THE HIGHLY EFFICIENT UNIT TRAIN TRANSPORTATION OF FERNALD REMEDIATION WASTE

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ABSTRACT

Remediation of eight waste pits at DOE's Fernald site, located northwest of Cincinnati, involves rail transportation of the processed excavated wastes to an off-site disposal facility. This unique transportation project, one of the largest in the history of CERCLA/Superfund remediation, will move at least 636,000-metric tons (700,000-short tons) of uranium- and thorium-contaminated Low Specific Activity–1 soil-like materials to the Envirocare site in Clive, Utah.

Conceptual planning for this project was discussed in a presentation at WM'95. Since then, detailed planning was completed in 1997, infrastructure built and railcars acquired in 1998, and shipping operations commenced in 1999. This paper updates the completion of planning and initiation of implementation of the current successful shipping campaign that is scheduled to continue through FY 2005. As of March 22, 2002, WPRAP has shipped 55-unit trains, accounting for 3,198-carloads and 313,000-metric tons (344,000-short tons) of processed pit waste.

We are pleased to report that no situations have arisen that were not anticipated in the planning of this project. However, the use of rail did require changes in the paradigms of conventional truck-based transportation planning. Using the lessons learned at Fernald, we believe that safer, less costly bulk/intermodal rail transportation can be effected at other sites in the DOE Complex, with rail availability, that are currently shipping wastes by truck.

INTRODUCTION

The presentation focuses on lessons learned as Fluor Fernald and DOE worked together to resolve issues related to:

- Packaging (gondola railcar)
  - ♦ Selection/development
  - ♦ Selection/specification of enhancements (permanent liner, disposable liner, and cover)
- Integrated logistics planning and scheduling
  - ♦ Railroad and route selection
  - ♦ Rail infrastructure improvements (off-site and on-site)
  - ♦ Tender conditions (unit train v. manifest service)
  - ♦ Unit train logistics and schedule management (on-site, railroad transit, and disposal site turnaround times)

  - ♦ Procurements (railcars, site locomotives, and disposal site)
  - ♦ Emergency response programs (site, local, and transited states)
  - ♦ Training programs (on- and off-site)
- Transportation operations
  - ♦ Railroad carrier interactions
  - ♦ Information management (railroads' and FEMP railcar tracking/management systems, liner inspection logs, railcar maintenance log, and unit train computer-generated documentation)
- Stakeholders and public interactions
  - ♦ Local community (Transportation Workshops, public meetings, Citizens Advisory Board meetings, progress meetings, site "open houses"/public tours, Branch Line "high-rail" tours, and grade crossing concerns)
  - ♦ Transited states (voluntary notification of en route shipments and DOE-sponsored training for emergency first responders)

DISCUSSION

Site Regulatory Background

The U.S. Department of Energy (DOE) owns the Fernald Environmental Management Project (FEMP), formerly known as the Feed Materials Production Center. Production operations were started in 1952, and were halted in 1989 due to declining demand for uranium metal products to support the nation's defense program. Available resources were then redirected to focus on environmental restoration of the FEMP.

Operable Unit 1 (OU1), at the Northwest portion of the FEMP, is comprised of Waste Pits 1 through 6, the Burn Pit, and the Clearwell. The pits were excavated into clay lenses, and in some cases additional clay and/or synthetic materials were installed to form liners. Chemical and metallurgical processes associated with uranium purification generated the pit wastes, consisting of a heterogeneous variety of slurried or dry process waste residues (e.g., slags, sludges, precipitates, filter cakes, and debris). Some pits were subsequently covered with soil after being taken out of active service. The focus of OU1 is remediation of the wastes, berms, liners, and underlying soils of the eight pits.

This paper addresses the transportation and disposal aspects of OU1 under the aegis of the Waste Pits Remedial Action Project (WPRAP) as implemented by Fluor Fernald, Inc. for, and in partnership with, DOE. The planning for these activities was instrumental to:

- Issuance of the Final Record of Decision in January 1995
- Commencement of unit train shipments of WPRAP waste in new, fiberglass-covered, lined gondola cars during April 1999.

Using information developed by the OU1 Remedial Investigation and Feasibility Study (FS), the Proposed Plan for Remedial Actions at OU1 developed the preferred remedial action alternative which included the following major components:

- Construction of waste processing and loading facilities and equipment
- Excavation of waste pit contents, caps, liners, and surrounding contaminated soils
- Pre-treatment (crushing/shredding) of waste
- Drying of waste
- Offsite shipment of waste in bulk by rail for disposal at a permitted commercial waste disposal facility (PCDF)

At the time, DOE Order 5820.2A prohibited the use of commercial facilities for disposal of low-level radioactive wastes of the type present in OU1. Pursuant to the exemption provision of the Order, approval was obtained in November 1994 for OU1 wastes to be dispositioned at a PCDF. Pending DOE's disposal contract solicitation, a representative PCDF was deemed to be Envirocare of Utah, Inc. (Envirocare) located approximately 121-km (75 miles) west of Salt Lake City which had truck and direct rail access. That PCDF was permitted for bulk receipt, unloading, and disposal of low specific activity materials.

