PROCESSING AND DISPOSING OF OAK RIDGE RESERVATION LEGACY LOW LEVEL WASTE: OVERCOMING A REGULATORY CHALLENGE

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ABSTRACT

Decades of operations in radiological and nuclear facilities on the Oak Ridge Reservation (ORR) near Oak Ridge, Tennessee, have produced huge volumes of radioactive wastes that must be safely dispositioned. These waste streams were collected in a combination of silos, tanks, warehouses, and storage pads at the former K-25 Gaseous Diffusion Plant, at the Oak Ridge National Laboratory, and at the Y-12 National Security Complex. Through an agreement negotiated with the Tennessee Department of Environment and Conservation (TDEC) and the United States Environmental Protection Agency (USEPA), the U.S. Department of Energy (DOE) committed to process and dispose of approximately 22,000 cubic meters of these low level radioactive wastes at three designated waste disposal facilities.

Duratek was one of the firms selected to process, repackage and dispose of these legacy low level wastes at its Bear Creek commercial waste processing facility in Oak Ridge. Duratek employed innovative strategies for meeting aggressive project schedules and mitigating the impact of issues related to operating commercial waste processing facilities under the stringent regulatory requirements associated with the handling and disposition of radioactive and hazardous constituents. The Company also developed processes to deal with constraints imposed through permitted limits for on-site storage of special nuclear materials (SNM). Innovations included provisions for creative use of staging and buffer storage areas, as well as optimization of waste processing and shipping schedules using decision support algorithms and implementation of “just -in-time” inventory management techniques.

INTRODUCTION

Oak Ridge Operations and Legacy Waste Generation

The DOE Oak Ridge Reservation is located in east Tennessee, in and around the city of Oak Ridge, approximately 40 km northwest of the metropolitan Knoxville area. This was one of three sites selected by the Manhattan Engineer District in 1943 on which to construct and operate facilities that would be key to development of the technology and production of the fission materials required to build the atomic bombs that would later be credited with bringing and end to the second world war.

The 15,000 hectares originally set aside for this federal reservation gave rise to three facilities, each making its individual contribution to the 60 plus-year legacy of atomic energy and weapons development programs to be conducted in the Oak Ridge area. The Oak Ridge Gaseous Diffusion Plant, or K-25 as it is historically known based on the code name given to it , housed the cascades where the gaseous diffusion process was used to produce a stream of gaseous Uranium Hexafluoride (UF6) enriched in the fissionable Uranium isotope U-235. The X-10 facility was constructed to support much of the development work required to perfect the techniques and processes necessary to control sustained fission reactions. It was the home of the experimental graphite reactor which served as the model for the Plutonium production reactor later built at the Hanford reservation in Hanford, Washington. The Y 12 plant was constructed to provide the capability for production of the components needed to assemble the first atomic weapons. This facility would become a primary repository for much of the weapons grade inventory of fissionable materials and would serve as a Mecca for development and dissemination of the nation's nuclear weapons production and manufacturing technology.

Beginning with these earliest weapons development and production activities at the ORR, radioactive by-products, radioactive wastes, and hazardous wastes containing radiological constituents were generated. However, at that time the priority for finding a solution to adequately address the issue of waste management and disposal was secondary to the urgency of establishing the ability to exploit the awesome power offered from this new energy source. Consequently the practice of accumulating materials in "interim" storage locations was adopted pending development of a solution for their longer term or permanent disposition.

The proliferation of enrichment technologies by the mid 1980s had resulted in excess international enrichment capacity and enriched Uranium stockpiles. These changed conditions and increased awareness of the environmental consequences presented by the legacy generated from decades of wartime and cold war research, development, and weapons production activities throughout the DOE Complex prompted DOE to shift its focus to environmental cleanup. A major consideration driving the priorities established for this and other remediation and environmental restoration programs to follow would be how to classify, characterize, safely contain, process and dispose of the tens of thousands of cubic meters of low level radioactive and mixed wastes accumulated in a variety of impoundments, silos, tanks and containers located throughout the three ORR facilities.

Regulatory Background

The highly sensitive nature of the operations and the need for security at the installations involved in the Manhattan Project transcended established criteria for oversight from existing Federal or state agencies. Consequently, in the early years of the ORR and other similar facilities around the country, the basis for regulation was self imposed through the Atomic Energy Commission (AEC) which was established in 1946. As the atomic energy research and development programs and the segments of society which they affected evolved through the 1950s and 1960s the need for additional controls to protect the public and to safeguard the environment was recognized, and agencies such as the Department of Transportation (DOT) and the Nuclear Regulatory Commission (NRC) were empowered to regulate activities and operations affecting use and transport of radioactive materials in open commerce. However, the DOE, established as a Federal Executive Branch cabinet level department in 1977, retained the authority to regulate activities associated with management and disposition of nuclear materials housed in its facilities and for weapons related programs.

