

**OAK RIDGE  
ENVIRONMENTAL MANAGEMENT WASTE MANAGEMENT FACILITY  
DOE-EM's FIRST ON-LINE PRIVATIZED DISPOSAL FACILITY**

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## **ABSTRACT**

The Environmental Management Waste Management Facility (EMWMF) project started in 1996 as the third attempt at a major on-site waste disposal facility on the Department of Energy's Oak Ridge Reservation (ORR). The project chose to pursue privatized funding because it fit the model for a moderately priced, well-defined scope and because such funding did not divert any resources from other cleanup projects. After approval of the requisite Privatization Report to Congress in October 1999 and signature of the Record of Decision in November 1999 authorizing the EMWMF, a privatized subcontract was awarded in December 1999 to design, construct, and operate the first phase of EMWMF – 305,000 m<sup>3</sup> of capacity. Operations started in May 2002 and within 4 months, the subcontractor had recouped its privatized investment, making EMWMF the first Department of Energy, Environmental Management privatized project to come to fruition. Currently, the ORR cleanup has consumed about 1/3 of the Phase 1 capacity and the subcontract for the Phase 2 build-out of 610,000 m<sup>3</sup> is underway.

In October 2003, at the close of the ORR Management & Integration (environmental restoration/waste management) contract, the Department of Energy and Bechtel Jacobs Company LLC (BJC) signed a contract extension in the form of a closure contract. The terms of this contract incentivize BJC to accelerate cleanup of the ORR by basing contract payments on completion of defined scope within a defined performance period. The most critical factor for the success of the accelerated cleanup is waste disposal. With over 1,520,000 m<sup>3</sup> of waste either in storage or to be generated during cleanup, cost effective and efficient waste disposal capacity will ultimately determine the success of the program. The EMWMF is the disposal site for low-level radioactive, hazardous, and mixed wastes generated by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) cleanup of the ORR. The EMWMF will operate through FY2015 with over 80% of the waste generated before the FY2008 end of the BJC closure contract from CERCLA response action projects.

This paper will address lessons learned in the design, construction, and operation of the first phase of the EMWMF and prospectively detail the role of EMWMF in the cleanup and closure of the ORR.

## **INTRODUCTION**

The site chosen for the EMWMF from among 35 ORR candidate sites was the eastern end of Bear Creek Valley just west of the Y-12 National Security Complex in Oak Ridge, Tennessee [see Fig. 1]. This location offered the appropriate combination of advantages and challenges to be acceptable to all stakeholders. On the plus side, it is situated in an area historically used for waste management activities. Additionally, it is close to the western perimeter of Y-12, making post-closure administrative and institutional controls more reliable. The challenges presented by the location included high groundwater, copious precipitation, steep topography, and a limited footprint for facility development.

