to generate an adequate escrow account over lifetime of the mill; or

   - performance bond maintained in the amount necessary to complete the above events.

3. Long-term financial requirements for maintenance and surveillance of the stabilized pile by the responsible agency should be assured through accumulation of an annuity by tax or fee per ton of ore processed.

4. Provision should be made in licensing agreements for transferring ownership of final disposal site to government and its agency responsible for maintaining the stabilized tailings pile. This is necessary because of the long-lived radionuclides in the tailings piles.

   Identification or construction of a price index suitable for adjusting the taxes, fees or bonds in order to maintain the purchasing power parity of the financial requirements identified in B.2 and B.3 above.

   NOTE: The cost of decontamination and clean-up of the mill, mill site, and other properties contaminated by the mill operations are not included in the above recommendations.

Submitted by:

WINB Committee on Mining and Milling
of Nuclear Fuel

October 13, 1976

APPENDIX II

A task force of the Conference of Radiation Control Program Directors (CRCPD) issued a report on April 5, 1976, with recommendations directly related to the objective of this report. (11) Parts of that report are presented with permission of the CRCPD.

Each state should investigate with its own legal counsel which of the two following approaches is appropriate for requiring bonds and establishing perpetual care funding within the state.

I. States Where Existing Legislation Is Deemed Adequate

For those states where legal counsel deems that the existing legislation provides sufficient statutory authority for the requirements of bonds and establishing perpetual care funding, the following criteria should be met;

A. The legislation should provide sufficient authority to establish the bonding and perpetual care fund requirement.

B. The authority to establish bonds should be broad enough to require bonds of adequate types and amounts.

C. The authority to establish perpetual care funding should be broad enough to cover the amounts needed for long term maintenance and surveillance of the site.

D. The legislation should specify wnere the proceeds of forfeited bonds are to be deposited and how they can be used.

E. The legislation should state any exclusions or exemptions from bonding and perpetual care requirements which may be deemed appropriate (e.g., state and local agencies) and should have a provision that additional exemptions by types of licensees may be provided by the state regulatory agency.

Where the state deems that the existing legislation is appropriate and meets the criteria as stated above, its rules and regulations implementing the statutory authority should be amended and, as a minimum, provide for the following.

A. A definition of what constitutes an acceptable bond (this may be defined within the state statute).

B. An effective date of the rule or regulation allowing at least a 90-day period for implementation.

C. A specific description of how the forfeited funds may be used; e.g., cleanup of contaminated facilities, etc.

D. A mechanism for administering the bonding and perpetual care requirements for existing state licensees.

E. A requirement that the bond be issued and in the possession of the state regulatory authority at the time the license is issued.

F. A requirement that the perpetual care fund be established prior to the time the license is issued.

G. A requirement for the provision of adequate bonding by range of dollar amount and a statement that all exemptions may be based on possession limit, form or other category deemed appropriate.

Appendix C, "Proposed Changes to the Suggested State Regulations," contains an example of the language necessary to amend Section C.25 to include the above requirements.

II. States Where is is Deemed That Amendment of Existing Statutes is Necessary to Authorize Imposition of Bonding and Perpetual Care Funding Requirements for Licensees

All of the criteria for legislation and provisions that should be incorporated in the state rules and regulations, as discussed in the previous section, should be followed in conjunction with the enactment of amendment of existing state statutes to authorize bonding. Suggested language for such amendatory legislation is contained in Appendix D "Suggested Legislation for Licensee Bonding and Perpetual Care Trust Funds."

III. Other Considerations

In addition to the legislative authority necessary to establish bonds and trust funds, each state regulatory agency should determine clearly what constitutes a legal bond or trust fund within the state. In the case of establishment of trust funds, the ownership of the land must be clearly defined. It is the Task Force's opinion that although bonds should be required of most specific licensees, trust funds for perpetual care are only necessary for waste handling licensees and ore refinery activities where tailings piles are generated. However, it was also considered that trust funds for perpetual care should probably be established for any former NRC licensed facility when it is decommissioned and when there is a likelihood that it will become a permanent disposal site as opposed to total dismantling of the facility or

decontamination. Most states already have requirements for trust funds for waste handling sites, but these are all located on state owned property. In the case of ore refinery sites and former NRC licensed facilities, they are normally located on private property and thus the problem of ownership of the land must be clearly resolved.

