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100 Area Pilot-Scale Soil-Washing Test Alternatives and Recommendations

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Bechtel Hanford, Inc.
Richland, Washington

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1.0 INTRODUCTION

Soil washing has been identified as a potential remedial alternative for reducing soil waste volumes in selected locations within the 100 Areas of the Hanford Site. Cribs, trenches, and contaminated soils underlying retention basins are the primary waste sites for which the technology may be applicable. The goal of soil washing is to remove contaminants from soil particles greater than a selected size such that the "coarse" soils will meet cleanup levels (to be established) and can be returned to the site or used as backfill in other sites. Contaminants are concentrated in smaller soil particles which will be further treated or disposed.

Where soil washing or physical separation technologies are successful, soil washing has the potential to significantly reduce the volume of 100 Area contaminated soils that may otherwise require additional treatment or disposal. Pilot-scale physical separation tests in the 300 Area at Hanford showed that the volume of contaminated soils in the 300 Area North Process Pond could be reduced by more than 90% in that area (DOE/RL 1994b).

As of June, 1994, bench-scale treatability studies have been completed using soil samples collected at depths of 10 to 30 ft from the 116-C-1 Trench, 116-D-1B Trench, and 116-F-4 Crib. These soil samples consisted of as little as 30% gravel (> 2 mm) material to over 80% gravel material. The primary contaminants in the samples were ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{60}Co, and ^{90}Sr. Of these, ^{137}Cs was consistently the primary contaminant and the most difficult to remove.

In some samples, such as those taken from the middle of the 116-C-1 Trench, the contaminant level of gravel and cobbles was low enough that a simple physical separation of coarse and fine particles (0.25 mm split) was sufficient to significantly reduce the volume of more highly contaminated soil. Based on numerous limited field investigation reports for the 100 Areas and historical information by Dorian and Richards (1978), this is expected to be true for many of the other waste sites in the 100 Areas.

In other samples, such as those taken from the inlets of 116-C-1 and 116-F-4, radioactivity levels were higher and ^{137}Cs contaminants were adsorbed and bound to the rock and had seeped into rock crevices and pores. With these samples, it was necessary to grind off as much as 3 mm of rock to reduce the level of radioactivity to meet test performance goals.

As a result of these laboratory and bench-scale studies, Westinghouse Hanford Company (WHC) recommended to the U.S. Department of Energy (DOE) and the regulators that a pilot-scale test be performed at the 116-D-1B site. Milestone M-15-07B was subsequently established to complete tests at 100-D by August 31, 1994. This milestone could not be met due to unavoidable delays in acquiring equipment for the test. As a result, a change request was submitted to the regulators which deletes Milestone M-15-07B and replaces it with Milestone M-15-07E which requires the test to start by March 31, 1995. The change request also includes three additional milestones:

- M-15-07F, submit 100-F bench-scale test report
- M-15-07G, conduct pilot-scale tests using 116-F-4 soils
- M-15-07H, conduct pilot-scale tests using soils from two other sites.

All tests are to be completed by July 31, 1995. As of June 6, 1994, this change request was being negotiated by DOE and the regulators.

In attempting to map out a strategy to meet these milestones, many issues and potential alternatives were identified. It was determined that these issues and alternatives should be brought to the attention of DOE as soon as possible. Therefore, this engineering study was prepared to document issues and assess alternatives associated with each of the four proposed milestones such that the information could be presented to DOE in an organized manner.

2.0 SCOPE, ISSUES, AND ASSUMPTIONS

This engineering study includes an evaluation of alternatives for 100 Area soil-washing treatability studies to transport, store, process, and dispose of soils from four sites at Hanford. Two of the sites are specified in previous Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) agreements; these are 116-D-1B and 116-F-4. The other two sites have not been selected at this time. For purposes of this study, it will be assumed that the sites are 116-C-1 and a crib within the 100-H Area. Sites will hereafter be referred to in this study as 100-D, 100-F, 100-C and 100-H sites. Except for 100-F, the sites are not considered radioactive areas at the ground surface; therefore, precautions will be required to minimize surface contamination caused by the test.

2.1 TRANSPORTATION AND SHIPPING

This study assumes that a soil treatment system will be assembled near the 100-D site. Consideration was given to siting equipment at the 100-F site; however, then soil from all other sites would have to be transported to the 100-F site and all soil, including 100-F soil, would have to be removed from the site at the conclusion of the test. 100-D was selected for the test site because it is more centrally located, and coarse soils processed in the 100-D test could be returned to the hole at the conclusion of the test.

Soils from 100-F, 100-C, and 100-H sites will be packaged and transported by truck to the 100-D site.

Other alternatives considered for equipment siting and transport included mobilizing equipment between tests to each test site or purchasing more than one system. It was determined by WHC engineers that the schedule to complete all tests between March 31, 1995 and July 31, 1995 does not allow sufficient time to mobilize equipment between tests. Purchasing of additional equipment would significantly raise the cost for these tests and is not warranted at this time.

It is assumed that all soils are Low Level Waste and must be packaged and transported to and from the treatment process per Department of Transportation (DOT) requirements for Low Specific Activity (LSA) soils. While DOT requirements are not required for transportation between the 100 Areas, DOE order 5480.3, change 1, Chapter 3 states that DOT requirements should be followed at the Hanford Site. This may mean that soils must be shipped in containers meeting LSA requirements (ie. 55-gal drums, B-25 LSA boxes, or other strong, tight containers).

2.2 STAGING BEFORE PROCESSING

The study assumes that all soils will be staged in piles covered with a tarp prior to processing. The tarp would be removed during processing and replaced at the end of each working day or prior to stopping work.

This approach would likely provide adequate protection to control dust and prevent soil contamination due to high winds. However, it may be necessary to build a tent or other temporary structure for the staged soils. This was not included in the budget, and would require additional funding.

It is assumed that dust suppressants, while shown to be effective in excavation treatability tests, will not be used in these soil-washing tests. This is because bench-scale tests for 100-F soils (WHC 1994a) found that significantly more flocculent and a different type of flocculent were required to remove suspended solids in water as compared to 100-D tests (DOE/RL 1994a). This was attributed to the effect of the dust suppressant.

2.3 STORAGE AND DISPOSAL AFTER PROCESSING

Soils processed for treatability studies will need to be stored in approved containers until final remediation, returned to the hole they came from, or packaged and sent for disposal.

It is assumed that 550 yd^3 (about 950 ton) of soil from the 100-F site will be processed as part of the soil-washing test. It should be noted that it is probably not necessary to process all of this soil to demonstrate soil washing and grinding for 100-F soils. However, DOE has agreed to remove by September 1995 all of the soil (550 yd^3) from a temporary storage unit where it was placed during excavation tests conducted in the fall of 1993.

The hole from which material was excavated at 100-F has since been backfilled. As a result it is assumed that the 100-F soil must be treated to meet standards for unconditional release before it can be used for backfill elsewhere. Since release standards have not been set for radioactive soils at Hanford, after processing, all of the 100-F soils will need to be managed as low level waste regardless of the effectiveness of the process. This means that all 100-F soil will need to be disposed of or stored in approved containers until cleanup levels are set.

About 120 yd^3 (200 tons) of soil will be processed from 100-D during Test #1 and Test #2, and as much as another 60 yd^3 will be processed during shakedown tests. Another 120 to 175 yd^3 (200 to 300 ton) will be processed from 100-C and 100-H areas combined.

After processing, coarse soils (> 2mm) from 100-D may be returned to the hole from which they were excavated as long as they are not designated as hazardous waste. Coarse soils from 100-C and 100-H may also be returned to the holes from which they were excavated as long as they are designated low level radioactive soils and are not regulated as hazardous waste. Based on characterization of soils and tests conducted to date, soils used in soil-washing tests are expected to be low level radioactive only. However, if the soils are designated as a mixed or hazardous waste they will be managed similarly to the 100-F soils.

For scheduling and cost comparisons, commercial storage units are assumed to be Terra Stor (Trade name of ModuTanks, Inc., Long Island, New York) units. These units were previously used for temporary storage of soils from the 116-F-4 excavation treatability test. Other types of temporary containment units may be fabricated or purchased. Costs and schedule for commercial storage units are the same as those for excavation tests conducted in FY 1993.

It is assumed that, after processing, all of the soil particles < 2 mm in diameter (sand and silt) from all areas will be stored near the 100-D site in LSA boxes. It is expected that all of this soil will be used in ex-situ vitrification tests scheduled to be conducted in September 1995.