Protection of the environment and natural resources became a source of great public debate and concern in the 1970s and many states began to enact legislation designed to place restrictions on activities with the potential to affect human health, insult the environment, or to compromise the beneficial use of natural resources. The response to this heightened environmental awareness across the country at the Federal level was creation of the U. S. Environmental Protection Agency (USEPA). This organization was endowed with broad authorities to regulate activities, including those of other Federal agencies and private enterprise, with the potential to adversely impact human health and the environment. A series of Federal environmental statutes were also passed from the mid 1970s through the 1980s that established stringent regulations for conduct of activities associated with the production, storage and disposal of various classes of hazardous materials. Some of the key pieces of federal legislation enacted during this timeframe that would have major impact on operations in DOE facilities across the country, the ORR notwithstanding, included the following:

- Comprehensive Environmental Response and Compensation Liability Act (CERCLA)
- Resource Conservation and Recovery Act (RCRA)
- Clean Air Act
- Clean Water Act
- Superfund Amendments Reauthorization Act (SARA)
- Toxic Substances Control Act (TSCA)

The advent of regulations promulgated under these statutes presented challenges to DOE and dictated that many of the approaches for dealing with operations involving management, storage and disposition of hazardous and radioactive wastes established in their own regulatory framework be revisited. In many instances this process resulted in debates with the Federal and state environmental regulatory agencies that could only be resolved through litigation in the courts or through arbitration that produced agreements formalized in consent orders.

Continued concerns expressed by the public and the State of Tennessee resulted in the ORR being placed on the National Priorities List (NPL) in 1991. Subsequent to this development, a number of consent orders were issued mandating specific corrective actions and due dates for their completion. As DOE made progress in reviewing and defining characteristics of its ORR low level radioactive legacy waste inventory, options for permanent off-site disposal of much of this material not suitable for on-site disposal were developed at other government and commercially operated waste disposal sites. The risks and prohibitive costs associated with off-site transport and disposal of the entire legacy waste inventory in this fashion, however, prompted DOE to pursue further negotiations with the Federal and State regulatory agencies in 2003 that would allow disposal of as much of this material as possible in the ORR's on-site CERCLA waste disposal cell known as the Environmental Management Waste Management Facility (EMWMF).

Key provisions of the agreements reached as a result of these negotiations included a requirement for DOE's ORR environmental restoration contractor, Bechtel Jacobs Company, LLC (BJC), to process the wastes and segregate constituents not meeting EMWMF waste acceptance criteria. Segregated items were to be managed and disposed of according to applicable regulatory criteria as defined by the types of materials identified. The agreement further authorized DOE and BJC to process and repackage these wastes as well as those destined for permanent off-site disposal at commercially licensed waste processing facilities located in the Oak Ridge area [1], [2].

LOW LEVEL WASTE PROCESSING AND SHIPPING (LLWPS) OVERVIEW

Objectives and Success Criteria

It was understood that characterization and eventual disposal of the large legacy waste inventory would present a challenge, primarily because documentation supporting decisions on appropriate disposal options was generated prior to the time that categorization and management of these wastes were subject to environmental statutes under which they are currently regulated. Nevertheless, DOE and BJC adopted an aggressive posture to move forward with categorization and removal of the legacy waste inventory from the ORR as one of the high priority objectives of the Accelerated Cleanup Program.

The Low Level Waste Processing and Shipping Project (LLWPS) was planned and implemented in part to meet commitments made to USEPA and the State of Tennessee in an Oak Ridge Accelerated Cleanup Plan Agreement presented by DOE and BJC in June 2002. This Agreement was developed to address Notices of Violation issued in 2001 in response to DOE notifications to the state regulatory agency in compliance with systematic discovery self-reporting criteria that potentially hazardous constituents might be present in legacy LLW containers. This Agreement was further supplemented by a March, 2003 Comprehensive Waste Disposition Plan that specifically defined an approach to characterize and remove or permanently dispose of the inventory of legacy low level radioactive and mixed wastes that had accumulated at the ORR by September 30, 2005 [3]. The requirement to segregate and appropriately dispose of non-conforming items and hazardous materials subject to regulation under RCRA, TSCA or other statutes was addressed under this plan as well.