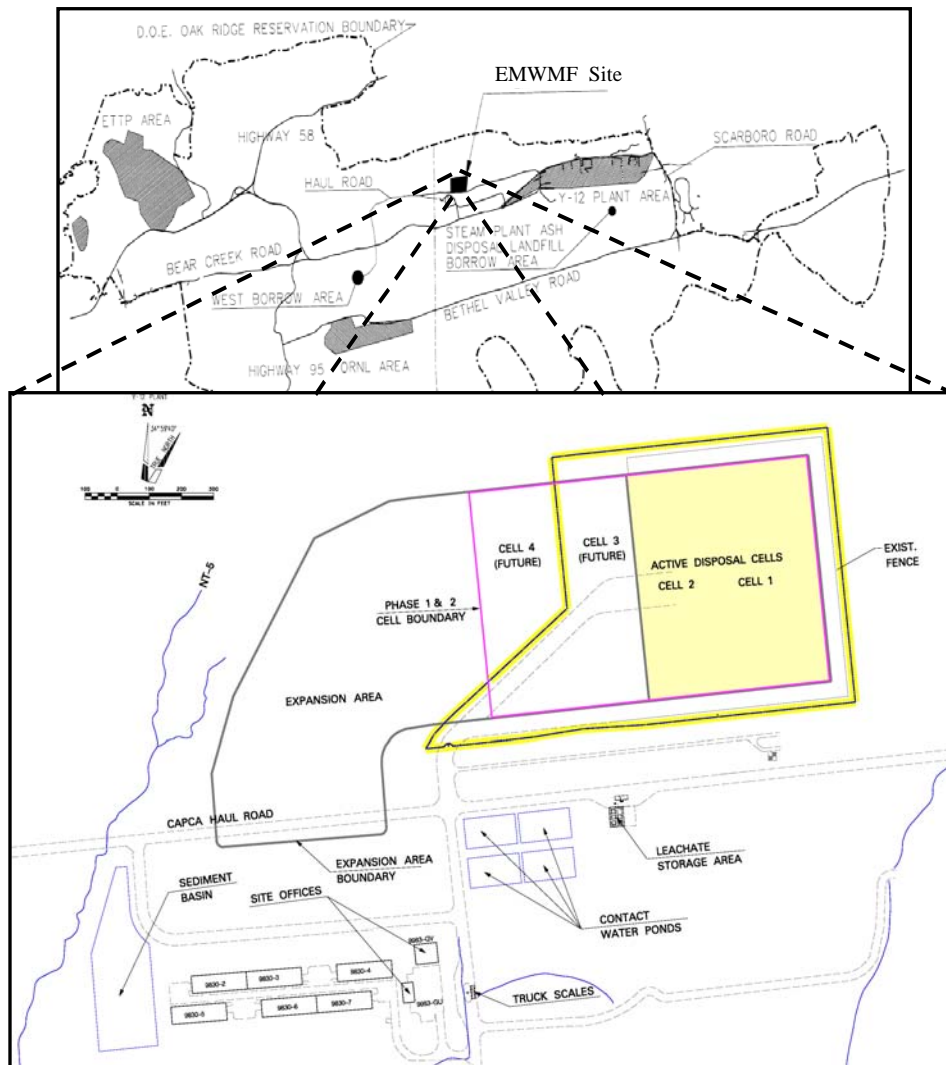


Fig. 1 Location and site plan for the Environmental Management Waste Management Facility

The project was designated for funding as a Defense Environmental Privatization Project under the National Defense Authorization Act for FY1998 because the subcontract to implement the EMWMF met the criteria in Section 3132 of the Act:

- (1) is awarded on a competitive basis;
- (2) requires the contractor to construct or acquire any equipment or facilities required to carry out the contract;
- (3) requires the contractor to bear any of the costs of the construction, acquisition, and operation of such equipment or facilities that arise before the commencement of the provision of goods or services under the contract; and
- (4) provides for payment to the contractor under the contract only upon the meeting of performance specifications in the contract.[1]

Most importantly, privatization of the contract offered a funding source that supplemented the normal appropriations for the Management & Integration contract. The requirement for submission of a Report to Congress was met in September 1999 [2]. Consequently, the contract for the design, construction, and operation of the EMWMF was ready for award after the required 30-day Congressional review.

On November 2, 1999, a Record of Decision was signed by the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the Tennessee Department of Environment and Conservation (TDEC) authorizing an on-site waste disposal facility with a capacity of 1,292,000 m<sup>3</sup> for the disposal of wastes resulting from CERCLA remedial actions at the ORR [3]. The Record of Decision included draft waste acceptance criteria that were based on a performance assessment model using a future receptor scenario that included a homestead adjacent to the closed facility. With the Report to Congress completed and the Record of Decision signed, Bechtel Jacobs awarded the contract for the first 305,000 m<sup>3</sup> of EMWMF capacity to Duratek Federal Services in December 1999.

## LESSONS LEARNED

To meet privatization project criteria above, the payment terms of the contract required Duratek to finance the design and construction of the facility and then recover their investment during the initial operating period. The proof of performance was disposal of waste delivered to the facility, along with operation of facility support infrastructure such as the leachate collection system. Based on a review of the waste generation forecast for the first remedial action projects scheduled to deliver waste to EMWMF, a conservative value of 96,000 tons was selected as the quantity of waste for the payback period. Thus the contractor's price for design and construction was divided by 96,000 to yield the increment of payment for each ton crossing the scales. Lessons learned during execution of the contract were derived from the nature of the scope as well as the peculiarities of privatized projects.