Small LSA boxes (2 to 3 yd^3) would provide a desirable feed stream for the ex-situ vitrification test, as presently planned, since the boxes could be dumped directly to a hopper. However, over 150 small boxes will be needed to store as much as 350 yd^3

(600 ton) of soil for vitrification tests. Storage in larger containment units may be more practical if they could easily be fed to the vitrification unit.

2.4 PROCESSING

2.4.1 Soil Treatment System

It is assumed that the base system used for the pilot-scale soil-washing test will consist of the processes defined in DOE/RL 1994b. This includes a grizzly to separate > 150-mm rocks, a screening process to wash and separate particles at 25 mm and 2 mm, two 2-stage attrition scrubbers to treat < 2-mm material, and a water clarifier and recycle system. Soils would be transferred on conveyor belts, and real time radioactive monitoring instrumentation would be installed on the feed conveyor and conveyors for material greater than 0.25 mm.

The last part of the 100-D test will involve the use of electrolyte in the attrition scrubber to remove ^{137}Cs contaminants from soil particles. 100-F, 100-C, and 100-H tests may include electrolyte and/or applying chemicals heated to 90° C to chemically extract ^{137}Cs. This study assesses chemical vs. non-chemical treatment alternatives.

2.4.2 Surface Grinding

The study assumes that a ball mill will be used for treating contaminated particles greater than 2 mm in diameter and that the ball mill will be at least as effective as the centrifugal barrel used in 100-F bench-scale tests.

This assumes that it is possible to remove a thin uniform layer about 3 mm deep from rock surfaces using commercially available equipment. A thin surface was removed using the bench-scale centrifugal barrel (DOE/RL 1994a). However, results of these tests were specific to the samples processed; more grinding was required for higher initial radioactivity levels of cobble material. It is inconclusive whether a uniform thickness would be removed consistently using the centrifugal barrel, and the centrifugal barrel is not available at a pilot scale.

A ball-mill or comparable autogenous grinding process would likely be used for pilot-scale tests. This process may require more retention time than the centrifugal barrel, since it will have to be slowed down to prevent crushing all of the rock as opposed to grinding off a thin uniform surface.

Bench-scale tests using a ball mill are required to assess the feasibility and practicality of surface grinding prior to conducting a pilot-scale test using 100-F soils.

2.5 EQUIPMENT NEEDS

Up to now, equipment for field work has been loaned from the WHC Environmental Restoration Operations resource pool on a priority basis. Because of the tight schedule for obtaining equipment, it has been preferred to pre-stage soils as much as possible to free up equipment as much as possible. As a result, for this study it is assumed that all soils from 100-D, and 100-F would be stockpiled at the 100-D site prior to processing. This will minimize the need for a dedicated backhoe and/or front-end loader and trucks to excavate and transport soils during processing. However, this will also require storage capacity for over 1,000 tons of soil. Soil from each site would need to be stored separately.

With the transition of work to a new contractor and an expanding work scope to process additional soils, it may be desirable to acquire dedicated equipment and obtain dedicated operators for 100 Area soil-washing tests. This would reduce storage requirements prior to processing and alleviate test constraints due to resource limitations.

3.0 ALTERNATIVE DESCRIPTION

3.1 100-D

3.1.1 Transport

The 100-D soils will be excavated, stockpiled, and processed at the site. No transportation or packaging for transportation will be required.

3.1.2 Pre-Storage

After excavation, soils will be stockpiled. Containment alternatives for the piles include plastic-lined earth berms, low walled, open steel containers, or a plastic liner with no walls.

The primary purposes of containing the soils are to minimize contamination of the ground surface as much as possible and to ensure that contaminated soils excavated from the pit are not mixed with non-contaminated surface soils.

Regardless of the alternative chosen, the stockpiled soil will need to be covered when not in use. It is assumed a plastic cover will be used with sand bags or other weights or anchors placed around the tarp for wind protection.

3.1.3 Processing

A description of 100-D tests is provided in test procedures (WHC 1994b). The tests using 100-D soils will consist of two parts.

Test #1 will use water only as a separation medium. Soils will be sieved and sand particles will pass through a two-stage attrition scrubbing process. Water will be treated using a clarifier and flocculent agents, then recycled in the process.

Test #2 will be the same as Test #1 and will use the same process except an electrolyte solution will be added in the attrition scrubbing process.

In both Test #1 and Test #2, soils will be separated into 5 size fractions: > 150 mm, 150 to 25 mm, 25 to 2 mm, 2 to 0.25 mm, and < 0.25 mm. Samples will be analyzed from feed soils and each of the process piles.

3.1.4 Storage/Disposal

At the completion of the test, soils less than 2.0 mm in diameter will be stored in LSA. The soils will be used in exsitu vitrification tests scheduled to be conducted starting in September, 1995.

Soil particles greater than 2 mm in diameter will be returned to the hole at the conclusion of the test. Additional backfill material will be added as needed to close the site.

Effluent will be handled in accordance with the waste control plan.

3.2 100-F

3.2.1 Transport

100-F, 100-C, and 100-H soils will either be packaged in LSA containers for transport on a flat bed truck or transported in a dump truck enclosed in plastic to prevent dust migration. Calculations for each of these alternatives are included in Appendix A.

Transport in a dump truck would only be plausible if DOT requirements are not applicable for transport between sites in the 100 Areas (See Appendix B). WHC engineers believe that even though this does not strictly meet DOT requirements, there would still be no exposure or environmental concerns associated with this alternative since the radioactivity level of 100-F soils is below the 2,000 pCi/g DOT limit.

Large LSA boxes (32 yd^3) are available from commercial vendors for $10,000 - $15,000/box depending on features. The boxes could also be rented for about $2,000/box. These hold more volume and would require fewer trips than the smaller boxes, but they would also be more awkward to handle and would require bigger equipment for lifting and dumping soils compared to using the smaller LSA boxes. LSA boxes would be reused after dumping and could ultimately be used for long-term storage and/or disposal of soils. It is estimated that 4 boxes would be required to transport soils. Approximately 20 boxes would be needed to store all 100-F soils simultaneously.

The smaller boxes are the standard size. They cost $600/box. They are manageable with smaller, standard equipment and they could be stacked during transportation. Eight boxes can be loaded on a truck, transported, and dumped to a stock pile while eight additional boxes are loaded.

Two-hundred-seventy-five B-25 boxes would be needed to store all of the soil from 100-F simultaneously. This may be desirable, if the boxes are also used for disposal.

Fifty-five gallon drums could also be used, but these would be difficult and time consuming to fill because their openings are much smaller than those of LSA boxes. The only advantage of using drums is that at this time drums may be required to send soils to the W-025 facility for disposal. However, approximately 2000 drums would be required to store all of the soil from 100-F simultaneously.

3.2.2 Pre-Storage

After being transported to the 100-D site, soils will be stockpiled. Containment alternatives for the piles are the same as for 100-D (Section 3.1.2). They include: placing them in plastic-lined earth berms, low walled, open steel containers, or a plastic liner with no berm. Stock piles would be covered with the cover secured for all alternatives.

The primary purpose of containing the soils is to prevent contaminated soils from blowing and exposing workers or contaminating the ground surface. Each of the alternatives would perform equally well for this purpose. A second reason for containing the soils is to minimize contaminating the ground surface as much as possible, and to ensure contaminated soils from 100-F are not introduced to non-contaminated surface soils at 100-D.

3.2.3 Processing

The same system used for processing soils at 100-D would be used for 100-F soils. However, first soils would be processed through a ball mill or other grinder to remove the outer surface of contaminated rocks. This would be done using water only.

Bench-scale tests showed that to treat sand particles to meet test performance goals required two-stage attrition scrubbing with electrolyte followed by 1/2-strength chemical extractant. However, this would only clean an additional 10% of the soils. Estimated processing costs with and without chemicals are included in Appendix C.

Soils are expected to be analyzed and separated by size fraction as in the 100-D test.

3.2.4 Storage/Disposal

At the completion of the test, soils less than 2 mm in diameter will be stored in LSA boxes. The soils will be used in exsitu vitrification tests scheduled to be conducted starting in September, 1995.

Several alternatives may be considered for disposal of soils greater than 2 mm in diameter. As stated in section 2.0, it is assumed that since no cleanup levels have been established at Hanford for soils containing radionuclides, and since the hole at 100-F from which these soils were exhumed has been backfilled, all of the 100-F soil particles > 2 mm will have to be stored at the site or disposed of.