APPENDIX D
SUGGESTED LEGISLATION FOR LICENSEE BONDING AND PERPETUAL CARE TRUST FUNDS

Section _____, Bonds

(a) The (Director of the Agency) or his duly authorized representative shall require the posting of a bond by licensees to provide funds in the event of abandonment, default, or other inability of the licensee to meet the requirements of the (Agency). The (Agency) is hereby authorized to establish bonding requirements by classes of licensee and by range of monetary amounts. In establishing such requirements, the (Agency) shall give consideration to the potential for contamination, injury, cost of disposal, and reclamation of the property.

(b) All bonds forfeited shall be paid to the (Director of the Agency) for deposit in a special fund by the (State Treasurer) called the (Radiation Reclamation Fund). All monies in such Fund are hereby appropriated and may be expended by (Director of the Agency) as necessary to assure the protection of the public health and safety. Monies in this fund shall not be used for normal operating expenses of the Agency.

(c) A bond deemed acceptable in (name of State) shall be a bond issued by a fidelity or surety company authorized to do business in (name of State), a personal bond secured by such collateral as the (Director of the Agency) deems satisfactory, a cash bond, or a letter of credit. (Acceptable bonds may be spelled out in existing State laws and this provision should be consistent with those laws.)

(d) All State, local, or other governmental agencies, or subdivisions thereof shall be exempt from the requirements of this Section_____.

The (Director of the Agency) is authorized to exempt classes of licensees from the requirements of this Section when a finding is made that such exemption will not result in a significant risk to the public health and safety.*

Section _____, Perpetual Care Trust Funds

(a) The (Director of the Agency) or his duly authorized representative shall require a licensee to deposit funds, on an (annual, semi-annual, or quarterly) basis, in a trust fund when it is deemed there is a reasonable possibility that the licensed activity may eventually cease to operate although still containing, or have associated with the site at which the licensed activity was conducted, radioactive material which will require maintenance, surveillance or other care on a continuing and perpetual basis.

(b) In order to provide for the proper care and surveillance o sites subject to paragraph (a) of this Section, the State may acquire by gift or transfer from another government agency or private person, any and all lands, building, and grounds necessary to fulfill the purposes of this Section. Any such gift or transfer is subject to approval and acceptance by the State.

(c) The (Department) may by lease or license with any person provide for the operation of a site subject to this Section for the purpose of carrying out the provisions of this Act. Any lessee or licensee, including all State, local, or other governmental agencies or subdivisions thereof, operating under the provisions of this paragraph (c) shall be subject to (Section_____, Bonds).

(d) The funds required by paragraph (a) of this Section shall be established at such rate that interest on the sum of all funds reasonably anticipated as payable shall provide an annual amount equal to the anticipated reasonable costs necessary to maintain, monitor and otherwise supervise and

*If a State constitutional problem exists, (Section C.25(e)(5) must be revised accordingly.

care for the lands and facilities as required in the interest of public health and safety. In arriving at the rate of funds to be deposited, the (Department) shall consider the nature of the licensed material, size and type of activity, estimated future receipts and estimated future expenses of maintenance, monitoring, and supervision.

(e) All funds accrued as interest monies deposited in the perpetual care trust fund are hereby appropriated and may be expended by the Director to monitor and maintain the site as required to protect the public health and safety on a continuing and perpetual basis.

(f) Recognizing the uncertainty of the existence of a person or corporation in perpetuity, and that ultimate responsibility to protect the public health and safety must be reposed in a solvent government, without regard to the existence of any particular agency or department thereof, all lands, buildings, and grounds acquired by the State under paragraph (b) of this section shall be owned in fee simple absolute by the State and dedicated in perpetuity to the purposes stated in paragraph (b). All radioactive material received at such site and located therein at time of acquisition of ownership by the State becomes the property of the State.

(g) In the event a person, licensed by any governmental agency other than the State of (name of State), desires to transfer a site to the State for the purpose of administering or providing perpetual care, a lump sum deposit shall be made to a trust fund . The amount of such deposit shall be determined by the (Director of the Agency) taking into consideration the factors stated in paragraph (d) of this section.

Section _____.

(a) The provisions of this Act are severable and if any part of the Act is declared invalid or unconstitutional, such declaration shall not affect the validity of the part which remains.

(b) This Act is cumulative and is intended to supplement existing laws, and no part shall be construed to repeal any existing law specifically enacted for the protection of public health and safety.

(c) The provisions of this Act shall take effect 90 days after is passage and approval by the Governor or its otherwise becoming a law.