Waste Population Characteristics and Disposal Criteria

The ORR legacy waste population has been subdivided into 11 general categories based on matrix type and other factors to facilitate completion of the characterization process and to establish a consistent approach for processing and disposal. The categories are:

- Dry Active Waste
- Radioactive Scrap Metal
- Construction Debris
- Soils
- Uranium Oxide
- Wastewaters
- Organic Liquids
- Sludge/Treatment Residues
- Resins/Trapping Materials
- Volume Reduction Residues
- Special Case Waste (e.g., classified, alpha-bearing LLW, high activity LLW, etc.)

The first three listed categories comprise 70% of the legacy waste inventory consisting of roughly 22,000 cubic meters of wastes stored in intermodal and sea-land containers, B-25 type boxes, and assorted drums. This waste population was thought likely to contain RCRA or TSCA regulated constituents as well as other non-conforming items that would probably not meet low level waste acceptance criteria established at the on-site EMWMF and other off-site government or commercially operated facilities. This position was based on the results of a 2001 preliminary inspection and sorting of 247 containers that yielded 1.5% by mass of materials determined to require segregation for management as hazardous(mixed) waste. Typical of the items segregated were:

- fuses
- flammable paint
- thermometers
- light bulbs
- capacitors
- lead
- printed circuits
- mercury switches

It was also established from process knowledge that these wastes could contain such materials as Beryllium and asbestos. Examples of other items subject to segregation from this population, primarily due to their status as non-conformers with respect to disposal site acceptance criteria, included: gas cylinders and pressurized containers, medical or biological wastes, free or confined liquids, and soils or soil-like materials.

Radiological activity and special nuclear materials (SNM) content also proved to be a major parameter driving the planning and implementation of the LLWPS project as will be illustrated in the discussion to follow. The per-container inventories as determined from recorded historical data supplemented by statistically based non-destructive assay (NDA) measurements and calculations ranged from non-detectable levels to more than 300 grams. Some waste lots, especially those generated from activities conducted at the X-10 and Y-12 facilities, also contained significant levels of removable and/or alpha-emitting radiological species that had the potential to create facility contamination and personnel exposure concerns during the sorting and segregation process.

Implementation Strategy and Constraints

In August, 2003 DOE, BJC and the State of Tennessee formally agreed to a strategy for executing the project that would accomplish characterization and disposal of the ORR legacy low level waste inventory by not later than September 30, 2005. The primary elements of the approach for characterization and disposal of these wastes are summarized as follows:

- Review and assess available characterization documentation for the waste,
- Conduct a visual inspection of the waste to confirm contents of containers,
- Divide the waste into groupings based on waste matrix, radiological content, and other relevant factors, such as generation source, enrichment and process knowledge, etc.,
- Collect additional characterization data as necessary,
- Sort and segregate waste to remove any components that do not meet the WAC for the selected disposal facilities,
- Maximize packaging efficiency for repackaged low level wastes to take advantage of volume reduction potential to offset waste disposal life cycle costs.

Given the urgency of the task at hand, the volume of waste involved, and the need to assure flexibility required to mitigate potential risks associated with meeting the mandated September 2005 completion milestone, BJC chose to secure the services of multiple subcontractors with waste processing facilities off the Reservation. Accordingly, Duratek was one of three subcontractors initially selected to perform the required waste sorting, segregation and disposal activities at its Bear Creek and Gallaher Road processing facilities, both located less than 2.5 km from the former K-25 plant site [3]. The choice of using off site facilities introduced an additional regulatory consideration into the project implementation process as well. These commercial facilities must operate subject to NRC regulations and are typically limited to a 350 gram on-site SNM inventory under radiological permits issued by the state of Tennessee.

Further allowances were also needed to address the fact that items known to require management under RCRA, TSCA, or other health and safety related statutes were contained in these wastes categorized in existing documentation as low level radioactive wastes. The provisions of the agreement with the State and USEPA established procedures as outlined below to give DOE, BJC and the sorting and segregating subcontractors a framework under which to address hazardous waste generator issues and to establish a means of managing and disposing of these items in compliance with applicable regulatory criteria.