Rail Shipment Concept

The FS envisioned the use of small capacity 68-metric ton (75-short ton) cars shipped in 20-car blocks in manifest car service to a PCDF. These cars would be incorporated into the railroads' regularly scheduled freight trains and make their way, via numerous switchyard transfers, to the PCDF. There was nominal discussion of "ways and means"; accordingly, detailed rail planning was commenced at the FEMP in early 1994.

FEMP Rail Access

The FEMP is situated within an exclusive service area of CSX Transportation, Inc. (CSXT). Rail access to the site starts from the Cottage Grove, Indiana interchange on CSXT's Indianapolis-Cincinnati Mainline. The FEMP is reached via travelling south along CSXT's 43-km (27-mile) Cottage Grove-Fernald Branch Line that traverses five bridges/trestles. The longest is the 258-m (846-ft) long x 20-m (65-ft) high open deck Okeana Trestle. Almost 213-m (700-ft) of the Okeana was of timber construction. During an initial planning meeting, FEMP personnel expressed a preference for unit trains, but CSXT's position was that three of these bridges/trestles, including the Okeana, would not be satisfactory for this traffic mode. The railroad's concern was that unit trains, comprised of identical cars, would set up potentially damaging harmonic vibrations. This illustrates the value/necessity of early and ongoing communication with the involved railroads for shipment projects.

From Figure 1, which depicts CSXT's rail system west of the FEMP and south of the trestles, the Branch Line is comprised of a Main Branch Track and a Passing Track. Switches at the North and South ends of the Passing Track connect it to the Main Branch Track. CSXT's seldom-used Shandon Switchyard is an appendage to the Passing Track and located between it and the FEMP. From the Shandon Switchyard, a long spur extends to the FEMP rail system.

FEMP Rail Background

From Figure 2, which shows the original configuration of the FEMP rail system, the CSXT spur continues as a single line of DOE-owned track after entering the FEMP. DOE's Main FEMP Spur extends past the North boundary of OU1, and bifurcates into parallel tracks (FEMP Tracks #1 and #2) that access 5-sharply curved spurs. These tracks allowed cars to be pushed South into processing areas at the East side of the FEMP. Crossovers between Tracks #1 and #2 allowed cars to be reversed and then pushed West and then South on a gently curved section leading to Track #12, immediately to the east of the OU1 area, into a processing area at the center of the site.

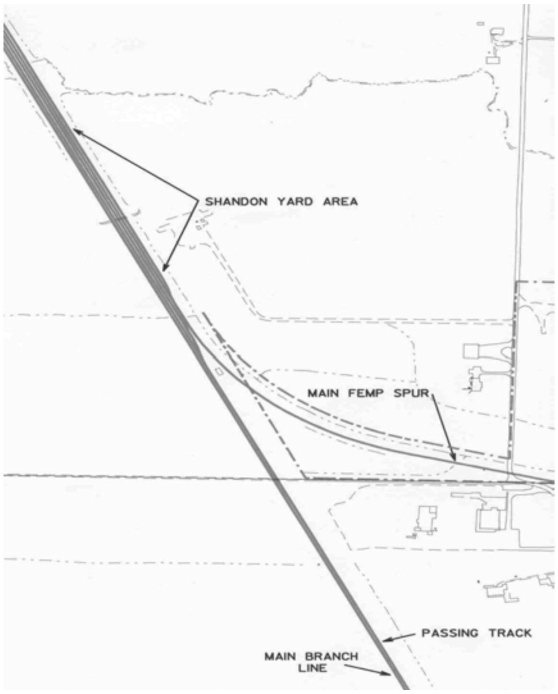

Fig. 1. CSXT Trackage Adjacent to the FEMP.

