ECONOMICS OF ALTERNATIVE URANIUM TAILINGS TRANSPORT METHODS

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ABSTRACT

The paper is directed at selecting an economic method for transporting tailings from existing locations to final disposal sites. The method of transportation chosen will depend on the quantity of tailings, the terrain and the distance to be transported. This paper outlines the methods for transporting tailings by truck, rail, conveyor, tram, and slurry pipeline and discusses the advantages and disadvantages of each method. Emphasis is placed on uranium tailings disposal. The paper provides economic data and recommendations that may be used for selection of a system for a particular situation. Finally, general conclusions are reached relating the characteristics of a system with economic alternatives for transporting the material.

INTRODUCTION

The Uranium Mill Tailings Remedial Actions (UMTRA) Project was initiated to carry out the Uranium Mill Tailings Radiation Control Act of 1978 enacted by the 95th U.S. Congress as PL 95-604. The project is directed at cleaning up 24 uranium mill tailings sites and vicinity properties throughout the United States. In many cases the tailings can be stabilized in place; in some instances, however, the tailings must be relocated to a different site for disposal. For many of the UMTRA sites, short distance relocation is required and there is not a great volume of material to be moved. Generally the total volumes are less than 3 million cubic yards which is roughly equivalent to 2.5 million tons (dry weight). The project life for the transportation systems averages two years per site in order to maintain the overall construction schedule. The methods used for transporting the tailings and vicinity property material has become a major economic concern to the project.

METHODS OF TRANSPORT

Several methods have been used commercially for transporting tailings material. These include truck, conveyor, rail, pipeline and tram systems. The following is a brief discussion of these transportation methods including their advantages and disadvantages.

Rail Transport

Rail has been used widely for transporting materials over medium to long distances, from 50 to 1500 miles. In areas where short haul is required and no existing line is available along the route, the building of a new line is usually economically prohibitive. New rail is sometimes advantageous, however, in areas where no infrastructure exists. Distances less than 50 miles have been found to justify a new rail system in such cases. Where new track is required there will be a long lead time for obtaining permits and for installing the track and road bed. In addition, the capital cost of the new track must be amortized over the life of the project; generally 15-25 years is required. If the project is able to use existing track, this will eliminate most of the startup expenses short of acquisition of rolling stock. Two additional disadvantages of the rail method are that (1) surface transport systems such as rail do have social (traffic) and environmental impact and (2) rail tariffs are not predictable and are subject to change with market and inflationary pressures (assuming that the rail facility is not owned by the user).

Pipeline Transport

A conventional slurry pipeline transports tailings in slurried form. Typical transport distances for this method range from 100 to 1500 miles. The tailings are ground and mixed with water usually at a 50 to 60 percent solids loading. The slurry is then either pumped through the pipeline, or gravity flow is used if available. Slurry pipeline is a viable method for transporting tailings; however, as with rail and conveyor systems, the high capital cost of the system must be justified by amortizing the cost over the project life (again 15-25 years is usually required). There is a long lead time associated with obtaining permits and constructing the pipeline. The major disadvantages of using this method for transporting uranium tailings are the dewatering of the slurry and cleanup of contaminated water, as well as preparation of slurry by grinding the material to a size distribution suitable for pumping. Grinding facilities at the preparation site would require strict control to eliminate dust and exposure to radon.

Dewatering methods must be investigated in order to obtain a product suitable for burial in an embankment. In some cases, it may be economical to recycle the water through a return water line.

By using liquid carbon dioxide (CO_2) as a carrier fluid it may be possible to avoid water contamination, as would be the case with a conventional slurry pipeline using water as the carrier fluid. Morrison-Knudsen found, however, that the system would be expensive and not advantageous for the following reasons.

1. The use of CO_2 as a carrier fluid is still under development.
2. Because of the low viscosity of CO_2, a fine grind is required (70-80 percent passing 200 mesh is recommended for slurry stability). Grinding and separation will have severe dust handling problems.
3. Potential for pipeline corrosion is greater as residual water in the tailings may react with the CO_2 to form carbonic acid. In addition residual water in the solids may freeze and form ice blocks.
4. The slurry must be prepared and stored below the critical temperature of 88°F and above the critical pressure of 1081 psi. This requires a closed system with thick pipe wall, special valves and storage tanks. Pressures in the pipeline are maintained between 800-2000 psi in most cases.
5. Low temperature operation may require insulation and cooling stations.
6. Problems are anticipated with pipeline restart and shutdown. Three phases may occur in the pipe.
7. Local plugging is probable with a rupture especially at 75 percent solids loading. The CO_2 will escape slowly from the rupture enhancing the potential for propagating fracture of the pipeline wall.
8. The power requirement for CO_2 liquefaction is high.