### Design

Design started immediately upon award of the subcontract. The scope included design package deliverables at 60%, 90%, 100%, and Issued for Construction. The Remedial Design Report containing the Issued for Construction design was approved by the regulators in March 2001 [4]. Several lessons learned were gleaned during the design; the most significant of which are identified here.

The lesson that most impacted the cost of the project was not having the design completed and approved by the regulators prior to getting a price for construction. Several changes were encountered during design that resulted in having to negotiate subcontract price increases in a non-competitive mode. Among the most significant changes were:

- Imposition during the 90% design review of a state rule requiring a geologic buffer of prescribed thickness and permeability beneath the facility [5];
- Imposition of a gas collection system in the facility cap design during the 90% review
- Inclusion of classified waste as a candidate waste stream just prior to the 90% design

Akin to line item projects, adjustments to funding for a privatized project can literally require an act of Congress. Thus, project resources were diverted to manage the Congressional reporting to keep the project compliant with privatization funding requirements.

The lesson that most impacted the overall execution and success of the project was regulator involvement. Prior to award of the contract, a Remedial Design Work Group (RDWG) was formed to provide a forum for frequent interaction with EPA and TDEC. While the participants in the RDWG were not necessarily

the decision-makers in their organizations, they provided a conduit to those decision-makers. With technical backgrounds and working level knowledge of the issues, the recommendations of RDWG participants to their management were critical to timely decisions by the regulatory agencies. The success of the EMWMF RDWG made it the prototype for the formation in 2003 of Core Teams for each of the major remedial action projects at ORR.

One of the challenges presented by the site location, high groundwater, is the source of several lessons learned that have impacted all aspects of the project. For the design aspect, the project learned that there is no such thing as too much independent subject matter review of the groundwater model. The facility footprint was bisected by a small tributary to Bear Creek, Northern Tributary (NT) 4 [see Fig. 2]. To make efficient use of the site, a diversion ditch was designed upslope of the facility on Pine Ridge in an attempt to redirect the flow of NT-4 near its headwaters and the balance of the NT-4 channel was filled. The designers correctly predicted that the groundwater level in the fill at the NT-4 channel would rise, but the magnitude of the rise exceeded predictions. As a result, an underdrain was constructed in 2003 that essentially reestablished the old NT-4 channel in the form of a 3.7 m wide x 1.8 m high rock-filled drain 7.6 meters below the site. Groundwater levels started dropping immediately upon construction of the underdrain.