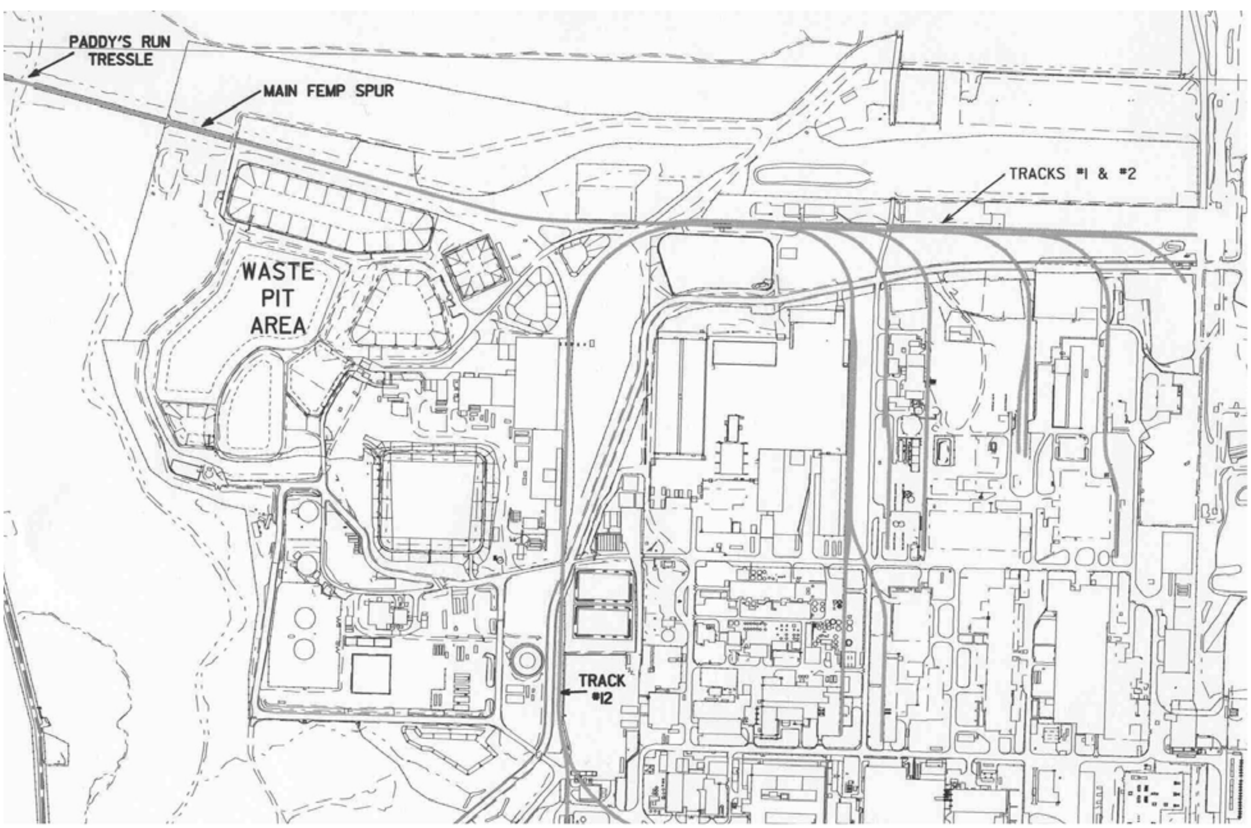

Fig. 2. Original FEMP Trackage.

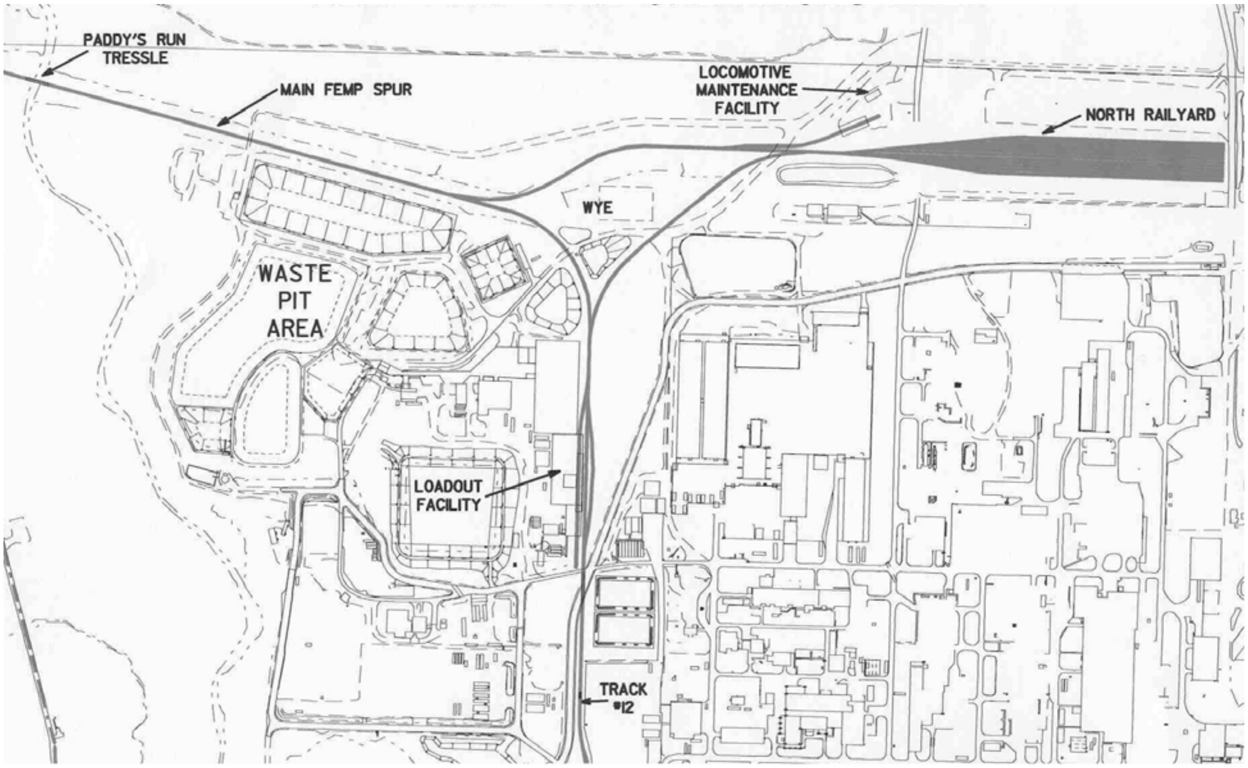

Fig. 3. Current FEMP Trackage to Manage WPRAP Unit Train Traffic.