APPENDIX III

U. S. URANIUM MILL SITES

2/17/77

Location	Operational Mill Owner	Present Owner	Status
ARIZONA			
Monument	Foote Mineral	Navajo Nation	Inactive
Tuba City	El Paso Nt. Gas	Navajo Nation	Inactive
COLORADO			
Durango	Foote Mineral	Foote Mineral	Inactive
Grand Junction	Amer. Metals Climax Div.	AMAX	Inactive
Gunnison	Gunnison Mining	Colorado Ventures, Inc.	Inactive
Maybell	Union Carbide	Union Carbide	Inactive
Naturita	Foote Mineral	Foote Mineral	Inactive
Rifle (old)	Union Carbide	Union Carbide	Inactive
Rifle (new)	Union Carbide	Union Carbide	Standby
Slick Rock	Union Carbide	Union Carbide	Inactive
Slick Rock	North Continent	Union Carbide	Inactive
Canon City	Cotter Corp.	Cotter Corp.	Active
Uravan	Union Carbide	Union Carbide	Active
IDAHO			
Lowman	Porter Bros.	Mich. Chemical	Inactive
NEW MEXICO			
Grants	Kerr-McGee	Kerr-McGee	Active
Grants	Phillips	United Nuclear	Inactive
Grants	United Nuclear	United Nuclear	Active
Bluewater	Anaconda	Anaconda	Active
Moquino	Sohio	Sohio	Active
Shiprock	Foote Mineral	Navajo Nation	Inactive

APPENDIX III (Continued)

U. S. URANIUM MILL SITES

2/17/77

Location	Operational Mill Owner	Present Owner	Status
OREGON			
Lakeview	Lakeview Mining	Atlantic Richfield	Inactive
SOUTH DAKOTA			
Edgemont	Mine Development	TVA	Standby
TEXAS			
Falls City	Conoco Pioneer	Conoco Pioneer	Active
Falls City	Susquehanna Western	Susquehanna Western	Inactive
Ray Point	Susquehanna Western	Exxon Company	Inactive
UTAH			
La Sal	Rio Algom	Rio Algom	Active
Moab	Atlas Corp.	Atlas Corp.	Active
Green River	Union Carbide	Leased to USAF	Inactive
Mexican Hat	AZ (Atlas) Minerals	Navajo Nation	Inactive
Salt Lake City	Vitro Corp.	SLC Suburban Sewage Treatment District	Inactive
Monticello	VCA	ERDA	Inactive
Hite	VCA	Park Service	Inactive
WASHINGTON			
Valley Ford	Dawn Mining	Dawn Mining	Active

APPENDIX III (Continued)

U. S. URANIUM MILL SITES

2/17/77

Location	Operational Mill Owner	Present Owner	Status
WYOMING			
Converse Cty.	Western Nuclear	Phelps Dodge	Inactive
Gas Hills	Fed. American	Fed. American	Active
Gas Hills	Utah International	Utah International	Active
Gas Hills	Union Carbide	Union Carbide	Active
Jeffery City	Western Nuclear	Western Nuclear	Active
Powder River Basin	Exxon	Exxon	Active
Shirley Basin	Petrotomics	Petrotomics	Standby
Shirley Basin	Utah International	Utah International	Active
Riverton	Susquehanna Western	Susquehanna Western	Inactive

NOTES

1. Includes Hite, Utah site which is now covered by Lake Powell.
2. Does not include separate listing for mills (such as United-Nuclear/ Homestake Partners) which have both an active and an inactive tailings pile on the same site.
3. Totals are:

Inactive	23 sites
Active	16 sites
Standby	3 sites
Under construction	Not listed

ADDENDUM

Idaho was inadvertently omitted from the state summaries.

A. Regulations: The Idaho Radiation Control Regulations (1973) Section I, Radiation Safety Requirements for Radioactive Mineral Mill Tailings, set forth terms for maintenance and monitoring of radioactive tailings from uranium and other ores. The enforcement of them is by the Radiation Control Section, Environmental Improvement Division, Idaho State Health Department.

B. Stabilization Guarantees: None.

C. Land Title Transfer: No regulations.

D. Perpetual Maintenance: No provisions.

E. Mills and Tailings: Idaho has one inactive mill tailings pile. Conditions on mill tailings management may be included in mill licensing regulations. Regulation of radioactive tailings is primarily focused on phosphate ore processing.