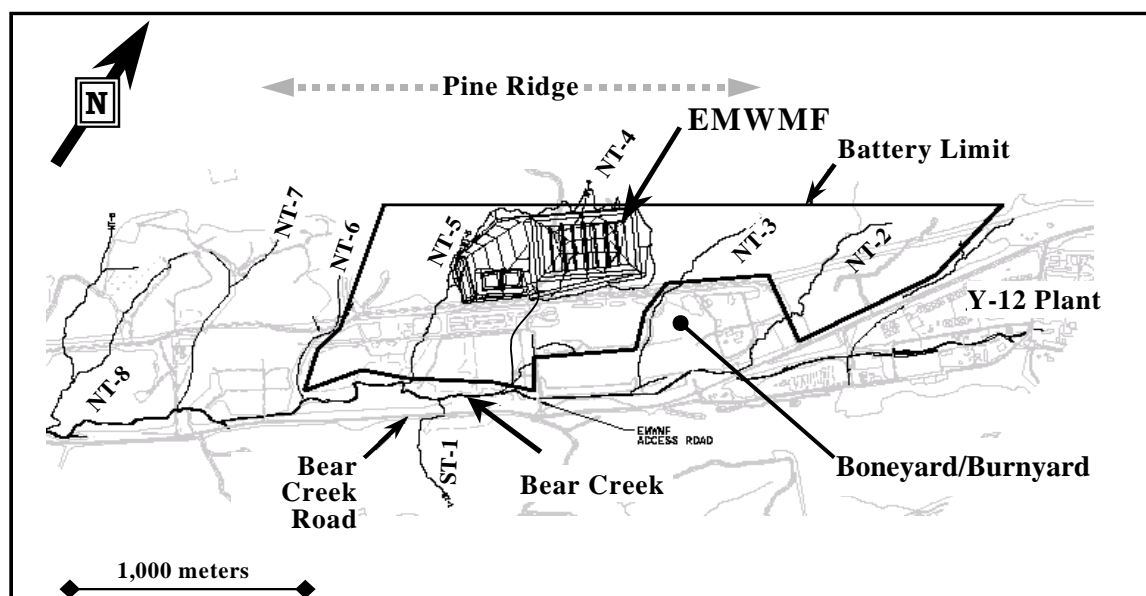


Fig. 2. EMWMF surface water features

A final design lesson learned that also spills over into construction is to conduct a thorough site characterization. More effort in this regard might have mitigated the impacts of having insufficient quantities of high quality low-permeability clay in the on-site borrow source and large quantities of unsuitable material to remove from the site. In addition, the impacts of the previously mentioned high groundwater at the site could have been accommodated better with a more thorough site characterization. During bidding for the EMWMF subcontract, bidders requested the opportunity to perform their own site investigations. These requests were denied due to time constraints, concern over bidders gaining an unfair advantage, and the inability to effectively enforce prime contract requirements on subcontract bidders who are essentially working for free in performing their own characterization.

## **Construction**

With enforceable milestones for remedial action projects that needed waste disposal capacity looming on the horizon, construction began immediately upon approval of the design. The site was developed from scratch to turn a heavily wooded, steeply sloped ridge into a waste containment structure with a service life of 200 to 1,000 years. Over the 13 months of facility construction, ample opportunities for lessons learned were present.

The trend of contract changes that surfaced during design cascaded into construction. The critical path construction schedule was impacted by the ad hoc geologic buffer requirement, by the shortage of low permeability clay in the on-ORR borrow site, by the prevalence of unsuitable materials in the footprint, and by a stop-work order resulting from a small brush fire during burning of cleared debris. The cumulative effect of these impacts pushed the weather-sensitive liner construction from the normally cool, dry fall into the cold, wet winter, which compounded the schedule impact.

One of the biggest lessons learned from this experience was to try to keep the organization as flat as possible. At times, there were five tiers between the Bechtel Jacobs managers of the subcontract and the subtier subcontractors actually performing the work. In addition to the obvious cost impact of a markup on subcontract changes at each level of the organization, this multi-tiered complexity slowed communications which, in turn, slowed response time to changes, which further increased costs.

In the course of executing changes to the fixed price, lump sum subcontract, it became apparent that having fixed unit rate pay items for reasonably anticipated changes (e.g. \$/m<sup>3</sup> for unsuitable material removal and replacement) and fixed unit rates for labor, equipment, material markups, etc. would have been invaluable in controlling cost and speeding up response to changes. Most importantly, a per day pay item for a critical path schedule extension would undoubtedly have yielded a better price for the more than 40 critical path schedule extension days that resulted just from the impact of pushing liner work into the winter.

On the positive side, the project employed a very successful strategy in securing regulator approval of the certification of construction. Knowing that there would be immense pressure to start operations as soon as possible upon completion of construction, the project produced Incremental Certification Reports (ICRs) each major facility component (e.g., compacted clay liner, leak detection system) was completed and the corresponding quality control/quality assurance documentation compiled. Each of these ICRs was sent to the regulators for review and approval as the subject component was finished. At the completion of construction, a Construction Certification Report (CCR) [6] was issued to document final regulator approval, but this (CCR) was mostly an index of the previously reviewed and approved ICRs. Thus, the CCR received regulator approval in just 21 days from the completion of construction.

## **Operations**

The first load of waste was delivered to EMWMF in May 2002. Over the subsequent 4 months, the 96,000 tons of waste required for payback of the privatized cost was delivered. The first project to utilize the EMWMF was the Boneyard/Burnyard, which disposed of 42,000 m<sup>3</sup> of waste. By removing this contaminated soil from the Bear Creek watershed and placing it into an engineered facility, uranium leaching from the Boneyard/Burnyard into Bear Creek was reduced by 2 orders of magnitude. The start up of every facility offers ample opportunities for lessons learned, and the EMWMF was no exception. These learning opportunities were increased by near record precipitation during the first 18 months of operation.