One alternative option would be to store in LSA boxes or covered stock piles all of the processed soil that is not used for exsitu vitrification tests. Since the soil is expected to be "clean," and radioactivity levels will be known, it follows that strict containment of the soils should not be needed. The soil would be stored until cleanup levels are established. At that time, if stored soils meet the cleanup levels they would be released from control and could be used as backfill at any site. If the soils do not meet cleanup levels, the soils would be disposed of appropriately.

This alternative appears to be more reasonable than immediate disposal of all of the processed material. Disposing of all of the soil just because cleanup levels are not established would probably not be considered a wise use of public funds. The primary disadvantage of this alternative is that if the soils are not determined to be "clean," additional costs will have been incurred to store soils prior to disposal.

Disposal options include sending the coarse soils to the Environmental Restoration Disposal Facility (ERDF), to W-025, or to low level burial grounds.

The ERDF is a mixed waste facility that is planned for bulk disposal of much of the Environmental Restoration Waste at Hanford. The facility has not been constructed and is not expected to be ready to accept waste until September, 1996. If this alternative is selected, the soils will need to be stored until the facility is operational. Current disposal costs for ERDF are estimated at $\$90/yd^3$.

W-025 is also a mixed waste facility. It has been permitted and constructed and is expected to be operational before treatability tests are completed. Currently, the facility permit requires that all waste sent to the facility be packaged for direct burial in drums or other containers. It is assumed that disposal costs will be about $\$135/yd^3$. This is 1.5 times higher than the cost for ERDF. W-025 is much smaller than the ERDF design and incorporates additional design features.

A final alternative is to dispose of soils to the low-level waste burial grounds, on-site. Disposal costs vary depending on the quantity of waste disposed at the facility over a given period of time. Costs typically range from \$60 to \$40 per ft^3. Current costs are $\$60/ft^3$ or $\$1,620/yd^3$. This cost will be used for comparisons.

3.3 100-C and 100-H

3.3.1 Transport

Alternatives are the same as for the 100-F soils.

3.3.2 Pre-Storage

Alternatives are the same as for the 100-F soils.

The primary purpose of containing the soils is to minimize contaminating the ground surface as much as possible, and to ensure contaminated soils from 100-C or H are not introduced to non-contaminated surface soils at 100-D.

3.3.3 Processing

To process 100-C soils would require a system similar to the system used for 100-F soils. A surface grinder for contaminated rocks may or may not be used for these tests depending on results of 100-F bench- and pilot-scale tests and depending on the radioactivity level of soils and distribution of contaminants.

The two alternatives for processing are whether or not to use chemicals in the system.

3.3.4 Storage/Disposal

At the completion of the tests, soils less than 2 mm in diameter will be stored in LSA boxes with a plastic liner. The soils will be used in exsitu vitrification tests scheduled to start in September 1995.

Soils greater than 2 mm in diameter will be returned to the hole from which they were excavated. This assumes that the soils are low-level waste only. If the soils were hazardous or mixed waste, they could not be returned to the site but would be handled similarly to the 100-F soil.

4.0 EVALUATION OF ALTERNATIVES

4.1 CRITERIA

No evaluation was necessary where only one alternative was presented. This was true for the 100-D test which has previously been defined. Where more than one alternative is presented, the following criteria were evaluated.

A. As Low As Reasonably Achievable (ALARA)/Safety
B. Cost
C. Schedule
D. Ease of Operation and Maintenance.

Each of the criteria were given an equal weight. Scores were assigned by ranking alternatives for each criteria. The best alternative is assigned the highest score. For example, if four alternatives are evaluated, scores would be 4, 3, 2, and 1 with "4" the best alternative and "1" the worst. The criteria were applied to each of the major tasks associated with the tests described in Chapter 3.0: Transport, Pre-storage, Processing, and Storage/Disposal.

4.1.1 ALARA/Safety

DOE Order 5400.5 requires that potential exposure to the public and workers resulting from all DOE facilities and activities must be ALARA. Similarly, DOE and WHC have continuously emphasized safety as the number-one priority for all jobs.

Scores are assigned subjectively by the author, based on a relative comparison of ALARA and safety for each of the alternatives.

4.1.2 Cost

Just enough cost information is presented to make a reasonable comparison between alternatives. Costs are for comparison purposes only, and should not be used for any other reason. Cost summaries are provided in Appendix B.

Scores to evaluate cost were assigned in inverse proportion to the cost of an alternative.

4.1.3 Schedule

Schedule is important to this project as tests are scheduled to start on March 31, 1995 and all soils from all ares need to be processed by July 31, 1995. Therefore, alternatives are compared for the relative time differences, if any, in implementing the alternative.

The highest scores were assigned for alternatives that can be implemented in the shortest period.

4.1.4 Ease of Operation and Maintenance

This is a catch-all category designed to evaluate performance and maintenance differences that are not already accounted for by cost or schedule evaluations.

The highest scores were assigned to alternatives that appeared to be the easiest to implement and maintain over the life of the project. Higher scores were also assigned for those alternatives that have the fewest obstacles to being implemented.

4.2 RESULTS

Scores and justification for scores, developed by five engineers within the WHC Environmental Restoration Division, follow.

4.2.1 Transportation and Packaging

Scores for each transportation and packaging alternative and criteria are shown in Table 4-1.

Table 4-1. Transportation and Packaging Evaluation.

ALTERNATIVE	CRITERIA				
	A	B	C	D	TOTAL
DUMP TRUCK AND PLASTIC COVER	1	4	3	4	12
LARGE LSA BOXES	4	3	3	3	13
SMALL LSA BOXES	3	2	2	3	10
DRUMS	2	1	1	2	6

A. ALARA/Safety
B. Cost
C. Schedule
D. Ease of Operation and Maintenance

The best scores for ALARA/Safety were assigned to large and small LSA boxes. LSA boxes are easy to load, require little or no manual handling, and would provide the least exposure to workers. They would also be the tightest containers for transporting soils between sites.

Drums were given the next highest score. Again, these are tight containers that would be expected to minimize exposure after packaging. Placing lids on drums and securing the lid should also be a low exposure task. However, approximately two-thousand 55-gallon drums would be needed for 100-F soil alone. This would require significantly more manual handling and result in the potential for more exposure to radioactivity than the LSA boxes and the potential for pinching fingers, back injuries, or other industrial safety problems.

The dump truck and plastic cover would likely be safer than using drums, but the potential for exposure would be greater. Placing plastic in the trucks and loading the soils would not be a problem. However, securing the plastic to form a sealed package would require manual effort. This would take some time and would likely present more of an occupational exposure concern than using the drums. The plastic would also not be as puncture resistant as drums or LSA boxes. It could tear or be punctured during transport and the potential, although still low, is higher for contaminated soils to be released during transportation as compared to using drums or LSA boxes. Based on past operations, the dump truck and plastic cover would likely be a physically safer operation than packaging drums.

Scores for cost are based on the following cost estimates. Hand written cost calculations and assumptions are included in Appendix B. Cost estimates are for comparison only and are not intended for any other purpose.

ALTERNATIVE	**COST**
Dump Truck and Plastic Cover	\$76.00/yd^3
Large LSA BOX	\$48.00/yd^3
Small LSA Box	\$127.00/yd^3
Drums	\$ assumed the highest cost/yd^3

The highest scores for schedule are assigned in progressive order from the largest to smallest container openings. While the dump truck may have a larger opening and will not require rigging equipment, it does require time to install and button up the liner for each load. Therefor equal scores are assigned for using a lined dump truck and transport using large LSA containers.

For ease of operation and maintenance the highest scores are assigned to the dump truck because no crane or rigging is required and soils will be more easily removed from the dump truck into stock piles. Drums are given the lowest score due to the number of drums required and the difficulty in finding a piece of equipment to feed the drums.

4.2.2 Pre-Storage

Scores for each pre-storage alternative and criteria are shown in Table 4-2.

The best scores for ALARA/Safety were assigned to the earth berm and low wall steel containers. This is because each of these alternatives would provide a berm for containment of liquids, if any, discharged from the process piles. The plastic liner, while assigned a lower score because it would not provide containment of liquids, will still provide the same level of protection to cover stockpiled soils and thereby prevent dust exposure, and it would isolate contaminated soils from the 100-D area surface soil. Water run-off from the piles due to rain or moisture in the soils is expected to be negligible or insignificant during the operating period.