- All wastes would be manifested and shipped to sorting and segregating facilities as low-level radioactive wastes
- Potentially regulated waste found in containers once opened for inspection would not cause the entire container to be categorized as regulated waste unless it was deemed impractical to remove the non-conforming items.
- Potentially regulated items would be considered newly generated waste at the time of removal from legacy waste containers and would be subject to management separately from that point consistent with applicable regulations.
- Segregated items would be subject to 90-day RCRA storage criteria and would be packaged and shipped directly to licensed treatment, storage or disposal facilities (TSDFs) when possible.
- Waste remaining in the containers would be repackaged, continue to be managed as low level waste, and be certified to the waste acceptance criteria of the following waste disposal facilities as determined by characterization category:
  - The on-site EMWMF at ORR
  - The Nevada Test Site (NTS) in Mercury, Nevada
  - Envirocare of Utah, in Clive, Utah
- Waste shipments to designated disposal facilities would be made consistent with existing waste shipment programs established for each disposal facility.

- Items segregated from wastes destined for disposal at one of the three designated disposal facilities because of inability to meet facility WAC could be shipped directly to one of the remaining two disposal facilities without being designated as non-conforming provided their WAC could be met.

Waste acceptance at sorting and segregating facilities was based on a set of waste acceptance criteria established by each subcontractor to address limitations under which their waste processing operations could be conducted. BJC prepared waste population profiles for review by the sorting and segregation subcontractors prior to shipping wastes to their facilities to provide assurances that the subject wastes could be processed once received.

WASTE PROCESSING AND DISPOSAL OPERATIONS

Processing Facilities Description and Capabilities

Duratek’s Bear Creek Operations (BCO) facility served as the primary location for sorting and inspecting waste for this project. This facility has years of experience in providing services to the Oak Ridge Operations (ORO) facilities. The BCO facility covers approximately 60 acres. The entire area is paved and contained within a perimeter fence. Aside from the production facilities and administrative buildings, the entire area is available for waste storage and for staging inbound and outbound shipments. The entire property is illuminated at night and guarded round-the-clock by the Duratek security force. The outbound staging area is approximately two football fields in size and can accommodate roughly two-dozen fully loaded trailers which can be used to stage B-25s and intermodals.

Two certified truck scales are available in the staging area at BCO and are calibrated on a quarterly basis. These scales confirm the waste weight as received at BCO and also ensure that the outbound weight of a fully loaded truck is within DOT-specified limits.
Other features of the BCO staging area include a “yard dog,” used to move fully loaded trailers to and from the processing facilities, concrete perimeter barriers for safety and security, and a series of stanchions and chains to direct foot traffic around the vehicle traffic. In addition to BCO, Duratek’s Gallaher Road facility adds over 10 acres of bonded storage space and truck staging area to the Project’s resources. This facility was to be used in the event shipments were rapidly received or staged for outbound shipment, especially if BCO approached a license limit for management of SNM.

Dominating the BCO facility is the Central Volume Reduction Facility (CVRF). Duratek’s processing capabilities at its local Oak Ridge and Kingston facilities include the following:

- Sorting and waste segregation
- Radioactive material/source consolidation and repackaging
- Supercompaction
- Incineration of DAW
- Size reduction of metals, woods, and other solid waste
- Melting and recycling of radioactively contaminated metal
- Decontamination of metal and lead
- Liquid waste volume reduction
- Green-Is-Clean services for assay and directed release of clean material to an industrial landfill

BCO operates two central sorting areas within the CVRF which are ideally suited for this project. Each area can accommodate receipt of waste in cargo containers, metal boxes or drums. These facilities are fully licensed and permitted and can be staffed for three shifts, seven days per week if necessary. The Sorting "A" facility is designed to receive bulk shipments of waste, primarily in B-25 boxes and cargo containers. This facility contains automatic conveyors that are placed immediately adjacent to the truck off-loading dock.

On the opposite side of the CVRF is the Sorting "B" facility, which is a linear-style, high-capacity sorting area. The equipment in this area is primarily designed to receive waste contained in metal boxes and drums. The conveyor-style sorting system allows four to six sorting personnel to view the waste as it is conveyed toward the compactor, providing multiple opportunities to identify and remove non-conforming items.

For scrap metal and construction/demolition debris, Duratek uses the steel-plated floor of the BCO Metal Melt Facility. Containers are brought into the building and the contents placed on the floor adjacent to the large air intake system. Scrap metal is sorted and size-reduced using a shear-baler, or torch-cut with plasma torches prior to repackaging. This equipment for size-reducing scrap metal is immediately adjacent to the off-loading and sorting areas.

