CONF-781127--2

INTERIOR DRAINS FOR OPEN PIT DISPOSAL OF URANIUM MILL TAILINGS*

W. P. Staub
Energy Division

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

Paper submitted for publication in Proceedings of
Symposium on Uranium Mill Tailings Management
Geotechnical Engineering Program
Civil Engineering Department, Colorado State University
Fort Collins, Colorado
November 20-21, 1978

*Research sponsored by the Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission under Interagency Agreement No. 40-549-75 with the U.S. Department of Energy under contract W-7405-eng-26 with the Union Carbide Corporation.

Symposium on Uranium Mill Tailings Management,
Fort Collins, Colorado, November 20, 21, 1978;
Geotechnical Engineering Program, Civil Engineering
Department, Colorado State University

INTERIOR DRAINS FOR OPEN PIT DISPOSAL OF URANIUM MILL TAILINGS

W. P. Staub*

ABSTRACT

A conceptualized interior drainage system is presented for reducing the environmental impact on natural groundwater by disposal of uranium mill tailings in a mined-out open pit. The evaporation/seepage ratio can be increased through the use of interior drains, long-term monitoring of groundwater quality can be eliminated, and the open pit will not require an extensive liner. Other advantages not related to groundwater are: control of fugitive dust and radon emanation during mill operations and timely reclamation after the impoundment is filled with tailings.

INTRODUCTION

During 1977 surface mining accounted for 46% of the U_3O_8 production in the United States.[1] Table 1 lists the currently active mills associated with these mines as well as several proposed mills, wherein applications

---

*W. P. Staub, Geotechnical Engineer, Oak Ridge National Laboratory, Oak Ridge, TN 37830

to handle radioactive materials have been received by the U. S. Nuclear Regulatory Commission (NRC).[1,2,3,4,5] Most of these mills (both existing and planned) are located in Wyoming.

The purpose of this paper is to present a new design for uranium mill tailings management featuring an interior drainage system in a mined-out open pit. Pits could be conveniently used for disposal of tailings for the majority of mills listed in Table 1. Some of these mills (active and planned) are located adjacent to surface mines, while other active mills could have been located more favorably with respect to them. While specific sites may be unsuitable,* perhaps 60 to 70% of the mills that process ore from surface mines could utilize mined-out pits for tailings disposal.

The NRC has adopted a favorable position with respect to disposal of uranium mill tailings above the water table in mined-out open pits.[6] Pit disposal of tailings prevents any potential for catastrophic release and reduces the likelihood of early gradual release to the surface environment. On the other hand, it is expected that the impact on groundwater from slurried tailings will be increased.

---

*It is recognized that not all open pits are convenient tailings disposal sites. An operator may prefer to site a mill near an underground mine to shorten the average hauling distance. Also sand tailings may be required to backfill portions of underground mines to prevent subsidence or collapse of haulage ways. Some open pits will not be suitable for tailings disposal because a shallow water table is present.

Table 1. Uranium mills associated with surface mines in the United States

ACTIVE MILLS

Mills	Location	Ore Capacity (MT/day[a])	Proximity of mines, other circumstances
Anaconda, Blue Water	Grants, NM	5450	5400 MT/day surface mines (Jackpile and Paguate), 80 km from mill and 1170 MT/day underground mines
Utah International Lucky Mc	Gas Hills, WY	1500 [2520][b]	95% of the ore comes from an onsite surface mine (Lucky Mc), the remainder from 2 small underground mines. Expansion of the mill is underway to handle additional ore from a recently opened offsite surface mine (Big Eagle)
Utah International	Shirley Basin, WY	1640	Both onsite and offsite surface mines
Exxon, Highland	Bowder River, WY	2730	Onsite surface mines, also 2 underground mines
Western Nuclear, Inc. Split Rock	Jeffrey City, WY	1550	Ore is evenly divided between offsite surfac and underground mines (about 24 km distant)
Union Carbide Corp. Gas Hills	Gas Hills, WY	1090	Ore nearby and 3 offsite surface mines
Federal American Partners	Gas Hills, WY	860 [2580][b]	Onsite and offsite surface mines, one underground mine is being developed
Rocky Mountain Energy Bear Creek	Powder River Basin, WY	910 [1260][b]	Onsite surface mine

Table 1 (Cont.)