Table 4-2. Pre-Storage Evaluation.

ALTERNATIVE	CRITERIA				
	A	B	C	D	TOTAL
EARTH BERMS W/COVER	2	2	2	2	8
STEEL CONTAINERS W/COVER	2	1	1	1	5
PLASTIC LINER W/COVER	1	3	3	2	9

A. ALARA/Safety
B. Cost
C. Schedule
D. Ease of Operation and Maintenance

Specific costs for the alternatives were not determined. All of the five engineers who evaluated alternatives indicated that the lowest cost would be for a plastic liner only, followed by earth berms, and the highest cost would be for steel containers. Hence the scores are assigned as follows:

ALTERNATIVE	**COST SCORE**
EARTH BERMS W/COVER	2
STEEL CONTAINERS W/COVER	1
PLASTIC LINER W/COVER	3

For the "schedule" criteria, scores are assigned subjectively by comparing the time it would take to implement each of the alternatives.

For ease of operation and maintenance the highest score is assigned to the earth berm, followed by the plastic liners, and finally the steel container. There will be more construction required for the container, and it would be more complex to disassemble, decontaminate, and remove at the conclusion of the project.

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4.2.3 Processing

Scores for each processing alternative and criteria are shown in Table 4-3.

Table 4-3. Processing Evaluation.

ALTERNATIVE	CRITERIA				
	A	B	C	D	TOTAL
WITH CHEMICALS	1	1	1	1	4
WITHOUT CHEMICALS	2	2	2	2	8

A. ALARA/Safety
B. Cost
C. Schedule
D. Ease of Operation and Maintenance

The best scores for ALARA/Safety were assigned to no chemicals. This is because chemicals present potential toxicity problems, introduce more contaminants into the secondary waste stream, and, for this application, require heating to 90° C, which presents more of a safety hazard.

Scores for cost are based on cost estimates for processing 100-F soils with and without chemicals and are included in Appendix C. Cost estimates consider treatment costs and disposal costs if, after processing, the remaining "contaminated" soils are disposed of to the W-025 Trench or ERDF. Cost estimates are for comparison only and are not intended for any other purpose.

DISPOSAL ALTERNATIVE	**COST** W/CHEMICALS	W/O CHEMICALS
W-025	2,526	2,165
ERDF	2,517	2,153

Processing and disposal costs for 100-D soils are also included in Appendix C. A significant difference in test costs and long term processing costs is noted with and without chemicals and with and without grinding of rocks.

The highest scores for schedule are assigned to the "no chemicals alternative." This is primarily because additional equipment would need to be purchased to perform chemical extraction tests. Chemical extraction processes may also impact production rates.

For ease of operation and maintenance the highest scores are assigned to "no chemicals." A chemical system would require significantly more maintenance and more caution during operations. It would require storage for chemicals before and after tests. Chemicals would also complicate the water treatment system required to circulate and reuse process water. Also, additional treatment may be required prior to discharge or disposal of secondary waste.

4.2.4 Storage/Disposal

Scores for each storage/disposal alternative and criteria are shown in Table 4-4. This evaluation applies to the > 2 mm soils from 100-F that are expected to be "clean" after processing.

Table 4-4. Storage/Disposal Evaluation.

ALTERNATIVE	CRITERIA				
	A	B	C	D	TOTAL
STORE UNTIL CLEANUP LEVELS ARE SET	1	4	3	1	9
DISPOSE TO ERDF FACILITY	2	3	1	2	8
DISPOSE TO W-025 FACILITY	2	2	2	2	8
DISPOSE TO LOW LEVEL BURIAL GROUND	2	1	3	2	8

A. ALARA/Safety
B. Cost
C. Schedule
D. Ease of Operation and Maintenance

For ALARA/Safety all alternatives except storage were assigned the same score because no exposure could result once the soils are sent to disposal.

Scores for cost are based on cost estimates for each disposal alternative included in Section 3.2.4. Cost estimates are for comparison only and are not intended for any other purpose. Storage was assigned the highest score because, in the event that soils are clean (which is expected), significant disposal costs will have been avoided.

The highest scores for schedule are assigned to storage and disposal to the low level burial ground. This is because these alternatives could be implemented immediately upon completion of the test. Disposal to ERDF is assigned the lowest score because the facility has not yet been built and will not be available until September 1996.

For ease of operation and maintenance the highest scores are assigned to each of the disposal alternatives. Storage would require occasional monitoring and more maintenance of the temporary storage facility.

4.2.5 Summary

The highest scores were assigned to the following alternatives for each task.

TASK	ALTERNATIVE
Transport and Packaging	Large LSA Boxes
Pre-Storage	Plastic w/Cover Earth Berm w/Cover
Processing	No Chemicals
Storage and Disposal	Store until Cleanup limits are set

If scores were based on ALARA/safety only, an earth berm with cover would be preferred over plastic with no berm. Also, direct disposal of processed coarse soils would be preferred over storing until cleanup limits are set. There was no difference in scores for the disposal alternatives although the potential for exposure is higher while storing soils. Since processed soils are expected to meet cleanup standards when set, there should be little or no exposure even if the soils are not contained. Therefore, the ALARA difference between these alternatives is insignificant.

If scores were based on cost only, the preferred alternative for pre-storage would be to use plastic with no berm, and storage until cleanup limits are set would be significantly less costly than any of the disposal alternatives.

5.0 DESCRIPTION OF RECOMMENDED ALTERNATIVE

Based on the assumptions made in this study and the alternative evaluations, the following scenario is recommended. The scenario basically involves setting up the soil-washing pilot plant at 100-D and transporting soils from other sites to the plant.

5.1 TRANSPORT

The 100-D soils will be excavated, treated and returned to their original excavation after treatment. This process is discussed in more detail in the pilot-scale test procedures.

All other soils will be transported to the 100-D site. Soils will be transported in large LSA containers that are DOT compliant. Each container will be filled at the origin, dumped at 100-D, and reused to transport more soils.

5.2 PRE-STORAGE

Soils from sites other than 100-D will be transported to the 100-D site in as timely and efficient a manner as possible to avoid unnecessarily tying up equipment. This will require a temporary storage facility for staging soils at the 100-D site. This facility will be constructed with soil berms and a plastic tarp. The stockpiled soils will be covered with a tarp to prevent fugitive dust. Soils will be stored in this facility until they are processed through the soil-washing plant. Only one site at a time will have soils stored in this facility.

Due to high winds at Hanford, it may be necessary to build a temporary structure (ie. tent) to house soils for pre-storage. Application of chemical suppressants to control dust is not recommended due to their negative impact on solids separation and water treatment processes.

5.3 PROCESSING

The processing of 100-D soils with the soil-washing plant will consist of two general approaches; wet sieving followed by attrition scrubbing of the soils less than 2 mm, and autogenous grinding of the surfaces of the material greater than 2 mm. There will be no chemical extraction attempted during any of these tests.

100-C, 100-H, and 100-F soils will be processed using water only. Attrition scrubbing with electrolyte was shown to be ineffective in electrolyte-complicated water treatment in 100-F bench-scale tests (WHC 1994a). 100-D tests showed that electrolyte treatment reduced radioactivity levels to 30 pCi/g and attrition without electrolyte reduced radioactivity levels to 37 pCi/g. Therefore, attrition without electrolyte may be nearly as effective as attrition with electrolyte. This will be further verified in the 100-D pilot test.

5.4 STORAGE/DISPOSAL

It is expected that two types of material will come out of the system after processing: "contaminated" material and "clean" material. The "contaminated" material will consist of the fines originally in the soils and the fines generated during the scrubbing and grinding processes. These fines will be stored in LSA boxes until they are utilized in a pilot-scale vitrification test.

Small B-25 boxes are recommended because they will be easier to feed to the hopper for vitrification tests. This will require approximately 150 B-25 LSA boxes for storing soils from 100-D, 100-C, 100-H, and 100-F.