In addition to the BCO "A" and "B" sorting areas, Duratek built and operates an Alpha Sorting Facility at Gallaher Road. This facility was designed specifically for alpha-bearing waste and contains a glovebox within a "permacon" structure. Some of the many features of this facility include dedicated ventilation for the permacon and isolated ventilation within the glovebox and stainless steel sorting table. Other features include video cameras to record package movement inside the permacon, a video camera inside the glovebox, an overhead crane, a drum crusher, and a B-25 box dumper.

Waste Processing and Repackaging

Waste profile forms providing characterization data pertaining to waste lots assigned to Duratek for processing were prepared by BJC and transmitted to allow screening against Duratek WAC. Containers for which insufficient data was available, or for which data indicated characteristics outside the WAC, were identified and BJC requested to provide supplemental data for further evaluation. Where supplemental data was not available or could not be practically obtained, subsequent screenings were conducted on a case by case basis to determine whether the parameters resulting in WAC non-compliance could be accepted under waiver. Typical parameters evaluated included:

- Waste Density
- Removable contamination levels
- Concentrations of constituents presenting health and safety concerns (e.g., Beryllium, asbestos, etc)
- Radiological activity level and type
- SNM content

Duratek's ability to receive waste shipments from a given waste lot and to develop schedules for the shipments was directly related to the per-container SNM inventory. This connection was based on the fact that the radioactive materials license issued to Duratek by the State of Tennessee restricted the on-site SNM inventory at any time to a maximum of 350 grams. Once waste lots were approved for receipt, BJC prepared shipping documents and transmitted them to Duratek for review and approval prior to physical transport to the processing facilities. Shipments were inspected when they arrived for compliance with DOT regulatory criteria and for consistency with shipping manifests to assure that all containers were properly configured and documented. The receiving process was the starting point for placing individual containers and their contents into the Duratek Accu-trak waste inventory and tracking system used to follow the progress of waste through the various processing steps performed at the processing facilities.

Waste containers documented as received into the system were staged in temporary storage locations at the facility pending movement into a designated processing area depending on waste matrix and other characteristics. Radioactive scrap metal was typically routed to the metal processing and melting facility while dry active waste was sent to the specially prepared processing area in what is referred to locally as the Parcel 4 (P-4) facility. Construction debris, depending on its physical characteristics and incoming container type, could be routed either to the metal melt facility or to the P-4 facility for processing. The metal melt facility is capable of processing weekly throughput rates as high as 91,000 kg while the P-4 facility can produce as much as 23,000 kg of sorted waste weekly. Although the Gallaher Road facility had the capacity to process additional waste it was used to continue waste processing for other Duratek customers and was considered to be back-up sorting capacity for this project. Some waste staging was done at this location due to the fact that it was separately licensed for storage of SNM.

RSM waste containers were moved into the metal melt facilities with various types of handling equipment, depending on container type, and contents were emptied onto the sorting and processing floor in an area equipped to operate under negative pressure with a HEPA filtration system and air monitoring systems. Sorting and processing personnel trained to recognize potentially non-conforming items inspected the waste, removed the suspect items from the container contents, and performed various types of size or volume reduction operations on the remaining materials in preparation for the repackaging process. Industrial hygiene and health physics specialists were also employed during sorting and segregation operations to monitor contamination levels and to provide direction for handling of non-standard items or items presenting potential health and safety concerns.

DAW and CD, which routinely came in B-25 type containers, was moved into the P-4 facility for processing with standard material handling equipment. Once inside, containers were placed in box turners specially made to invert them so the contents would be deposited onto a platform equipped with a hooded ventilation system containing HEPA filtration. Waste sorting and processing personnel positioned around the platform removed potentially non-conforming and suspect materials from the platform and channeled the remaining low level waste onto conveyors that returned the waste to a waiting container for repackaging. As in the metal melt facility, industrial hygiene and health physics technicians were employed to monitor contamination and to provide assistance with questionable items.

Containers were selected for waste repackaging based on acceptance criteria established by the receiving waste disposal facilities. In other cases containers in which the waste was received for sorting could be re-used as long as they met the DOT strong-tight criteria for transportation purposes and were filled according to disposal criteria. Subcontractors were also given flexibility to employ re-usable bulk containers for repackaging of sorted wastes. Duratek chose to repackage sorted wastes destined for the EMWMF into re-usable intermodal containers, primarily to take advantage of the volume reduction efficiencies that could be gained by use of a bulk container. This would allow placement of wastes from multiple donor containers into a single daughter, thereby minimizing void space that would inevitably be present in individual donors.