Continuental Oil Co. and Pioneer Nuclear, Inc. Conquista	Falls City (Deweesville), TX	2640	Onsite surface mine. Other mines dispersed through Karnes Co. and parts of Live Oak Co. Shallow water table
Dawn Mining Co.	Ford, WA	360	Surface mine (Midnite) 35 km distant. Precambrian metamorphic rock
		PROPOSED MILLS[c]	
Petrotomics Co.	Shirley Basin, WY	1360	Renovated mill scheduled to be restarted. Onsite surface mine.
Kerr-McGee Nuclear	Powder River Basin, WY	2270	Mill may be constructed near underground mines; surface mines approximately 9 km distant
United Nuclear, Morton Ranch Project	Powder River Basin, WY	1800 [2720][b]	Onsite surface mine and offsite underground mine
Minerals Exploration, Sweetwater Project	Red Desert, WY	2720	Surface mine 3 to 6 km away
Homestake Mining Company Pitch Project	Gunnison (Sargents), CO	680	Surface mine 1 mile away. Shallow water table, surface drainage, rugged terrain
Tennessee Valley Authority	Edgemont, SD	NA[d]	Present abandoned mill to be decommissioned; millsite to be moved.

[a] multiply by 1.1 to convert to short tons

[b] [] = proposed expansion

[c] applied to NRC or State of Colorado for a license to handle radioactive materials

[d] NA = not available

REVIEW OF PROPOSED METHODS OF TAILINGS CONTAINMENT IN A MINED-OUT OPEN PIT

Various methods have been proposed for reducing the impact on groundwater caused by disposal of tailings in mined-out open pits. While some of these methods may be environmentally effective, their economic viability ranges from uncertain to prohibitive. Among the suggested methods are fixation of tailings by asphalt or cement.[7] It has also been suggested that unconsolidated tailings could be contained by construction of thick natural clay liners or by application of chemical sealants along the highwalls in combination with compacted natural clay or synthetic liners on the floor of the pit.[7,8]

Typically, uranium mills in the United States produce slurried tailings that are oversaturated with water. Nearly all the operating mills listed in Table 1 use an acid leach process and pregnant (uranium bearing) liquid is separated from pulp by countercurrent decantation (CCD) in thickeners.[3] The barren pulp is then discarded by reslurrying it and transporting it via pipeline to a tailings impoundment. Water is decanted from the tailings pond and recycled for use in the pipeline slurry. Tailings discharged in this manner contain about 55% by weight (76% by volume) water.[9]

Impounded tailings remain oversaturated during mill operations despite losses by evaporation and seepage and the recycling of water from the tailings pond. Table 2 lists the estimated percentage of water input to the tailings that is either recycled to the mill or lost

Table 2. Water budget for mill to tailings circuit.[a]

	% total input		
	input	output	stored
Wash water (1st time through)	64.1		
Recycle water	35.9	35.9	
Water removed by evaporation		10.1	
Water removed by seepage		8.1	
Water retained in impoundment			45.9
Total	100.0	54.1	45.9

[a]maximum evaporation rate and maximum seepage rate through a lined impoundment, Morton Ranch Mill, Powder River Basin, Wyoming

through evaporation and seepage from a lined and completely filled impoundment (maximum evaporation and seepage rates). Probably substantially more than half the input water is stored in the tailings as the pit is being filled because evaporation and seepage losses are lower during the earlier stage of operation. Eventually a majority of the stored water will be removed by seepage in the long term unless the tailings are dewatered. Table 3 lists estimated weight and volume percentages of water in sands and slimes after impoundment. Estimates for the horizontal belt filtration method of liquid-solids separation[10] with "dry" tailings impoundment are provided for comparison. If saturated sand retains a maximum of 30% water by volume the data from Tables 2 and 3 clearly indicate that seepage from and settlement of oversaturated tailings will continue after mill operations cease. While "dry" tailings would retain substantially less water than slurried tailings, seepage and settlement of the segregated slime portion can be expected to occur over the long term.