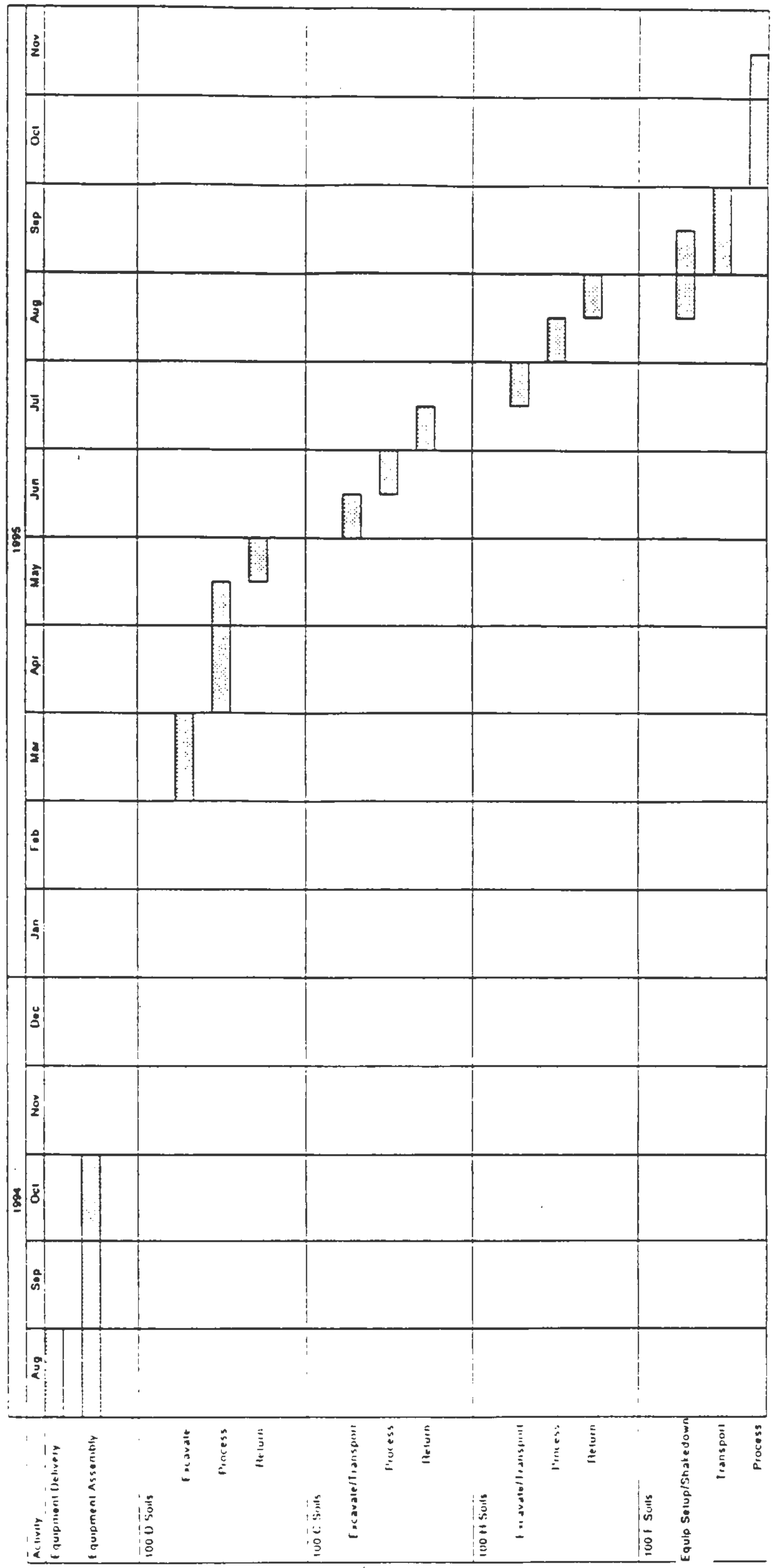
Since there are no clean up levels established, the "clean" material cannot be released after processing. For sites other than the 100-F site, these soils will be returned to the excavated site they came from as long as they do not contain hazardous constituents. Since the excavated site at 100-F was backfilled, 100-F soils > 2mm in diameter will be stored in a bermed, lined facility after processing. The soils will be covered with a tarp to prevent fugitive dust. The soils will remain in storage until cleanup standards are established and will then be released, further treated, or sent to disposal.

5.5 SCHEDULE

Figure 5-1 shows the proposed schedule for completion of the 100 Area soil-washing tests being considered. A number of assumptions were made in developing this schedule. Many of the assumptions are discussed in Chapter 2.0 of this study and others will be addressed here.

The schedule indicates that equipment delivery will conclude at the end of August 1994. There is additional equipment being purchased (ie. multi-deck screen) for which the delivery schedule is unknown. Current plans are to require a delivery date of September 1, 1994.

Figure 5-1. Proposed Schedule for 100 Area Pilot-Scale Soil-Washing Tests.



The schedule shows equipment assembly going on until November 1, 1994. Although assembly will be ongoing as equipment arrives, WHC feels that it will not be completed before November 1.

The period between November 1, 1994 and March 1, 1995 is open due to winter weather. Additional equipment and precautionary measures to "winterize" the system would be required to operate in the winter. WHC believes this would unnecessarily complicate and prolong the treatability test.

Processing of the 100-D soils is scheduled to begin March 31, 1995. Excavation of these soils is scheduled for the month prior to processing. It is not likely that a full month will be required; however, the weather is unpredictable and may have an affect on the schedule. Processing of these soils, including the shakedown period for the equipment, is scheduled for 6 weeks (March 31, 1995 to mid-May 1995). At the end of processing, a two week period is set aside to finish returning the 100-D soils to the original excavation and make any preparations to the site and system that may be required before the next test.

Upon completion of the processing of the 100-D soils, excavation and transport of the 100-C soils can begin. The assumption here is that the same personnel (soil-washing personnel) will be required to do this work. It cannot, therefore, be scheduled any sooner. If other personnel were involved, and a separate pre-storage facility is constructed, 100-C soils could be excavated and transported sooner. This is also true of the 100-H, soils which are scheduled for excavation and transport from July 15 to July 31, 1995.

Once the 100-C soils are ready to process, a two-week period is allotted for processing. Two weeks are also scheduled to transport the soils back to the 100-C excavation. The process is then repeated for the 100-H soils.

As with the other tests, a two week period is allotted for returning the 100-H soils to their excavation. During this period, the required equipment setup for 100-F soils will begin. This is scheduled for 4 weeks and includes shakedown tests. Depending on what may be required (based on future bench-scale tests) this time may have to be altered.

Beginning September 1, 1995, the 100-F soils would be transported to the 100-D site. At this time, it is felt that this could be done in conjunction with the equipment setup and shakedown tests. Because of the amount of soils involved and the method of transport (LSA boxes), a full month is set aside to complete this work.

Processing of the 100-F soils is scheduled for six weeks, beginning October 1, 1995. The six-week time frame is a rough estimate based on 10 ton/h for 5 h/day with contingency time included. It is unknown at this time if a production rate of 10 ton/h is reasonable for the rock-grinding process. This would complete processing by November 15, 1995. After processing the 100-F soils, all the soils will be placed in a storage facility until cleanup levels are determined.

The schedule shows that only two tests (100-D and 100-C or 100-H) could be completed by July 31, 1995.

To conduct 100-F tests, the schedule requires the following between July, 1994 and mid-August 1995.

- A bench-scale ball-mill will be purchased
- Bench-scale ball-mill tests for 100-F soils will be conducted
- Tests will be successful
- Scale up of the ball-mill to process soils at a rate of 10 ton/h is possible
- A pilot-scale ball-mill will be acquired
- The ball-mill will be integrated into the 100-D plant.

Based on previous procurement experiences at Hanford, and given that procurement will not start until bench-scale tests are completed successfully, it is felt that this schedule is achievable.

6.0 REFERENCES

DOE-RL, 1994a, *100 Area Soil-washing Bench-Scale Tests*, DOE/RL-93-107, Draft A, U. S. Department of Energy, Richland Operations, Richland, Washington.

DOE-RL, 1994b, *300-FF-1 Operable Unit Remedial Investigation Phase II Report: Physical Separation of Soils Treatability Study*, DOE/RL-93-96, Rev. 0, U. S. Department of Energy, Richland Operations, Richland, Washington.

Dorian, J.J. and V.R. Richards, 1978, *Radiological Characterization of the Retired 100 Areas*, UNI-946, United Nuclear Industries, Richland, Washington.

WHC, 1994a, *100 Area Soil washing: Bench-Scale Tests on 116-F-4 Pluto Crib Soil*, WHC-SD-EN-TI-268, Rev. 0, Westinghouse Hanford Company, Richland Washington.