Wastes bound for Envirocare could be placed into intermodal containers, B-25 type boxes, or other suitable containers such as sea-land or cargo containers. Duratek chose to use B-25 type boxes, again for economic reasons related to permitted re-use of containers in which the waste was received for sorting. One aspect of the container receipt inspection at Bear Creek was to assess the potential of a given container to retain its strong tight status on the more than 3600 km journey to Clive, Utah. In cases where the long distance transport integrity of the containers was in question, a more sturdy container was substituted or a transportation overpack was used.

Containers, once repackaged and prior to movement, received appropriate bar coding identification that would permit traceability back to donor containers. Other labeling required by DOT regulations was also affixed at this time. After labeling and identification, the repackaged containers were moved back outside the processing facilities to an outbound waste staging area to await further processing for transport to the designated disposal facility.

Non-Conformers Identification and Disposition

Waste accumulation areas were established in the processing facilities to accept suspect hazardous or non-conforming materials removed during the sorting activities. These areas were set up to meet the regulatory criteria for RCRA 90-day accumulation areas or TSCA waste storage areas. Provisions were also made for items not considered hazardous but that might exhibit physical or other characteristics making them unsuitable for disposal at a given disposal site. Containers were provided in these areas to allow further separation of hazardous and non-conforming items by matrix type or category. Hazardous examples include PCB-bearing vs potentially PCB-bearing, or RCRA hazardous vs potentially RCRA hazardous. Non-hazardous but unacceptable items could include intact gas cylinders, radiation sources, or items of mechanical equipment with hold-up materials potentially remaining in them.

Logs were prepared and maintained to document information that would allow traceability of non-conforming items back to source containers and generator locations. The date of generation for these wastes, for purposes of RCRA or TSCA waste management, was considered to be the date on which the item was separated from the source waste container. Items for which identification was readily determined were accumulated until sufficient quantities could be economically packaged into DOT compliant containers for transfer to a licensed TSDF. To assure compliance with the requirement to remove these materials from RCRA accumulation areas within 90 days, BJC directed that any materials not disposed of at an alternate TSDF within the 90-day timeframe be returned to an ORR licensed facility for interim storage until such time as a final disposition option could be defined. This 90-day return requirement was also established for materials not subject to management under RCRA regulatory criteria.

Potentially hazardous items requiring further characterization before identification were retained in the temporary storage area pending review of additional data obtained, either from data requests to the generator transmitted through BJC, or from sampling and other investigative processes. Experience demonstrated that the quantities of items found in these categories were relatively low by comparison to the total volume of materials removed from the waste stream. These materials were usually confined to unidentified liquids contained in vials or other containers. A notable example found in the Duratek waste processing activities was a set of 11 glass vials, shown in ***Figure 1***, containing an unknown liquid. The contents of the source waste container were inconsistent with the types of wastes with which items of this type would normally be found. Inquiries to the generator location also produced no additional information from which identification could be made. The absence of definitive data forced a full RCRA analysis of the vial contents to make a determination. Ironically, the sampling required for the analytical process consumed the entire volume of material contained in the vials.

Much of the hazardous material removed from the waste containers involved combinations of materials which, after some additional processing could be disposed of as mixed waste at Envirocare. The items involved contained various amounts of lead and other metals generally found in batteries of various types, printed circuit boards and the like. Once treated to prevent leaching they could be accepted for disposal. The Envirocare facility uses a macro-encapsulation process to treat such items prior to disposal, so arrangements were made to package and ship this material to their Utah facility for processing and disposal.

Segregated items categorized as hazardous or potentially hazardous during the sorting process were found

Fig. 1. Glass vials containing unknown liquid.

for the most part to be consistent with findings documented during the 2001 preliminary waste investigation conducted by BJC. There were however, a variety of non-hazardous items segregated from the waste containers because they were considered unacceptable for disposal at the EMWMF or at Envirocare. Examples of some items recovered include:

- Intact gas cylinders of various sizes
- Air conditioning units with held up refrigerant
- Radioactive sources
- Sealed radioactive gas canisters
- A lithium glove box

Many of the items in the above categories were thought to have been properly processed for safe disposal prior to being placed in their waste containers but still carried labels or markings making it difficult to verify that this was indeed the case (***Fig. 2***). In instances where it was determined for safety reasons that Duratek personnel should not undertake actions to verify proper processing or to convert these items to a configuration acceptable for disposal, they were packaged and returned to BJC for further disposition.