Capsule pipelines, a method by which containers on low friction rollers and connected in a train are propelled through a pipeline by a low pressure blower, may be appropriate for uranium tailings transport. Capsule pipelines are designed to compete with trucks and conveyors at distances between 5 and 100 miles. These systems are in use in Russia and are still under development in this country.[1]

A capsule pipeline system planned in the U.S. will be used to transport 2 million tons per year of coal for a period of 15 years. The pipeline will be operational by 1987. As currently envisioned, a typical capsule pipeline system has the following characteristics.

- 30 inch diameter pipeline
- maximum slope: 20 percent
- maximum loading/unloading rate: 500 tons per hour
- 4-5 cars per train
- cars are 25 inches x 14 feet with 27.5 ft^3 capacity
- fill area of car is 20 inches wide (this may not be suitable for large tramp material)
- pipeline can be located above or below ground
- pipeline can be broken down and moved to other sites
- 1-10 psi operating pressures

Pipeline systems are advantageous because costs are not affected by inflation as much as rail since annual costs are small compared to initial investment, and they are environmentally attractive.

Conveyor Transport

Conveyors are used primarily for transporting material over short to intermediate distances, up to 50 miles. They have a high capital cost but become advantageous where large volumes are to be transported over long periods. Over long distances, greater than 50 miles, the energy costs associated with conveyors make this method of transport unattractive. Another disadvantage to the conveyor system is that scrap material will cause accelerated belt wear. At the UMTRA sites, tailings piles contain large amounts of scrap material and rubble from vicinity properties. The size and characteristics of this material make it unsuitable for conveyor transport. Conveyor systems generally last 20 years; however, at the UMTRA sites their cost must be amortized over a 2-3 year period making it difficult to justify the initial capital expenditure.

Truck Transport

Trucks have been a favored method for transporting material over short distances, generally less than 50 miles. The economics of truck transport are route dependent. Morrison-Knudsen has developed a computer model which simulates truck behavior for a given route, speed, and loading; this model is then used in estimating the cost of a particular haul.

Trucks are limited to approximately 25 tons over most public roads. Larger loads, up to 85 tons, can be carried by off-highway trucks; however, roads must be provided to accommodate these trucks.

A major advantage of truck transport is a short lead time and flexibility concerning startup and shutdown of the project. In many cases existing roads can be used. The disadvantages of this method are: (1) the truck haul is labor intensive, (2) the increased traffic in some areas may be a social concern, (3) trucks are more limited in the volume which can be handled over a given route than any of the methods previously discussed, and (4) trucks incur high energy (diesel) requirements especially with a no-load return.

Tram System

A tram system uses an aerial cableway to transport bulk materials. A major advantage of these systems is their ability to adapt to difficult terrain. Maximum capacities for a conventional tram system are generally around 650 tons per hour; however, recent systems have been designed to carry up to 2500 tons per hour. The cableway is powered by electricity and has a low power consumption. If the terrain is predominantly downhill, the system may be able to generate its own power.[2] Tram systems usually become competitive with rail, truck and conveyors at distances over 2 miles. Alignments for the tram system can be straight as it easily overcomes obstacles by moving above them. In addition, tram systems are environmentally attractive and do not require extensive acquisition of right-of-way.

Tram systems were considered unsuitable for uranium tailings transport because of their tendency to dribble material along the route.

COSTS

Figure 1 is a composite graph showing transportation costs in U.S. dollars per ton as a function of throughput for the different alternatives. Figure 1 is based on Morrison-Knudsen experience, in-house cost estimates and published information.[3] Comparable costs for tram systems were unavailable and were not included. The costs presented include annual operating costs plus amortized direct capital costs. The base year used is 1982 and the inflation rate assumed was 5%. Actual system costs will fluctuate with changes in energy and labor costs and inflation; however, Fig. 1 illustrates how the alternatives compare in general.