WHC, 1994b, *Soil-washing Field Test Procedure for the 100-DR-1 Operable Unit*, WHC-SD-EN-TI-255, Rev. 0, Westinghouse Hanford Company, Richland Washington.

APPENDIX A

PACKAGING AND SHIPPING RECOMMENDATIONS

9 1 3 3 4 1 0 0 5

Westinghouse Hanford Company | **Internal Memo**

From: Packaging Safety Engineering | 84100-94-WAM-183
Phone: 376-0422
Date: June 1, 1994
Subject: PACKAGING RECOMMENDATIONS FOR PLUTO CRIB RETRIEVAL

To: R. T. Moore H6-01

cc: J. G. Field G2-02
J. E. Mercado G2-02
J. E. Rugg H6-30
J. W. Thornton G2-03
E. F. Votaw G2-02
WAM File/PSE Route/LB

Reference: cc:mail, R. T. Moore to W. A. McCormick, "Transportation and Packaging Investigation For F Area Wastes to be Treated at D Area," dated May 1994.

By March of 1995, it is planned that approximately 540 cubic yards of radioactively contaminated F Area soil from the Pluto crib will need to be transported to the D Area for treatment and soil washing. After transporting to the D Area, two separate material streams will be generated. One will be essentially clean soil, the other will contain radioactive material concentrated by the treatment process.

The purpose of this memo is to categorize the three different materials from a transportation perspective, and to provide recommendations for safe and cost effective transport for each phase of this operation. Based on the reference, the materials to be transported are identified as the "feed" material to be transported initially from F Area, the "cleaned" material resulting from the soil wash, and the "disposal" material which will be the radioactive component resulting from the treatment process.

Based on the radioisotopic distributions, soil masses and volumes, and weight fractions provided in the reference, the three waste streams were categorized. The attachment provides the tabulated output from this analysis. The feed material is classified as being Low Specific Activity (LSA) radioactive material. The clean material does not meet the minimum activity level of .002 microcuries per gram as defined by the Code of Federal Regulations, 49 CFR, Part 173 and therefor is not regulated for transportation purposes. The disposal material is classified as LSA radioactive material.

112 #

Further analysis shows that in order to ship the feed material as a Limited Quantity (LQ) shipment, no more than 51 kilograms may be packaged in any one shipping container. In order to ship the disposal material as an LQ amount, no more than 18 kilograms of material may be packaged in any one container.

40 #

49 CFR Part 173.425 provides the packaging requirements for LSA materials. To summarize, this Part requires that the material be packaged in a Type A container for non-exclusive use shipments. For exclusive use (no other hazardous materials on the transporter) shipments, a strong, tight container is required. This Part further stipulates that it is the responsibility of the shipper to ensure that the packaging is strong, tight. Since both the feed and the disposal materials will be transported onsite and north of the Wye barricade, it is recommended that a strong, tight container be used for bulk transport. At minimum these containers should exhibit the following characteristics. They should be manufactured from minimum A36 carbon steel. They should have a gasketed, mechanically fastened lid closure system. They should be capable of being tied-down to the transport vehicle meeting the requirements of 49 CFR Part 393. Lastly, the containers should be capable of being removed from the transporter safely by meeting the requirements of the Hoisting and Rigging manual.

Of additional note, there are several container manufacturers that can provide containers which meet the above recommended requirements in sizes to fit the required volumetric needs of this project. Some will even provide strong, tight certification if requested. A purchase specification will be all that is required to initiate the procurement process. Packaging Design Engineering can provide this service.

In regards to the clean material; as stated earlier this will not be regulated as hazardous material by transportation regulations. Unless there are some other, more conservative regulatory requirements for the Hanford site, this material may be transported by any suitable means, such as a dump-truck. It may also be transported in the same containers used to transport the feed and/or disposal material, provided the containers are decontaminated prior to use.

Unless there is a need for offsite shipment for sampling purposes, or some other need to ship very small quantities of the feed or disposal material onsite, there is no real benefit in trying to ship LQ quantities. If a need is foreseen to ship an LQ amount of material, there are a large variety of packagings which are suitable and readily available.

Please feel free to contact either myself at 376-0422, or J. G. Field at 376-0781 if you have any further questions or comments.

W. A. McCormick
Advanced Engineer
Packaging Safety Engineering

dmr

Attachment

9 . [illegible] 0 0 7

84100-94-WAM-183
ATTACHMENT
3 Pages

Evaluation of 116-F-4 Soil, before and after washing

	feed	after soil wash: cleaned	after soil wash: disposal
volume (m3)	412	271	93
mass (g)	7.42E+08	4.87E+08	1.67E+08
density (g/m3)	1.80E+06	1.80E+06	1.80E+06
weight fraction	1	0.657	0.343
activity fraction	1	0.04	0.96
activity (pCi/g)			
Co-60	5.78E-02	3.49E-03	1.62E-01
Cs-134	9.93E-02	6.00E-03	2.78E-01
Cs-137	1.11E+03	6.69E+01	3.10E+03
Eu-152	3.95E+00	2.39E-01	1.11E+01
Eu-154	1.11E+01	6.69E-01	3.10E+01
Eu-155	1.01E+01	6.13E-01	2.84E+01
Sr-90	7.53E+02	4.55E+01	2.11E+03
U-238	1.30E+00	7.85E-02	3.64E+00
Pu-239/240	3.50E+01	2.11E+00	9.79E+01
total	1.92E+03	1.16E+02	5.38E+03
	LSA	not radioactive	LSA

DON'T SAY IT — *Write It!*

DATE: June 7, 1994

TO: R. T. Moore H6-01

FROM: W. A. McCormick G2-02

Telephone: 376-0422

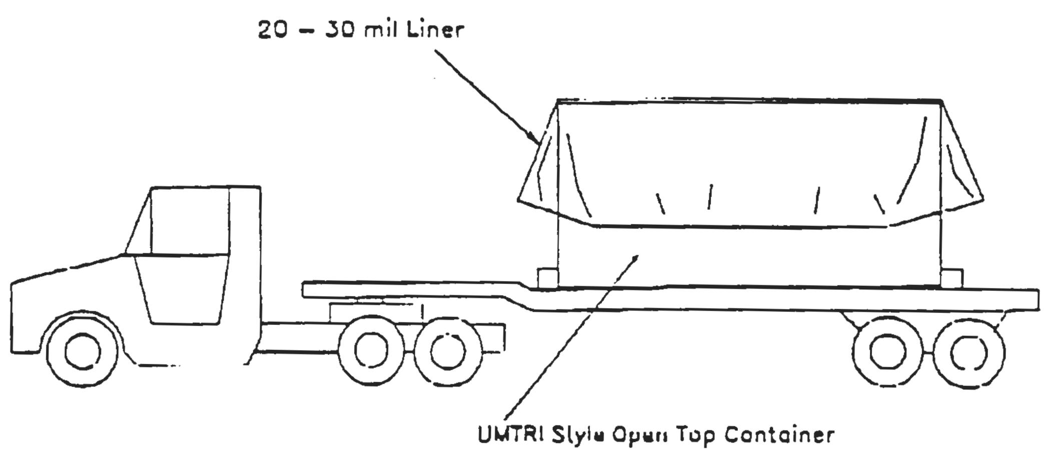
cc:

SUBJECT: PROPOSAL FOR LOW ACTIVITY TRANSPORT USING PLASTIC LINER

As I understand it from our conversation yesterday, you are proposing that for the transport of low activity material from various locations in the outer areas to D Area, a container similar to that used at the Grand Junction uranium mill tailings retrieval project (UMTRI container) be utilized.

Since the UMTRI container does not have a lid, and the use of a surfactant is not practical here at Hanford, we would line the container with some type of plastic or poly liner, and fill the container. After filling, the overlapping liner would be folded over the payload and taped closed. The figure below depicts the basic arrangement as I see it prior to closure.

Low Activity Transport Proposal Schematic



In discussions with Jim Field and others, my understanding is that most of the material targeted for transport is at or below the Department of Transportation (DOT) threshold activity of .002 microcuries per gram. However, the Hanford lower bounds for radioactive material control is lower. Therefor we have a situation where some of the material, though not regulated by DOT, cannot be free released as unregulated material onsite.

I believe that the proposed method for transporting these materials may be worth investigating. However, a study should be done to ascertain whether or not the operation will maintain ALARA and whether it will yield a cost savings over using a container with a mechanically fastened lid. Because of the somewhat awkward task of folding and taping the liner, worker exposure may increase using this method. Additionally, the disposal cost of the plastic must be considered, as it is doubtful it could be re-used.