The Main FEMP Spur and Track #12 were in excellent condition and were constructed with rail weighing 65-kg/m (131-lb/yd). Rail of this weight is suitable for the current genre of rail cars having a gross rail weight of 129,730-kg (286,000-lb). Tracks #1 and #2, however, were only in fair condition and had been constructed with only 40-kg/m (80-lb/yd) rail.

Rail Route between the FEMP and the PCDF

The Western terminus of CSXT, the originating railroad, is East St. Louis, Illinois. While in the planning stages of the project, CSXT stated that using that railroad's FEMP-Indianapolis-East St. Louis route would not be possible due to a washout and the Consolidated Rail Corporation (Conrail) system in that area would have to be used. As a goal of the WPRAP planning team was to minimize tracking and interchange problems, we were reluctant to utilize three railroads to effect the trip via the more direct route through Indianapolis. Thus early WPRAP rail traffic traveled almost 270 degrees around the Greater Cincinnati area while en route between the FEMP and East St. Louis. With CSXT's subsequent partial acquisition of Conrail, WPRAP shipments are now routed through Indianapolis.

After the interchange between CSXT and the UPRR, the route continues west through St. Louis, Topeka, Cheyenne, and Salt Lake City to the Clive, Utah spur servicing Envirocare.

The cross-country CSXT and UPRR route is comprised of mainline trackage, and no non-routine upgrades would be necessary. Railcar inspections would be performed at transfers between FEMP/CSXT, CSXT/UPRR, and Envirocare/UPRR. In addition, a Federal Railroad Administration-mandated 1,600-km (1,000-mile) inspection would be conducted in UPRR's North Platte Nebraska.

Shipment tracking was a primary concern of the FEMP, and the unit train concept allows for shipment consolidation and easy tracking by the railroads. Tracking data are received from railroad car transponders located along the tracks at intervals of up to about 32-km (20-miles). With this system, the location of each car can be determined on the basis of the last transponder. Authorized FEMP personnel can readily use the Internet to access the railroads' systems for determining the locations of the trains/cars across the almost 3,200-km (2,000-mile) rail route.

PCDF Rail Background

For planning purposes, Envirocare was initially used as the representative PCDF. Envirocare has several long spurs on its property, onto which are delivered railcars from UPRR's Clive spur. The site was already receiving bulk materials in covered gondola cars that are "spotted" for staging or unloading by Envirocare's locomotives. The facility has a permitted roll-over machine which straddles one spur, and effects a controlled "drop" of the contents into a concrete pit 9-m (30-ft) below. Waste is removed from the pit for interment in the landfill. After dumping, PCDF personnel externally decontaminate the gondola cars with high-pressure salt-water spray for return to the originating facility. Railcars scheduled for free release are internally decontaminated.

It was determined that the facility's infrastructure could handle the number and type of gondola cars that were under consideration by the FEMP.

Rail Route Evaluation

This, initial determinations were that:

- Substantial FEMP infrastructure enhancements were mandatory to support unit-train-based rail traffic and the associated fleet of railcars
- CSXT could originate and deliver unit train traffic to the FEMP with:
  - Modest rehabilitation of the Shandon switchyard
  - Extensive trestle rehabilitation on the branch line
- No significant upgrades would be needed by the representative PCDF

On-Site Rail Infrastructure

The basic FEMP infrastructure requirements were a:

- Spur for railcar loading
- Rail yard for staging of empty and filled gondolas
- Interconnecting rail involving a "Wye" and switches
- Switching locomotive(s) to interchange cars among the railcar loading spur, rail yard and Main FEMP spur

A Wye is a track arrangement, shaped like the letter "Y", with a short connecting segment between the two upper legs. A switch at each intersection allows a series of movements by a locomotive, similar to the "K-turn" used by automobile drivers, to reverse the facing direction of a string of railcars. Alternative, but much more expensive, systems are either a turntable or circular length of track.

After the basic concepts had been developed, DOE held a series of Transportation Workshops to present the rail shipment concept and to solicit community input. Local stakeholders requested a prohibition of staging railcars by:

- CSXT and/or Fluor Fernald in the Shandon yard
- Fluor Fernald along the Main FEMP spur (other than the 1-day origination/receipt of a unit train)

Additionally, Fluor Fernald management required that the FEMP rail yard must:

- Not be in a contaminated area
- Not interfere with other remedial projects at the FEMP
- Store all railcars on-site in the event that production operations were to be temporarily suspended
- Allow commencement of operations with a full inventory of stored empty railcars (i.e., without "gridlock")
- Efficiently originate and receive unit trains under normal production operations
- On the basis of initially anticipated site funding, handle the loading facility's expected output of four railcars per day over five days/week.

Input was also solicited from a Fluor Corporation rail consultant who recommended that:

- Switches be limited to those actually necessary
- Crossovers, between adjacent rail yard tracks, be as few as possible to avoid over-complication of operations and increased potential for derailments

For a considerable period of time, WPRAP planning for the rail yard centered on repairing existing Tracks 1 and 2 and installing new parallel tracks in the area. In this manner, the existing light rail spurs could have been used for storage of empty cars. New track, constructed of heavy rail, would have been designated for management of filled cars. However, this option conflicted with the FEMP's soils remediation project and was abandoned in favor of constructing an entirely new rail yard to the north on a decontaminated (by soil removal) and subsequently filled part of the site property. Figure 3, depicting the as-built FEMP rail system, shows the location of the 11-track "Christmas tree" patterned rail yard. The yard was sized to allow storage of 196 railcars, providing a 60-car contingency allowance. As discussed in a following section, the original WPRAP planning anticipated the acquisition of 135-railcars. A locomotive and railcar maintenance building was added to the rail yard.