It is clear from the above discussion that the dewatering of slurried tailings by current practice (decantation from the top of the pond) is inadequate. More effective dewatering can be achieved either by the horizontal belt filtration method of liquid-solids separation or by installing an interior drainage system in the pit used for conventional slurried tailings. The former method is the subject of another paper presented at this seminar.[10] A conceptualized interior drainage system for disposal of slurried tailings in a mined-out open pit is presented here.

Table 3. Estimated water contents for slurried and dried uranium mill tailings.[a]

Milling process	Slurried tailings conventional CCD liquid-solids separation			"Dry" tailings horizontal belt filtration liquid-solids separation		
	Sand	Slimes[b]	Total	Sand	Slimes[b]	Total
Weight % water	31	60	36	16	47	20
Volume % water	55	80	60	33	70	40

[a]Assumed solids were 90% sand and 10% clay by volume, 80% of the bulk wet volume was sand and 20% was clay, water having a tendency to separate out with clay to form slime in ponded areas.

[b]Includes ponded water

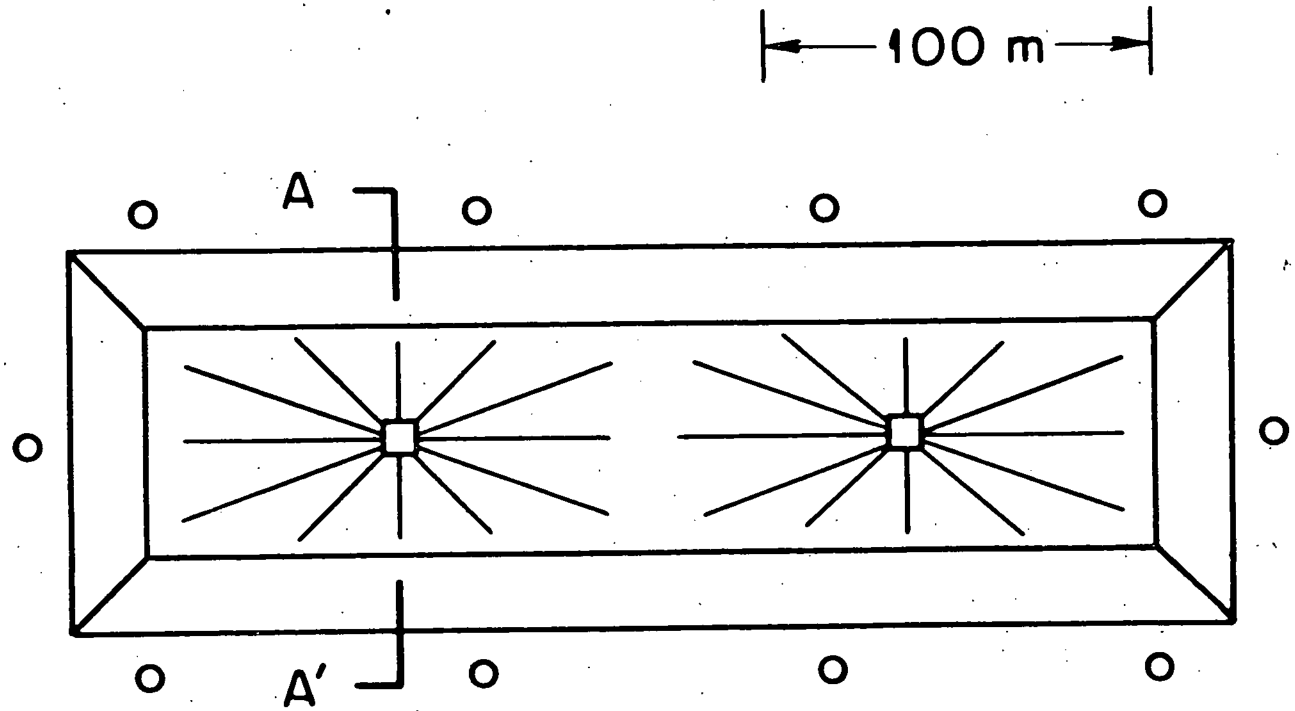
DESCRIPTION AND OPERATION OF AN INTERIOR DRAINAGE SYSTEM

A plan view of the interior drainage system is illustrated in Fig. 1. In a typical elongate-shaped pit[9] (400 m x 200 m) two caissons with finger drains radiating outward would be required. A 40 m deep pit would store between 1 and 3 years supply of tailings (depending on the depth to the water table) from an 1800 metric ton (2000 T) per day mill.[9]