Water management was the most notable challenge during the first year of EMWMF operations. The average annual rainfall for the site is 130 cm. The rainfall during the first year of operations (May 2002 through May 2003) totaled nearly 195 cm, or 50% above average. That trend continued for the balance of calendar year 2003, which made it one of the wettest years on record. Included in that period was a storm in February 2003 that was calculated to have a 67-year recurrence interval. The design basis for the site is required to accommodate only a 25-year, 24-hour storm. The abundance of rain created problems in management of all types of water – leachate, contact water, and storm water – as well as in waste placement operations.

The design took advantage of the facility's hillside location to create a 5% slope along the centerline of each cell to direct surface water and leachate to the south. The waste placement plan stipulated filling the facility from south to north. This was intended to provide drainage control to minimize contact water (precipitation that has or might have come in contact with waste and thus requires management) and maximize uncontaminated storm water (which can be discharged through the site sedimentation basin). The idea was for contact water to collect at the base of the waste face and percolate into the leachate system, or be removed by portable pumps. The unusually high rainfall combined with the predominantly clayey and silty nature of the soil waste generated across the ORR resulted in an in-cell waste mass that remained saturated and unworkable for up to several days after major rains. In addition, the top layer of the facility's Resource Conservation and Recovery Act (RCRA)-compliant liner, the protective cover, was a locally derived, clayey material that originally had a fairly low permeability. The protective cover grew even less permeable with each rain as fines were washed from the berm side slopes and settled onto the surface of the protective cover from standing water. The result was a quagmire at the working face after significant rainfall events.

To mitigate this problem, waste was reconfigured to create a collection basin at the southwest corner of Cell 1. Waste placement techniques ensured that the waste mass was sloped, to the extent possible, to drain runoff to the basin [see Fig. 3]. A clean fill berm was constructed across the Cell 1 floor upslope of the working face to reduce the amount of runoff into the contaminated, which improved both the working stability of the waste mass as well as the amount of contact water.