Processed Waste Transport and Disposal

All waste shipments originating from Duratek's Bear Creek facility were subject to regulation under DOT hazardous materials transport regulations regardless of destination and were subject to preparation by appropriately trained and certified waste shippers. Processed and repackaged waste awaiting transport and disposal was placed in staging areas located at Bear Creek until appropriate approval for waste receipt at the designated disposal facility could be obtained. Once this approval was obtained shipping manifests

Fig. 2. Lithium glovebox segregated during waste sorting.

and accompanying documentation was prepared and provided to BJC for final review prior to release of the shipment. When all appropriate approvals were received the loads underwent final inspection and the shipments were released. The entire process typically took several days to complete and proved to be a major challenge to efforts to maintain high rates of material movement through the facility.

Shipments to the EMWMF site, which was slightly more than six km from the Bear Creek facility, were made with closed top intermodal containers loaded onto roll-on/roll-off type transport vehicles. Scheduling of EMWMF shipments required close coordination with facility operations personnel due to the large volume of shipments this facility received on a daily basis from other environmental restoration projects underway at the ORR. The waste receipt scheduling protocol employed an appointment system that established a time window within which a given shipment was to arrive. Delays in release of a scheduled shipment from Bear Creek translated into a missed “appointment” at EMWMF and movement to the back of the que for the shipment in question.

The preferred mode of shipment for waste bound for Envirocare was via truck and flatbed trailer loaded with B-25 type boxes. Although greater numbers of B-25 type boxes could be placed on rail cars, the rail car mode was considered less favorable due to the need to reduce the staging time for accumulating sufficient containers to complete a load. This was important because the more frequent release of truck shipments opened more time windows at Bear Creek for receipt of additional waste shipments for sorting and segregation. Duratek considered many of the B-25 boxes in which some of this waste was received at Bear Creek unsuitable for use as long-distance transport containers under DOT regulations. A number of transportation over-pack configurations acceptable to Envirocare, including sea land containers and cargo vans transportable by truck were initially employed to address this situation. However the cost premiums associated with disposal of the unused void volume in these over-packs forced other options to be evaluated. One of the options that proved to be acceptable to Envirocare included rail shipment of these questionable B-25s using gondola cars to act as transportation over-packs. This shipping configuration would, however require Envirocare, with an accompanying additional handling expense, to remove the waste containers from the gondola cars prior to disposal.

The timing and frequency of outbound shipments was so closely linked to Duratek’s ability to receive inbound shipments that significant effort was spent in looking for ways to reduce cycle time for waste processing prior to release for disposal. A tactic utilizing off-site buffer storage and in-transit staging areas was developed for use when required to provide additional flexibility in the waste shipment planning process and to relieve some of the pressure on the need to maintain high facility throughput rates.

PROJECT IMPACT MITIGATION STRATEGIES AND INNOVATIONS

Environmental/Regulatory Impacts

Requirements for compliance with applicable environmental and health and safety related regulations during waste sorting and segregation operations created a number of issues with regard to timely and efficient disposition of materials processed through Duratek facilities. A primary challenge was associated with the fact that Duratek’s hazardous waste licenses did not permit treatment or secondary processing of many of the non-conforming items encountered. This dilemma was underscored by the fact that no firm definition could be developed on the specific types of items waste processing personnel might expect in the sorting process.

Items determined to be RCRA hazardous or potentially RCRA hazardous would, of necessity, be transferred to a 90-day accumulation area until an approach for dealing with them could be determined. Although many of these items could be returned to licensed storage facilities on the reservation, some could not be transported back to BJC through open commerce or accepted into the BJC storage facilities in their as-discovered configuration. This situation created concerns early in the project that the mandated 90-day deadline for disposal or return of segregated items would be exceeded. Consultation with the State regulatory agency and review of the DOT regulations governing definition of waste descriptions for purposes of disclosure on hazardous waste manifests produced relief through use of a special variance category that would allow these materials to be received at BJC. Transport in open commerce was also successfully addressed by closing the roads between BCO and the licensed storage facilities at ETTP to public traffic whenever such items were to be shipped.

The 90-day time limit for disposal or return of segregated items was initially applied to both RCRA and non-RCRA regulated materials. This constraint introduced inefficiencies and additional costs into the management and disposal of non-RCRA wastes because it failed to consider the accumulation rates that would produce volumes more economically packaged and disposed of. A request to the State to review this requirement in light of the impacts being experienced resulted in permission to allow management of these items in appropriately configured storage areas for up to one year if necessary.