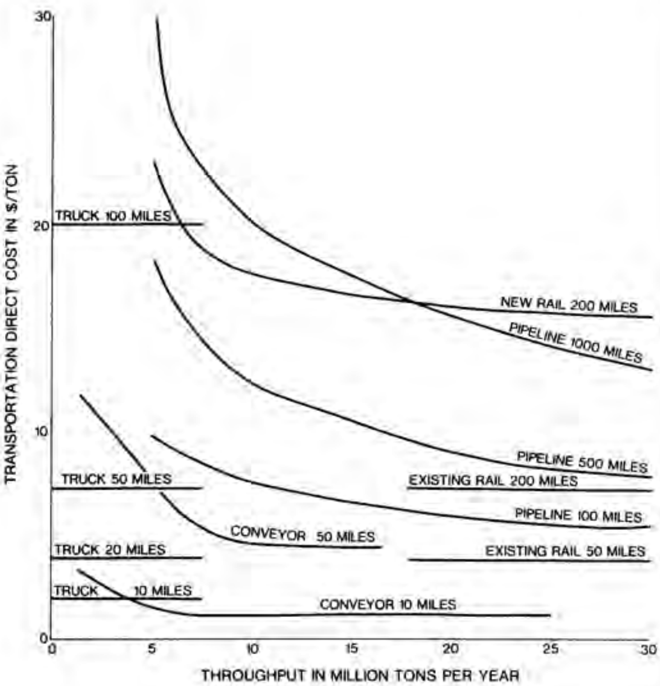

Fig.1 Transportation Costs

SUMMARY AND CONCLUSIONS

The selection of the most economic transport method is site specific and requires detailed study. Selection is made based on factors including tonnage of material to be moved, material characteristics, distance, existing available transportation, project life, and terrain. In addition to economic factors, a method of transport may be selected for political or aesthetic reasons. For instance a pipeline may be selected over truck or rail because it is a more attractive alternative environmentally. Many of the systems are ideal for large tonnages and long distances, for example, pipelines and rail systems.

Table I is a summary of advantages and disadvantages for each of the alternatives. Table II presents typical costs of the alternatives and typical distances where the alternatives become economical.

For the UMTRA sites, where transportation of tailings usually involves relatively low throughput over short distances, the most common economic alternatives are conveyor systems, truck haul systems or a combination of these. Conventional slurry pipeline systems may be feasible in cases where water is readily available and a gravity system can be used.

Capsule pipelines are a promising alternative; however, they are not yet used commercially. Rail systems may be suitable when the sites are located along an existing track. The method selected for each site must be evaluated on a case by case basis.

TABLE I

Advantages and Disadvantages of Alternative Methods of Transport

SYSTEM	ADVANTAGES	DISADVANTAGES
Truck Haul	1. Low initial capital investment 2. Flexibility of interface points, routes, capacities 3. Good existing infrastructure (public roads) 4. Good reliability	1. High lifetime capital cost 2. High operating cost 3. Labor intensive 4. Fuel intensive 5. Some safety problems
Rail Haul	1. Good existing infrastructure (commercial railroad) 2. Fuel efficient 3. Comparatively low rates (but rising rapidly) 4. Good reliability, safety	1. High capital cost if private construction required 2. Labor intensive 3. Lack of flexibility of interface points, routes
Conventional Slurry Pipeline (H_2O)	1. Low operating cost 2. Fuel efficient 3. Labor efficient 4. Highly reliable (except dewatering) 5. Good safety 6. Requires no existing infrastructure 7. Environmentally attractive	1. High capital cost 2. Requires large amounts of water 3. Dewatering technology not mature 4. Lack of flexibility of interface points, routes, capacities
Overland Belt Conveyor	1. Low operating cost 2. Good reliability 3. Fuel/labor efficient 4. Requires no existing infrastructure 5. Can negotiate difficult terrain 6. Some flexibility of interface points	1. High capital cost 2. Some safety problems 3. Lack of flexibility of routes, capacities
Tram	1. Low operating cost 2. Energy efficient 3. Requires no existing infrastructure 4. Can negotiate difficult terrain 5. Environmentally attractive	1. High capital cost 2. Some safety problems 3. Lack of flexibility of interface points, routes, capacities

TABLE II

Typical Costs and Distances for Alternative Methods of Transport

TRANSPORTATION	TYPICAL MILES	COST PER TON MILE
Truck	0 - 50	$.15 - $.20
Existing Rail	50 - 1500	$.02 - $.07
Conventional Slurry Pipeline	100 - 1500	$.006 - $.015
Capsule Pipeline	5 - 100	$.10
Overland Conveyor	0 - 50	$.09 - $.12
Tram	2 - 50	?

REFERENCES

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3. Thomas C. Aude, and Terry L. Thompson, "Coal Transportation The Economic Alternatives," 7th International Technical Conference on Slurry Transportation, Lake Tahoe, Nevada, March 25, 1982.