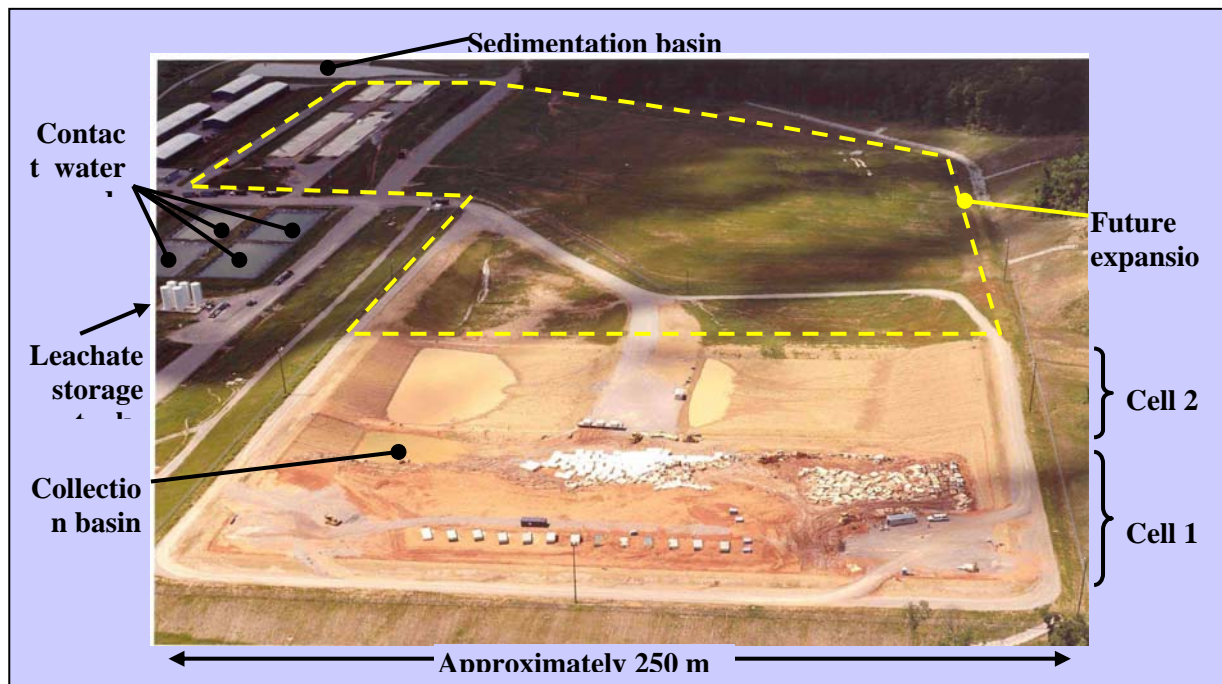


Fig. 3 EMWMF aerial view, facing west, from May 2003

As this problem was solved, another was created. Significant quantities of contact water were accumulating in the collection basin. With no relief in the wet weather trend, the four 1,938,000-liter contact water ponds quickly filled. The process of sampling and analysis followed by hauling contact water to the on-ORR treatment facility in tanker trucks could not keep up with the rate at which contact water was being generated. In calendar year 2003, nearly 26,495,000 liters of contact water was shipped for treatment. In addition, 7,570,000 liters of leachate was generated, which is double the annual quantity estimated in the project design basis. On two occasions, the in-cell collection basin was overwhelmed and runoff from Cell 1 flowed into Cell 2, contaminating an area that had not yet received any waste.

To recover, contact water hauling operations went around the clock and extra tankers and drivers were acquired. The goal was to maintain at least one contact water pond (1,938,000 liters) available to handle storm flow. That capacity would accommodate 5 cm of rainfall across Cell 1.

The last precipitation-related challenge was clean storm water runoff. During construction, 20 hectares of the site had been denuded. Most of the runoff from the site is discharged through a 10,977,000-liter sedimentation basin. Again, the clayey nature of the site soils presented a problem by creating a high load of fine and colloidal particles in runoff. The success of the revegetation effort at the conclusion of construction was negated by an insect infestation that killed the grass. The amount of total suspended solids in the site discharge to Bear Creek drew the attention of state water quality regulators. Just as the second revegetation effort was achieving some success, the construction of the groundwater underdrain started and 10 hectares was disturbed. Even though state-recommended best management practices were being employed, the sediment load in the discharge remained objectionably high. In response, the rip rap check dams in the ditches were augmented with a layer of filter fabric overlain by gravel on the upstream face. Results were immediate and positive. That, coupled with an aggressive revegetation effort that went very heavy on straw mulch, solved the problem.

## **THE EMWMF AND THE ACCELERATED CLEANUP OF THE ORR**

At the time the Remedial Investigation/Feasibility Study for the EMWMF was approved in 1998 [7], the waste volume with high confidence of being disposed at EMWMF was 270,000 m<sup>3</sup>, with an upper bound, low confidence volume of 836,000 m<sup>3</sup>. The reason that these volumes were low was a combination of the infancy of the overall ORR cleanup effort (incomplete characterization of waste and lack of CERCLA decision documents) and skepticism on the part of the remedial action project managers who were supplying waste generation forecasts that EMWMF would ever come to fruition.

By the middle of 2001 when the EMWMF construction was well underway and the Waste Acceptance Criteria Attainment Plan [8] was nearing completion, the forecast for waste to be disposed at EMWMF had grown to 1,976,000 m<sup>3</sup>. At the time of the writing of this paper, the oscillations appear to be damping out and the EMWMF volume seems to be converging on the 1,500,000-m<sup>3</sup> mark. Having adequate airspace at EMWMF to accommodate all of the CERCLA cleanup waste suitable for disposal there is essential to the success of the accelerated cleanup.

### **Challenges**

A waste volume of 1,500,000 m<sup>3</sup> presents some challenges to the cleanup. First is the fixed area available for future facility expansion. Next is the ratio of soil to debris in a cleanup program that includes decontamination and demolition (D&D) of hundreds of buildings. Finally, it will be necessary to utilize that airspace at a rate approaching 38,000 m<sup>3</sup> per month during the peak years of FY2006 through FY2008. Add to these challenges those of the performance based, incentive fee structure of the Bechtel

Jacobs closure contract, and it becomes apparent that the period between now and the end of FY2008 when the contract expires, will likely be the most exciting and eventful in the history of the ORR cleanup.