For material whose specific activity is clearly above the DOT regulatory threshold defining radioactive material (.002 μci/g) (49 CFR 173.403), this alternative will probably not be approved without analyzing the radiological risk and dose consequence involved with the operation. Because this would have to be done for each identified site, unless the material is Type A or Type B the time and expense involved to do these analyses will probably outweigh simply purchasing a strong, tight container.

- COST ABOUT A PUSH
- ALARA BETTER WITH MECH. FAST. LID.

APPENDIX B

COST ESTIMATES FOR PACKAGING, TRANSPORTATION, AND PRE-STORAGE

KTM
6/7/94

1/3

850 CY FROM "F" → "D"

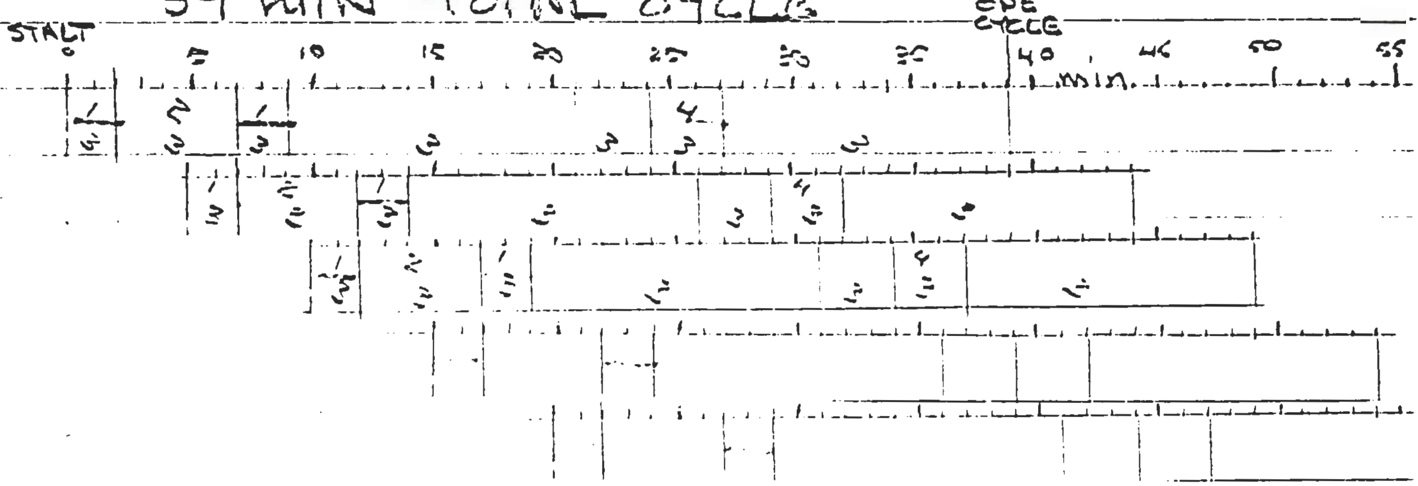
(DUMP TRUCK w/ LINER)

ASSUME:

- 6 MI ONE WAY
- 30 MPH AVG TRVL SPEED
- 4 min LOAD + 1 min TURN & SPOT AT "F"
- 3 MIN TURN SPOT & DUMP AT "D"
- USE DUMP TRUCK w/ 20-30 MIL LINER (CLOSED TOP)
- 3 MIN DECON REAR OF TRUCK AT "D"
- USE 966 LOADER AT "F"
- 2 min TO PLACE LINER
- 2 min TO CLOSE LINER

CYCLE TIME:

2 min PLACE LINER
5 min TURN/SPOT/LOAD @ "F"
2 min CLOSE LINER
12 min TRAVEL TO "D"
3 min TURN/SPOT/DUMP @ "D"
3 min DECON @ "D"
12 min TRAVEL TO "F"
39 min TOTAL CYCLE



39 min CYCLE/5 min LAG = 8 TRUCKS
8 TRUCK CYCLE USES 40 min + 39 min = 79 min (1 HR 19 m

5 1/2 HR OPER TIME/DAY (330 min) PER 8 HR SHIFT
330/79 = 4.2 CYCLES OF 8 TRUCKS AT 15 CY/LOAD
(~4) CYCLES (8) TRUCK 15 CY = 480 CY. 550 CY/480 CY = 1.15 SHIFTS

CREW AT "F"
1) LOADER OPERATOR – 1
LINER HANDS – 2
HPT – 1
OTHER (SPOTTER ETC.) – 1
5

CREW @ "D"
DECON HANDS – 2
OTHER (SPOTTER ETC) – 1
3

TRUCK DRIVERS – 8

ASSUME 2 SHIFTS FOR MTL MOVE (1.15 ACTUAL)
1 SHIFT TRNG
1 SHIFT MOB/DEMOB
4 SHIFTS TOTAL

8 DRIVERS + 5 AT "F" + 3 AT "D" = 16 EMPLOYEES
(16)(4 SHIFTS) 8 HR/SHIFT = 512 M.H.
(512) $23.00/HR (TEAMSTER RATE) = $12.1K $12.1K + 25% G&A C.S.P. = $15.2K

EQUIPMENT ?

1 EA 966 CAT LOADER – 2 SHIFTS AT 30.00/HR M&O = 2.2K
+ 1 WEEK RENTAL (1900.00)

8 EA 15 CY BELLY DUMPS – 3 SHIFTS AT 15.00/HR M&O = 8.[illegible]
+ [illegible] RENTAL ([illegible])

DECON EQPT (L.S.) — 2^K

20-30 MIL LINERS

160# TOP & BOTTOM + 450# SIDES ≅ 600#

600# @ 25¢/SF = 150$/LOAD (37 LOADS) — 5.6^K

$2.2^K + 8.6^K + 2.0^K + 5.6^K = 18.4^K$

18.4^K + 15.2% MPR = 21.2^K

21.2^K + 25.5% G&A/GSP = 26.6^K

$26.6^K + 15.2^K = 41.8^K$ TOTAL FOR 550 CY.

41.8/550 CY = 76$/CY. (DUMP TRUCK & PLASTIC COVER

ETM
6/14/94
1/3

550 CY. F → D 11015

(LARGE LSA BOX W/TAILGATE & REMOVABLE LID)

ASSUME:

- 6 MIL ONE WAY
- 30 MPH TRVL SPEED
- 6 min TO LOAD AT F
- 1 min TO REMOVE LID AT F
- 1 min TO TURN & SPOT AT F
- 1 min TO REINSTALL LID AT F
- 12 min TRAVEL TO D
- 1 min TO TURN & SPOT AT D
- 2 min TO DUMP AT D (ASSUME LID IS NOT REMOVED)
- 12 min RETURN TRIP TO D
- USE (4) 32 CY (27 CY LOAD) LARGE LSA BOXES

CYCLE TIME:

1 min TO TURN & SPOT AT F
1
6
12
1
2
12 TO TRAVEL D → F

35 min

4 TRUCK CYCLE USES (4)(1+1+6+1) min + 35 min
= 36+35 = 71 min (1 HR 11 min)

ASSUME
5 1/2 OPER TIME/DAY (330min) IN 8HR SHIFT
330/71 = 4.6 CYCLES ON 4 LARGE LSA BOXES AT 27CY/LOAD

(4 1/2 CYCLES)(4 BOXES)(27CY) = 486 C.Y./SHIFT
550/486 = 1.13 SHIFTS

CREW AT "F"
LOADER OPERATOR - 1
FORKLIFT OPERATOR - 1
HPT - 1
OTHER - 1
4

CREW AT "D"
OTHER - 1
1

TRUCKDRIVERS - 4

ASSUME 2 SHIFTS TO MOVE MTL
1 SHIFT TRNG
1 SHIFT MOB/DEMOB
4 SHIFTS TOTAL

4 DRIVERS + 4 AT F + 1 AT D = 9 EMPLOYEES
(9)(4 SHIFTS)(8HR/SHIFT) = 288 MHS
(288)(23.65) + 25.5% = 8.5K

6/14 3/5

EQUIPMENT

(1) 966 LOADER 2 SHIFTS AT 20.00 M&O = 2.2K
+1 WK RENTAL (1900.00)

(4) TRACTORS 2 SHIFTS AT 20.00 M&O = 6.0K
+1 WK RENTAL (1200.00)

(4) TRAILERS 2 SHIFTS AT 10.00 M&O = 2.2K
+1 WEEK RENTAL (400.00)

(4) LG LSA BOXES W/LID 1 WEEK RENTAL @ 200.00 = 0.8K

(1) ALL TERRAIN FORKLIFT 2 SHIFTS @ 20.00 M&O = 1.1K
+1 WK RENTAL (800.00)

12.3K

12.3K + 15.2% + 25.5% = 17.8K (EQPT W/ADDERS)

17.8K EQPT + 8.5K LBR = 26.3K FOR 550 CY.