A more detailed description of the interior drainage system is illustrated by the block diagram in Fig. 2. If the pit extends below the water table, construction of this system would require an underdrain below the clay liner. Water would be pumped from the underdrain to prevent rupture of the liner by artesian pressure. The finger drains would be laid in pea-sized gravel and surrounded by a sand-sized filter medium. Construction of the liner and sand drain along the highwall would be accomplished as overburden is backfilled and roll compacted to a height of about 3 m above the natural water table. As a construction option an additional 2 to 3 meters of highwall could be coated with a spray sealant.

The interior drainage system becomes operational as tailings impoundment begins. Water would be pumped from the bottom of the caissons to be sprayed on the tailings sand beach, returned to the mill, or removed to an evaporation pond. As water is withdrawn from the caissons the hydrostatic head is lowered and settlement of the tailings is accelerated. Well points would be used to monitor for seepage and, if necessary, to withdraw contaminated water for disposal in the evaporation

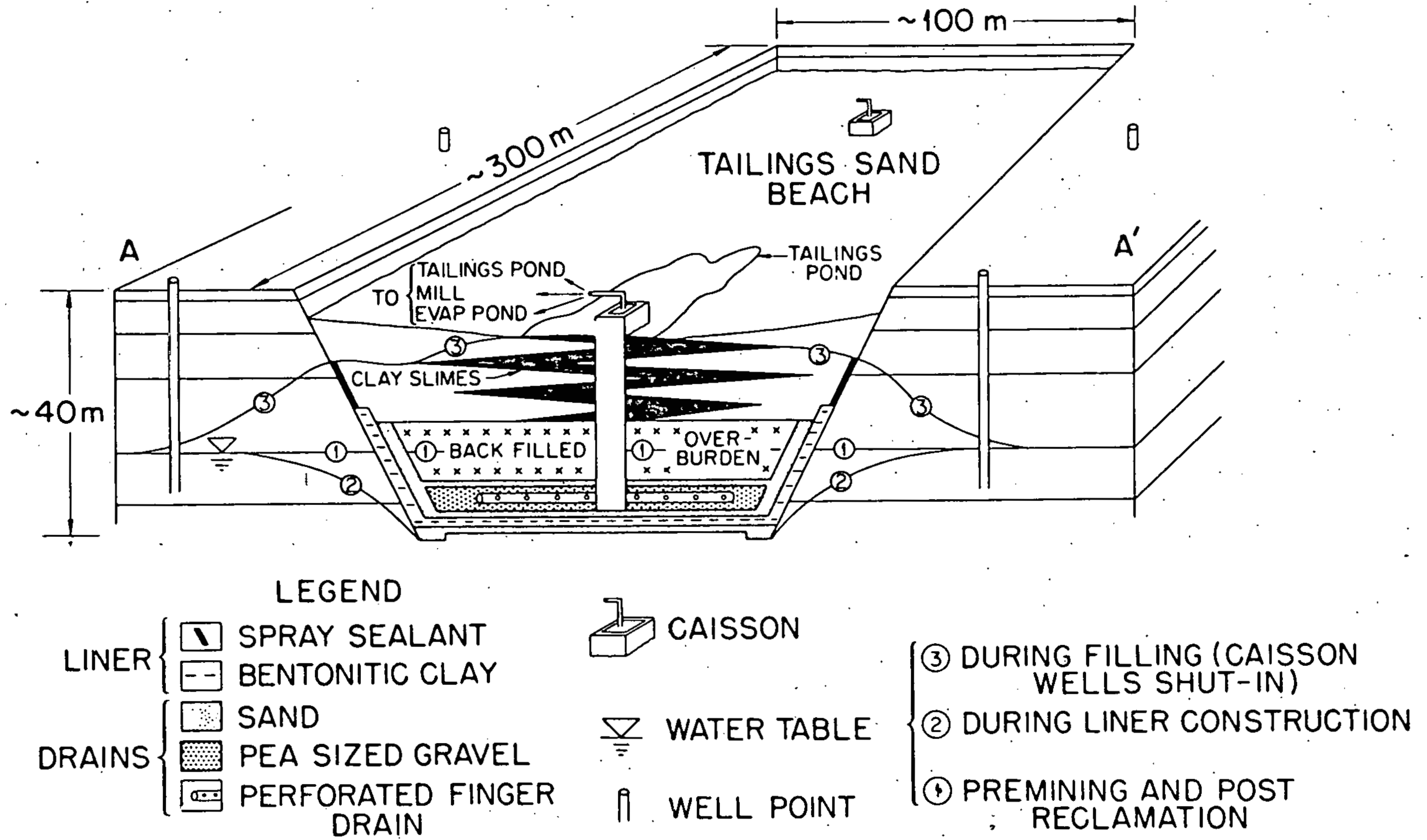
ORNL-DWG 78-20205



Plan View of the Caissons, Finger Drains, and Well Points for Tailings Disposal in a Mined-Out Open Pit.

Figure 1

ORNL-DWG 78-20204



Block Diagram of the Liner and Drains for Tailings Disposal in a Mined-Out Open Pit.

Figure 2

pumped from the caissons until drainage is virtually eliminated (the elevation of the water table inside and outside the pit is approximately equalized). When the caisson pumps are removed groundwater monitoring would be discontinued and the tailings cap would be installed. Waste residues from the dried out evaporation pond would be transferred to the last tailings pit awaiting reclamation.

ADVANTAGES OF AN INTERIOR DRAINAGE SYSTEM

An interior drainage system possesses several environmental, economic, and operational advantages. Among the environmental advantages are:

(1) the evaporation to seepage ratio is increased,

(2) short term seepage is reduced through lowering the hydrostatic head,

(3) long term seepage is virtually eliminated,

(4) fugitive dust and radon emanation can easily be reduced during mill operations, and