The site area available for expansion of the waste containment area is bounded on all sides [see Fig. 1 and 2]. To the north is the steep top of the slope of Pine Ridge. To the east and west are Bear Creek tributaries NT-3 and NT-5 that cannot be crossed or encroached upon. To the south is the extremely shallow groundwater table as the topography flattens at the base of Pine Ridge adjacent to Bear Creek. A conceptual layout of the site at maximum capacity indicates that the maximum amount of airspace that can be developed at the site is in the range of 1,672,000 m<sup>3</sup>, with a tolerance of +25% and -10%. Comparing that figure to the most recent waste generation forecast of 1,500,000 m<sup>3</sup> is cause for some concern.

During the period in which the waste generation forecast was 1,976,000 m<sup>3</sup>, regulator concern about the capacity of the site to handle that much waste led to the development of an ad hoc document called the Comprehensive Waste Disposition Plan (CWDP) [9]. As the name implies, this document provides the strategy to ensure that all of the waste from the ORR cleanup has a viable disposition. In addition, the CWDP made two notable commitments affecting EMWMF. First, the project was committed to amend the Proposed Plan and Record of Decision (ROD) for the EMWMF because the forecast waste volume far exceeded the ROD-approved capacity of 1,292,000 m<sup>3</sup>. Second, the project was committed to maintain a “lockbox” of EMWMF capacity of 228,000 m<sup>3</sup> to assure that the airspace at EMWMF wouldn't be consumed in the near term, leaving the outyear projects (FY2009 to FY2015) with no on-site disposal alternative.

Sensitivity analysis of the data supplied by waste generators, however, indicates a likelihood that the actual waste volume will be lower than currently forecast. This analysis includes consideration of the amount and likely bias of the characterization data (sampling efforts are normally oriented to find contamination and to find the maximum concentrations) to determine a “confidence in volume value.” Also considered is the “confidence in decision” which reflects the project's state of completion of its CERCLA decision document and range of possible/probable outcomes. Comparison of historical volume estimates from remedial action projects that are now at or near completion to the actual volumes of waste generated, confirm a trend toward conservatism and overestimation of volumes when characterization is incomplete and the CERCLA decision has yet to be finalized. If the waste volume turns out to be only nominally above the 1,292,000-m<sup>3</sup> ROD-approved capacity, the ROD might be revisited in the form of an Explanation of Significant Difference, instead of a ROD amendment. This would allow the Cell 5 to come on-line 4 to 6 months earlier.

Regardless of where the final waste volume number ends up, additional capacity beyond the current 305,000 m<sup>3</sup> will be required in FY2005. To meet this imminent need, a second privatized subcontract was awarded in October 2003 to build another 610,000 m<sup>3</sup> of capacity (by adding Cells 3 and 4). Unlike the Phase 1 privatized effort, this one does not include operations as the vehicle for payback. To do so would require just-in-time delivery of Cells 3 and 4 such that the current operations contract for Phase 1 would be complete, thus preventing the situation of having two operators at the facility competing for waste. Instead, payment will be made upon regulator approval of the Construction Completion Report. Design of the build-out will be completed in May 2004 and the additional capacity will be on-line in May 2005. Immediately thereafter, work on the final expansion will commence.

The concern over site capacity is exacerbated upon first glance at the details in the waste generation forecast. Approximately 40% of the waste stream is debris that requires additional fill to manage void space. Not only is the soil waste comprising the remaining 60% of the waste stream insufficient to manage this challenge, the sequencing of remedial actions yields prolonged periods of time during which the ratio reverses to make debris the majority of incoming waste [see Fig. 4]. Thus, efforts are underway



to identify ways to optimize the physical form of debris to minimize fill required (compaction, crushing, grouting, etc.) and to adjust sequencing to improve the soil waste to debris waste ratio as much as possible. With an absolute site capacity in the range of 1,672,000 m<sup>3</sup>, success at this endeavor is essential.