$26.3K/550 = 48.00/C.Y. (LG LSA BOXES) (INCLUDES RENT THE BOXES)

SEE OPT. F→D1 1 TO 1 8
(IN SMALL LSA BOXES - B-25's)

ASSUME:

- 6 mi ONE WAY
- 30 MPH TRUCK SPEED
- USE (3) TRACTOR/TRAILERS w/8 B-25's/LOAD
- USE 245 HOE AT F TO FILL B-25's & TO LOAD THEM
- 1 min TO TURN & SPOT TRUCK
- 2 min TO RIG EACH BOX @ F & @ D
- 1 min TO SET EACH BOX ON TRAILER @ F
- 2 min TO BOOM EACH BOX DOWN @ F
- 1 min TO UNBOOM EACH BOX @ D
- 1 min TO SET EACH BOX OFF AT D
- 2 min TO FILL B-25 @ F
- USE FORKLIFT AT D TO UNLOAD B-25's
- BUY B-25's

CYCLE TIME:

* 16 min.	FILL 8 B-25's AT F
* 16	RIG 8 " " "
1	TURN & SPOT AT F
8	SET 8 " ON TRAILER
16	BOOM DOWN 8 B-25's ON TRAILER
12 min.	TRAVEL TO D
1	TURN & SPOT AT D
8	UNBOOM 8 B-25's
~~16~~	~~RIG " "~~ (USE FORKLIFT)
8	SET OFF B-25's AT D
12 min	TRAVEL TO F
*66 min	(ASSUMING CONTAINERS ARE FILLED & RIGGED WHILE TRUCKS ARE IN TRANSIT.

3 TRACTOR/TRAILER CYCLE USES 3(1+8) + 66 min
= 93 min

5 1/2 HR OPER. DAY = 330 min
330/93 = 3.5 CYCLES AT (3 TRUCKS)(8 B-25'S/TRUCK)
(24 B-25'S) 3.5 CYCLES = 84 B-25'S/SHIFT
EACH B-25 ≅ 2 CY. 84(2) = 168 CY./SHIFT
550/168 = 3 1/4 SHIFTS

CREW AT F		CREW AT O	
BACKHOE OPERATOR	1	FORKLIFT OPER.	1
RIGGERS/LID HANDLER	2	HPT	1
HPT	1	OTHER	1
OTHER	1		
	5		3

TRUCK DRIVERS — 3

5 + 3 + 3 = 11 EMPLOYEES

ASSUME 4 SHIFTS TO MOVE MTL
1 SHIFT TRNG
1 SHIFT MOB/DEMOB
6 SHIFTS TOTAL

(11 EMPLOYEES)(6 SHIFTS)(8 HRS/SHIFT) = 528 M.H.
(528)(23[illegible]) = [illegible] = 15.[illegible]K

EQUIPMENT:

(1) 245 HOE — 4 SHIFTS AT 65.00/HR M&O = 8K
+ 1 WK RENTAL (6000.00)

1 FORKLIFT — 4 SHIFTS AT 20.00/HR M&O = 1.4K
+ 1 WK RENTAL (800.00)

(3) TRACTORS — 4 SHIFTS AT 20.00/HR M&O 5.5K
+ 1 WK RENTAL (1200.00)

(3) TRAILERS — 4 SHIFTS AT 10.00/HR M&O 2.6K
+ 1 WK RENTAL (400.00)

B-25 BOXES — 550 CY / 2 CY PER BOX = ~~275~~ BOXES ~~146.9K~~ 25.6
48 (~~275~~) 534.00

TOTAL ~~164.4K~~

~~164.4K~~ (43.1) + 15.29% + 25.5% = ~~238K~~ (60.6) EQPT

~~238K~~ EQPT + 15.1K LBR = ~~254K~~ (70.1) FOR 550 C.Y.

~~254K~~ (70.1) / 550 = 461.00 (127) / C.Y. (B-25 BOXES) (INCLUDES BUYING THE B-25'S)

APPENDIX C

COST ESTIMATES FOR PROCESSING WITH AND WITHOUT CHEMICALS

Table C-1. Cost X $1,000, Estimates for Processing 100-F and 100-D Soils (Costs are for comparison purposes only).

ITEM	100-F W/ CHEMICALS	100-F W/O CHEMICALS	100-D
Soil Processed	930	930	120
Soil Feed	10 ton/hr	10 ton/hr	10 ton/hr
Anticipated Clean Soil[1]	66%	55%	84%
Anticipated Soil to Disposal %	34%	45%	16%
Operating[2] Time, hr	150	150	50
Operating Power, kW	640	170	80
Equipment Costs, $			
Coarse Screen	35	20	20
Attrition Scrubbers	45	60	60
Ball Mill	800	800	0
Dewatering Screen	25	15	15
Clarifier and Vacuum Filter	335	335	335
Spiral classifiers	55	60	60
Extraction System	315	0	0
Wash Water Treatment System	100	60	60
Miscellaneous	100	100	100
Total Equipment Cost	1,810	1,450	650
Operation and Maintenance			
Basic O&M[3]	180	180	180
Analytical[4]	500	500	250
Electricity[5]	6	2	< 1
Extraction or attrition chemical[6]	5	0	1
Ion exchange resin, @ $100/CF[7]	< 1	0	0
Total O&M cost	691	682	431
Total Processing Cost	2,501	2,132	1,081

Notes for Table C-1

CF cubic foot
O&M operation and maintenance

1. Based on results shown in DOE/RL 1994, and WHC 1994.

2. Includes shake down time. Based on a processing rate of 10 ton/hr.

3. Assumed to be 10% of capital costs.

4. Rough estimate based on 100-D bench-scale and 300-FF-1 onsite and offsite laboratory costs. Assumes samples will be taken from 5 locations for every 20 tons of soil processed. 10% of the samples taken will be sent to offsite laboratories.

5. Cost @ $0.06 per kWh

6. Extraction by non-toxic, biodegradable, organic acid, white powder, at $1.82/lb. Estimated use would be 242 lb/hr. Attrition by ammonium citrate and citric acid at $0.50/lb.

7. Mixed bed ion exchange resin estimated use rate of 0.015 CF/ton soil processed.

Table C-2. Treatability Test Processing and Disposal Costs.

ITEM	100-F W/ CHEMICALS	100-F W/O CHEMICALS	100-D
DISPOSAL COST, $/ton			
W-025	50	50	50
ERDF	80	80	80
SOIL DISPOSED, tons	315	420	20
DISPOSAL COST, $ X 1,000			
W-025	25	33	2
ERDF	16	21	1
TEST PROCESSING + DISPOSAL COST X $1,000	2,526	2,165	1,083

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Table C-3. Estimated Full scale processing and disposal costs for soil from 100-F and 100-D.

ITEM	100-F W/ CHEMICALS	100-F W/O CHEMICALS	100-D
Rough Processing Cost, $/ton	80	30	20
Cost to Process 1,000,000 tons, $ X 1000.	80,000	30,000	20,000
Amount of soil to Dispose of after processing	340,000	450,000	160,000
DISPOSAL COST, $ X 1,000			
W-025	27,200	36,000	12,800
ERDF	17,000	22,500	8,000
TEST PROCESSING + DISPOSAL COST X $1,000			
W-025	107,200	66,000	32,800
ERDF	97,000	52,500	28,000

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References

DOE-RL, 1994, *100 Area Soil-Washing Bench-Scale Tests*, DOE/RL-93-107, Draft A, U.S. Department of Energy, Richland Operations, Richland, Washington.

WHC, 1994, *100 Area Soil Washing: Bench-Scale Tests on 116-F-4 Pluto Crib Soil*, WHC-SD-EN-TI-268, Rev. 0, Westinghouse Hanford Company, Richland Washington.

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