In contrast to the standard approach of having an engineering department completely design the rail yard, WPRAP transportation-personnel developed the layout on the basis of railroad information concerning switch configurations. This allowed planning to proceed. Ultimately, the design was turned over to the engineering group for incorporation of civil engineering specifications.

Figure 3 shows that the FEMP railcar loading facility is served by a new loading spur (Track 13) constructed west of, and parallel to, Track 12. A switch at the north end of the loading spur connects it to Track 12, immediately south of the new South Wye Switch. Track 13 is long enough to allow a string of four cars to be loaded at any one time. Another new spur (Track 14) was constructed to the east of Track 12 to provide additional railcar staging capability for the loading operation or an alternative loading area for containers on flatcars.

For purposes of describing the rail operations at the site, the following terminology is used for the involved new switches:

- The East Wye switch accessing the new rail yard
- The West Wye switch leading to the Main FEMP spur
- The South Wye switch on the north end of Track 12

The Wye will be comprised the following trackage:

- Part of the existing curve from the new rail yard to Track 12 (the East Leg)
- New curve between the Main FEMP spur and Track 12 (the West Leg)

- New Trackage between the Main FEMP spur and the rail yard (the Top Leg)

Construction of the above-noted FEMP rail infrastructure cost almost $4 million. However, almost half was spent for intensive filling/grading of the new rail yard area.

Packaging Selection/Specification (gondola railcar)

Although described separately, the packaging and on-site logistics selections proceeded in an integrated mode. With respect to rail shipment, the only viable options were bulk waste loaded into:

- Containers to be shipped on flat cars
- Gondola railcars

After considerable discussion with the railroads, a transportation rate was received for six 15-m^3 (20-yd^3) roll-off containers, transported on special articulated flatcars from the FEMP to the PCDF. However, the primary problems were the:

- Cost and availability of the flatcars
- Cost of the triple set of containers required for:
  - Transportation
  - FEMP loading
  - Disposal site unloading

Federal regulations prohibit shipment of radioactive waste in convenient top-loading and bottom-unloading hopper cars. Another Superfund site is using leased railroad-owned bottom-dump cars with high walls and internal cross bracing for shipments of 11e(2) waste for disposal. However, the bottom doors have been welded shut, and the cars are unloaded via a rollover unit at the disposal site. Therefore, WPRAP elected to use gondola railcars for bulk transport of the processed waste. A gondola is an uncovered long car with:

- Low walls
- No internal braces
- A solid floor

The gondola is intended to be loaded and unloaded from the top, or dump-unloaded by means of a car rollover unit. Unloading the cargo from the top is time consuming and presents an unacceptable risk of damage to the railcar walls/bottom. For bulk shipments to a PCDF, the only choice was that the gondola cars be loaded from the top and unloaded via a rollover unit. This method limits disposal options, and a gondola could not be easily unloaded at the FEMP in the unlikely event that the loaded car were to be rejected. As compared to container cars, gondolas offer minimum logistical and space requirements, as it is not necessary to fill, stage/manage, and track the equivalent of up to six containers per car in addition to the railcars. Each gondola railcar load of waste alleviates five-truck shipments and the attendant traffic safety problems.

After discussions with the railroads and railcar manufacturers, it was determined that gondolas are available with interior lengths between 16.0-m (52.5-ft) and 19.8-m (65-ft) with wall heights from 1.52-m (5-ft) to 1.67-m (5.5-ft). The standard width of gondolas is 2.90-m (9.5-ft). It was recommended that, to the greatest extent possible, general-purpose cars with after-market fiberglass covers and sprayed-in polyurea liners be selected. This would have the lowest initial cost and best possibility for resale to the greatest number of potential customers after WPRAP completion.

The conundrum was to match the railcar capacity with the estimated density of the processed waste such that the railcars would be simultaneously weight- and volume-limited. By a trial and error method, it was determined that waste with an estimated density of 1.616-g/cm^3 (100.87-lb/ft^3) would fill a 16.0-m (52.5-ft) long car, to a depth of 1.31-m (4.3-ft). In order to allow for contingencies, a car with 1.67-m (5.5-ft) walls was selected. Allowing for a 15-cm (6-in) minimum freeboard, there was a 21-cm (8.4-in) volume contingency. Subtracting the estimated 30,400-kg (67,000-lb) lightweight of the car, the estimated 680-kg (1,500-lb) weight of the fiberglass cover, and the 36-kg (80-lb) weight of the disposable liner from the 129,730-kg (286,000-lb) maximum gross rail load yielded a 98,621-kg (217,420-lb) net cargo capacity. However, for capacity planning, a 0.5 per cent weight allowance was retained to allow a target fill weight with allowance for prevention of overfilling. Thus, the net practical cargo capacity of the railcars was 98,129-kg (216,333-lb) for WPRAP planning. At the time of capacity planning, the concept of the polyurea permanent liner had not been developed.