(5) post reclamation failure of the tailings cap by settlement is unlikely to occur.

Economic and operational advantages are:

(1) an elaborate liner will not be required,

(2) the tailings surface can easily be kept wet.

(3) internal dikes will be more stable,

(4) timely reclamation can take place, and

(5) long term groundwater monitoring can be eliminated.

REFERENCES

1. Department of Energy (1978), "Statistical data of the uranium industry", GJO-100(78), Grand Junction, Colorado.

2. Reed, A. K., H. C. Meeks, S. E. Pomeroy, and V. Q. Hale (1967). "Assessment of environmental aspects of uranium mining and milling", EPA-60017-76-036, Industrial Environmental Research Laboratory, Office of Research and Development, U. S. Environmental Protection Agency, Cincinnati, Ohio.

3. Stone and Webster Engineering Corp. (1978). "Uranium mining and milling: the need, the processes, the impacts, the choice: administrator's guide", EPA-908/1-78-004, Prepared for Western Interstate Energy Board under contract to the U. S. Environmental Protection Agency, Contract No. 68-01-4490, Denver, Colorado.

4. Engineering and Mining Journal (1978), "Uranium expansion: the rush is on", pp. 73-150, Vol. 197, No. 11.

5. U. S. Nuclear Regulatory Commission (1978). "Regulatory licensing, status summary report", NUREG-0329-78/7, Washington, D. C.

6. Scarano, R. A. and J. J. Linehan (1978), "Current U. S. Nuclear Regulatory Commission licensing review process: uranium mill tailings management", Seminar on Uranium Mill Tailings by OECD, Nuclear Energy Agency, Albuquerque, New Mexico.

7. Sears, M. B. et al. (1975). "Correlation of radioactive waste treatment costs and the environmental impact of waste effluents in the nuclear fuel cycle for use in establishing 'as low as practicable' guides - milling of uranium ores", ORNL/TM-4903, Vol. 1, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

8. Staub, W. P. and E. K. Triegel (1978). "Analysis of disposal of uranium mill tailings in a mined-out open pit", Seminar on Uranium Mill Tailings by OECD, Nuclear Energy Agency, Albuquerque, New Mexico.

9. United Nuclear Corporation (1976). "Environmental report on the Morton Ranch, Wyoming uranium mill", Vol. 1, UNC-ER-2, Casper, Wyoming.

10. Frankfort, J. H. (1978), "A milling process providing flexibility to tailings disposal methods", this symposium.