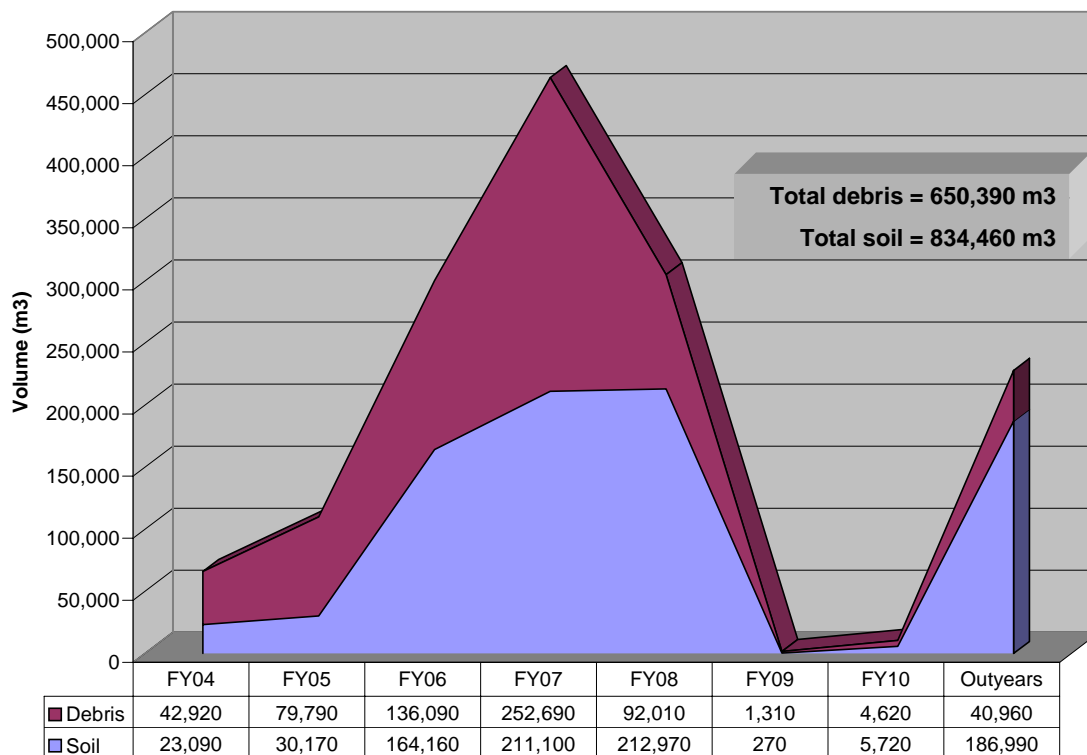


Fig. 4 EMWMF Waste Forecast – Soil to Debris Ratio

There is only one way to address the challenge of rate of delivery of waste – adequate infrastructure to support multiple working faces and extended hours of operation. As with the site capacity issue, the location of the site compounds the rate of delivery issue. The only access to the waste containment structure is from the south. Construction of additional capacity as the facility is expanded to the west impacts access from that direction. Additional access from the south at the east end of the facility is being designed as part of the imminent build-out. That will provide uninterrupted access to the top of the 10.7-meter high perimeter berm to allow waste placement from multiple locations as the waste mass in Cells 1 and 2 grows vertically. It will also be important to maintain the access from the west to the floor of the facility to the extent possible. To handle waste deliveries during peak periods, extended shifts and lighting will be required. Preparations are being made to operate around-the-clock for 6 days per week, if required to keep up with the remedial action projects.

All of these challenges are magnified by the contract under which Bechtel Jacobs will complete the bulk of the ORR cleanup. In simplest terms, the contract requires completion of numerous remedial actions at the Y-12 National Security Complex, the Oak Ridge National Laboratory, and the East Tennessee Technology Park by the end of FY2008 for a fixed cost. Early completion yields incentive fee; late completion incurs a penalty. The cost of off-site disposal is substantially higher than on-site disposal, thus full use of EMWMF will ensure the most efficient and accelerated cleanup of the ORR. However, the fixed capacity of the site means that alternatives for waste management and disposal must be fully explored. Remedial action projects are evaluating waste streams to determine if selected building debris

can either be rubblized and used as backfill or disposed at the ORR sanitary landfill. This is all the more important because the lockbox requirement from the CWDP was included as a contract stipulation that there must be at least 228,000 m<sup>3</sup> of capacity remaining at EMWMF at the close of the contract.

## **SUMMARY**

To meet the performance criteria for the EMWMF and the closure contract, operation of the EMWMF, future expansions of the facility, and the remedial action project customers must be fully integrated.

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