The conservative selection of the 1.67-m (5.5-ft) wall height was justified, as the processed waste is less dense than originally anticipated. Thus, the cars are usually loaded to minimum freeboard and maximum weight, yielding a cargo volume of at least 70.6-m^3 (2,494-ft^3)/car at an average net weight of 97,848-kg (215,715-lb). This corresponds to a density of 1.386-g/cm^3 (86.5-lb/ft^3). Our current capacity utilization factor for a volumetrically filled car is almost 99.9 per cent by weight.

Disposable railcar liners were specified in order to reduce gross contamination of the gondola car interiors, and, when folded out for loading over the sides of the railcars, to shield the exteriors of the cars from spills of contaminated materials. They are believed to facilitate unloading of semi-frozen car contents. In addition, a lap-over reinforced plastic cover was specified in order to minimize the infiltration of water during staging and shipment. The cover would also eliminate any wind borne releases during transportation when used in conjunction with the interior disposable liner. Discussions, during planning meetings with the railroads and Envirocare, revealed that metal covers deformed during multiple uses.

As a final enhancement, the standard gondola weep holes were sealed and replaced with 5-cm (2-inch) drain plug at each corner of the railcar. In order to ensure sealing of the each railcar, the entire interior was sprayed with a 0.15-cm (60-mil) minimum thickness polyurea coating. The weight of such a permanent liner was not considered in the capacity determination of the railcars in view of the generous overfilling allowance.

As gondola cars are a long lead-time item, all manufacturers requested placement of procurement at least 12-months prior to the required delivery date. On the basis of the expected loading rate of 20-railcars per week, an initial procurement of 135-cars was effected. The cars were received in two-batches between August and September 1998. In order to accommodate an increased average production to almost 30-railcars per week, a second procurement of 35-cars was placed. These railcars arrived in October 1999. The total acquisition cost was approximately $11.5 million.

Shipment Mode Selection/Specification

Unit train shipment of the railcars was selected on the basis of offering the following advantages over groups of railcars, released to the railroads for inclusion in regularly scheduled freight trains ("manifest service"):

- Faster transit time, minimizing en route delays (5- v. 30-days)
- Greater security as railcars do not sit unattended on sidings waiting for the next train
- Safer as cars are not switched from one train to another in various rail yards while en route
- Railcar damage and derailment possibilities reduced by avoidance of "humping" in railroads' switchyards
- Lower number of train shipments which simplifies railcar position tracking because they are in one or two unit trains and rather than scattered across the country
- Confining DOE's new cars to a limited number of unit trains affords:
  - Reduced probability of involvement in grade crossing incidents
  - Noninvolvement with older cars which might be more prone to mechanical failures
  - In the remote event of a derailment incident, DOE's cars would not be mixed with others carrying extremely hazardous materials that could:
    - Hinder the immediate initiation of cleanup actions due to the need to stabilize poisonous and/or burning materials
    - Cause a release to become a mixed waste and, in turn, a mixed liability problem
- Railroad car routing is specified under terms of DOE Tender
- Lower cost due to:
  - Discount afforded to unit train traffic
  - More efficient utilization of cars as faster transit time results in less nonproductive layovers on yard sidings

The overarching criterion was to accomplish the task with the minimum number of railcars to reduce procurement and on-site rail infrastructure requirements. The analysis:

- Was complicated by the use of unit trains
- Had to be cognizant of the railroads' initial specification that unit trains had to be comprised of at least 40-cars
- Addressed 49 CFR 174.85 which mandated that a "buffer car", filled with an inert material, must be positioned in each unit train between the locomotives and the string of railcars loaded with radioactive material

Towards this end, the original logistics concept was three 47-car unit trains operating on a 24-day cycle. Two trains would be in round-trip travel or being unloaded at Envirocare. The third train would be in the process of being constructed at the FEMP as cars were loaded and their cargo accepted for shipment. Three gondolas in the fleet would be filled with sand, and assigned as buffer cars.

Locomotive Procurement

While the railcars were being selected, the obvious focus was the means by which they would be moved on site. The "easy" solution was to procure an expensive Trackmobile®; the more difficult, but less costly was to locate suitable switching locomotive(s) from government surplus via the Defense Reutilization and Marketing Organization. Ultimately, after significant research and track-down, the FEMP acquired three 60-ton 500-horsepower completely re-manufactured Baldwin-Lima-Hamilton locomotives from two Army depots. The total acquisition cost, including transportation, was approximately $45,000. Two locomotives were received in June 1998 and the third in April 1999.

Primary Services Procurements

In April 1999, on the basis of significant work by the FEMP team, a three-year rail tender was executed among DOE, CSXT, and UPRR. The terms provided for unit train movements of WPRAP materials from the FEMP to Envirocare via DOE-owned gondola railcars, having a maximum gross real weight of 129,730-kg (286,000-lb) in 40-, 50-, or 60-car unit trains. The tender affords significant savings over the cost of truck transportation, and enhanced transportation safety. Each unit train would have a buffer car filled with inert material between locomotive, and the tender provides free transit for the buffer car.

DOE's Ohio Field Office negotiated a favorable multi-site disposal contract with Envirocare of Utah Inc. which featured pricing for disposal for low level radioactive waste received in lined railcars. The contract was awarded in June 1998, and renewed 3-years later.

Logistics Scheduling

Unit train logistics and on-/off-site schedule development were the critical issues (i.e., on-site time, railroad transit, and disposal site turnaround). Resolution of these matters determined the numbers of railcars required and, in turn, the required on-site infrastructure to manage them effectively After significant discussion, WPRAP operating personnel, the railroads, and Envirocare represented that their efforts could be completed in an 18-day round-trip involving:

- 1-full work day for on-site train makeup and inspection
- 1-full work day for departure
- 1-full calendar day by CSXT (outbound)
- 4-full calendar days by UPRR (outbound)
- 5-full work days at Envirocare
- 3-full calendar days by UPRR (inbound)
- 1-full calendar day by CSXT (inbound)
- 1-full calendar day for arrival
- 1-full work day for "cutting" of cars and inspection

Execution of the project has shown that, for the most part, this schedule has been met. Occasional delays of up to 1-week have been equally attributable to the railroads and Envirocare. For the most part, these delays have been weather-related. As a lessons-learned, even with the increased fleet of 170-railcars, the FEMP has not had the railcar capacity to effectively manage:

- Disposal site and railroad delays
- A loading rate of up to 32-cars/week for several weeks in succession
- The railroads' mandate for 60-car trains v. their original approval of 47-car trains that requires almost 2-more day's production per each unit train.

In deference to the original planning, the above loading rate is almost twice that anticipated. Recently, WPRAP purchased an additional 20-covered, lined gondolas which on a 3-weeks/month loading schedule will handle yearly shipments of 1,546 cars conveying 167,000 tons/year. This affords some contingency for contractor delays.

On-Site Rail Logistics Planning

The purpose of this section is to illustrate the attention to detail required by rail. Casual readers may skim the following description of on-site rail operations, which was developed in the planning documents in order to verify that the proposed infrastructure could handle the traffic.

As opposed to truck transportation, after track is laid, there is extremely little flexibility for managing change. Therefore WPRAP transportation planning personnel made extraordinary efforts to determine operating and logistics expectations, and to communicate back with WPRAP operations personnel to verify that sufficient support would be provided by the rail layout.

The primary rail operations requirements are to move cars between the rail yard and the:

- Loading area
- Main FEMP Spur

En route to the Loading Building on Track 13, four empty cars are pulled out of the rail yard and travel west across the Top Leg past the West Switch and onto the Main FEMP Spur. The locomotive reverses direction and shoves the cars south along the West Leg to Track 12 and then onto Track 13 for loading. The alternate way, assuming that the rail yard tracks with crossovers are clear, is for the locomotive to perform a "runaround" (as described later) to push the cars from the rail yard along the East Leg to Tracks 12/13. The movements are reversed to return the filled cars to the rail yard.

Outside the north end of the Loading Building, the FEMP locomotive pushes the empty cars South until they can be coupled to the Loading Contractor's car mover. The FEMP locomotive will not enter the Loading Building for radiation control reasons. The car mover pulls the cars South entirely through the building until the northernmost car reaches the station where lids are removed and temporarily staged. The disposable liner is placed into the car and it is then moved north into the loading area where it is filled with waste. The car is then pulled south to the station where the lid is replaced. The car is pushed north, past the loading area, to the station where the exterior is decontaminated and surveyed for radiation. All cars in the string are loaded in the same way, and the string stays together during entire four-car loading operation.

In order to make up the train, successive strings of about 15 filled cars, designated and approved for the departing train, are pushed out of the rail yard and the train is successively built-up, starting at the far end of the Main FEMP Spur and moving back. Although the Wye may be used, the rail crew prefers to utilize the parallel crossover tracks. The locomotive moves east on a clear track and switches across to get behind the filled cars on an adjacent track. Then the cars are pushed West out to the Main FEMP Spur. The crossover track is replenished with cars by pulling them to the West from other tracks until the switches are cleared and then pushing them East onto the crossover track. The process is repeated as many times as necessary to build unit trains up to about 65-cars.

In order to return a unit train, after the push-in of empties onto the Main FEMP spur, the process is reversed.

It was also necessary to plan the logistics for CSXT. The process for originating a unit train of filled cars is simple in that the railroad's string of 2- to 3-locomotives merely enters the "locomotive enclave" at the West end of the main FEMP spur, couples to the string of cars and pulls away. In order to return a unit train of empty cars, CSXT's locomotives pull the train south from the Main Branch Line Track onto the Passing Track via the North Branch Line Switch. The locomotives stop immediately north of the switch accessing the Main FEMP Spur. At that location, the cars are uncoupled and temporarily staged.

CSXT's locomotives continue south on the Passing Track to the South Branch Line Switch where the Main Branch Line Track is accessed. Then, CSXT's locomotives move north on the Main Branch Line past the North Branch Line Switch. After that switch is "thrown" to access the Passing Track, the locomotives cross the switch and move south onto the Passing Track. After coupling to the rear of the unit train, the locomotives push the string of empty railcars completely onto the Main FEMP Spur. The string is uncoupled, car brakes are set, and the CSXT locomotives pull away.

FEMP Training Programs

As FEMP rail operations had ceased for several years, there were no rail-qualified salaried or wage personnel. In order to properly prepare WPRAP procedures and planning documents, the core WPRAP Rail Operations Planning Group attended a four week rail operations training course presented by the Academy of Industrial Training (AIT) in Philadelphia, PA during March-April 1998. The AIT Instructors were retired, senior, railroad operations personnel. This course was invaluable for preparation of FEMP procedures relating to:

- Locomotive daily inspection, startup, and shutdown
- On-site railcar movement, storage, and coupling
- Railcar handbrake operation
- Plan of the day/safety meeting
- On-site notifications
- Railcar inspections
- FEMP switch operations and inspection
- Locomotive and railcar re-railing
- Rail radio communications and hand signals
- Record keeping
- Safety

In concert with receipt of the railcars, wage personnel received a four week rail operations course presented on-site by AIT in October 1998. This heavily safety-oriented program training combined lecture sessions and field hands-on equipment training. The agenda addressed:

- Locomotive and railcar inspection and servicing
- Track and switch inspection and maintenance
- Locomotive operation and railcar movements
- Trackmobile® operation and railcar movements
- Braking/air hoses/chocking
- Switching/coupling/uncoupling
- Derailments and re-railing
- Railroad safety/signaling/document preparation

One-week refresher training has been conducted annually to maintain proper certification requirements.

In addition to productivity statistics, safety metrics provide an even better measurement of accomplishment. To date, there been only minor first-aid injuries among rail yard personnel.

Emergency Response Programs

Both UPRR and CSXT provided Emergency Response Plans for the contingency of immediate response to any incidents involving a FEMP shipment. The railroads are required to place adequately trained/equipped/organized response personnel at an incident site within 4-hours of the event. The primary objectives are to:

- Protect the health and safety of the involved public, workers, property, and equipment
- Preclude releases of radioactive/hazardous materials from the impacted site
- Restore rail operations
- Perform recovery actions

During the winter of 1998, WPRAP Rail Operations provided courtesy notifications of the planned initiation of shipping operations to transited states' environmental/radiation control/emergency response offices. In view of the ramifications of the events of September 11, 2001, non-specific notifications are provided to interested agencies in transited states prior to each shipment.

Via a program awarded to the International Association of Firefighters, DOE arranged for training of response personnel in transited states.

Transportation Management

Fluor Fernald personnel access the Netredi®, ShipCSX® and UPRR systems for shipment tracking via the Internet. These extraordinarily useful customer interfaces afford unit train and car movement information including origin, destination, current location, and loaded status. In addition, WPRAP personnel have developed the following:

- Visual Basic® application, as the front-end to an Access® database to afford a seamless graphical interface to multiple users for managing onsite traffic/inventory/status of 170-railcars over 15-on-site tracks
- Relational Oracle® database for recording and correlating railroad maintenance invoices with the standard railroad maintenance codes
- Oracle database for railcar liner inspections and a report to record field observations

Stakeholder Interactions

In order to involve the local community, DOE and Fluor Fernald sponsored a series of transportation workshops, public meetings, site "open houses", and tours. CSXT assisted by participating in the meetings and affording "high-rail" tours of the Branch Line for community leaders. Presentations were held at Citizens Advisory Board, progress meetings, etc. The community was supportive, particularly with the safety aspects of rail transportation and reduction of truck traffic through the area. CSXT was responsive in promptly addressing legitimate community concerns about the trackage and grade crossings. Voluntary notifications of the date of initial shipment were addressed in a prior paragraph. DOE-sponsored training was provided for emergency first responders.

CONCLUSIONS AND FUTURE WORK

The first unit train departed on 26 April 1999 and returned on 12 May 1999. The elapsed time by the railroads and Envirocare was as planned. Since that time, the FEMP has shipped a total of:

- 55-unit trains
- 3,198-loaded gondolas
- 313,000-metric tons (344,000-short tons)

The only significant changes in project execution, from the original plans, were:

- Shift from three 47-car unit trains to two 60- to 65-car trains
- Increased production rate

The increased train length was requested by the railroads to be effected in January 2000 after the first calendar year of shipments.

We cannot overemphasize that the logistical planning requirements for this campaign were quite complex and a large amount of infrastructure was required. Five-years elapsed between the commencement of detailed rail planning and the departure of the first unit train.

The message that can be drawn from this paper is the rail transportation, particularly in bulk, is extremely efficient, cost-effective and safe. The only incidents have been a few railroad-detected routine maintenance issues such as brake replacement. This is a minor consideration, and is not of any concern. Use of the maintenance database has indicated that brakes have a 64,000-km (40,000-mile) service life. The only other problem, which is still a relatively commonplace occurrence, was the detection of a "hot box", which indicated a bearing problem, by a transponder. A railroad crew was dispatched, and the car was repaired and underway within nine hours of the initial report of the occurrence.

Fernald continues to evaluate innovative shipping technologies. We hope to report back in the future on the success of current investigations/tests of rail shipments via: Super Sacks® in gondolas, containers on flat cars, and mixed dedicated trains of gondolas and containers-on-flatcars for other FEMP projects.