Waste Characterization and Profile Acceptance Impacts

Incomplete characterization data for certain waste lots proved to be problematic with respect to Duratek's ability to confirm full compliance with sorting facility WAC before approving shipments for receipt. Waste profiles transmitted from BJC relied primarily on documented historical information supplemented by statistical sampling data. Although this information often provided a statistical basis to establish that the pertinent waste characteristics would fall within acceptable limits for waste receipt, it did not provide the detail required to assure that individual containers would not present characteristic parameters exceeding action levels for worker or facility safety. Knowledge of waste characteristics related to such parameters as removable alpha contamination, Beryllium, or friable asbestos content was critical to timely implementation of protective measures to prevent facility contamination, worker exposure or environmental releases.

Approvals of waste profiles with incomplete data were typically delayed pending receipt of additional information as a conservative measure for safety. However these delays represented disruptions in the waste receipt scheduling process and adversely affected sorting facility throughput. Total lot sampling campaigns in such situations were considered undesirable from a time and cost standpoint, so other alternatives for securing the needed information were investigated. An alternative approach adopted included research of operating records from the waste generator facility as a first step to obtain process knowledge that would assist in establishing likely upper limits on the presence of constituents of concern. Additional statistical sampling and survey of the waste lot was conducted where indicated to provide further assurance that the upper limits established were valid. These upper limits were then employed as a conservative basis for implementing protective measures in the sorting facilities.

Because many operations in ORR facilities involved Beryllium, Duratek developed and implemented a Beryllium awareness program that included worker orientation and training and baseline screening. Facility baseline surveys were also performed to establish a reference point for monitoring during waste sorting and segregation activities. Routine sampling was performed to assure early detection of any elevated facility contamination levels and to limit the potential for worker exposure.

SNM and Radiological Permit Impacts

The Bear Creek facility provided waste processing and disposal services to other customers, including other projects underway at the ORR, concurrent with the LLWPS Project. This meant that the 350 gram on-site SNM inventory limit imposed by the facility radiological permit had to be apportioned among all parties relying on BCO for waste processing services. The impact of this constraint was manifested in nearly every aspect of the waste processing and disposal operations from scheduling inbound waste shipments to release of outbound shipments for disposal. Early Project progress on waste processing and disposal capitalized on the fact that the per-container SNM inventory for waste lots passing through the sorting facilities at that time were relatively low. Receipt and staging of large quantities of waste to create a processing backlog was facilitated by these conditions. The backlog was important to maintenance of a stable processing rate and allowed mitigation of the lead time required for BJC to prepare, stage, and release shipments to Bear Creek for processing.

As the waste lots with lower per container SNM inventories were exhausted it became more challenging to maintain the higher volume of inbound shipments to the sorting facilities because fewer containers were required to reach the on-site SNM inventory limit allocated to the legacy waste received from BJC. The throttling of inbound shipments created lower on-site processing backlogs and the BJC shipment preparation lead time became a limiting factor in scheduling of waste receipts to feed the process. The key to resolving the issues related to increases in the average per-container SNM inventory could be found in an accompanying increase in Duratek’s capacity to receive and stage the higher gram inventory containers for feeding the process. It was felt that staging areas, not co-located at Bear Creek but under Duratek operational control, would provide the responsiveness and flexibility required to efficiently support the processing backlog needs of the sorting facilities.

Some relief was obtained through utilization of additional staging and SNM inventory capacity under the separate 350 gram radiological permit at Duratek’s Gallaher Road processing facility. It was understood however, that this added capacity would be an interim solution at best. Duratek determined that access to a facility in close proximity to Bear Creek but not subject to the constraints of its radiological permit limits would be essential to provide the flexibility for managing inbound SNM inventories as average per container values continued to rise. A proposal to allow establishment of a buffer storage area under Duratek’s operational control on the ETTP was prepared and submitted to BJC for approval to address the need for greater flexibility in receiving and staging inbound high-gram waste shipments as required. This buffer storage area, located on the DOE reservation and less than 2.5 km from Bear Creek, was not subject to the commercial radiological permit constraints associated with the Duratek facilities. The basis for its use would be tied to decisions to divert inbound high-gram shipments to this location once Bear Creek SNM capacity was consumed. Its use would also allow phased introduction of containers from this location into the processing que as SNM capacity windows were opened through release of outbound shipments from the facility. A decision algorithm developed for this process is presented in ***Figure 3***.

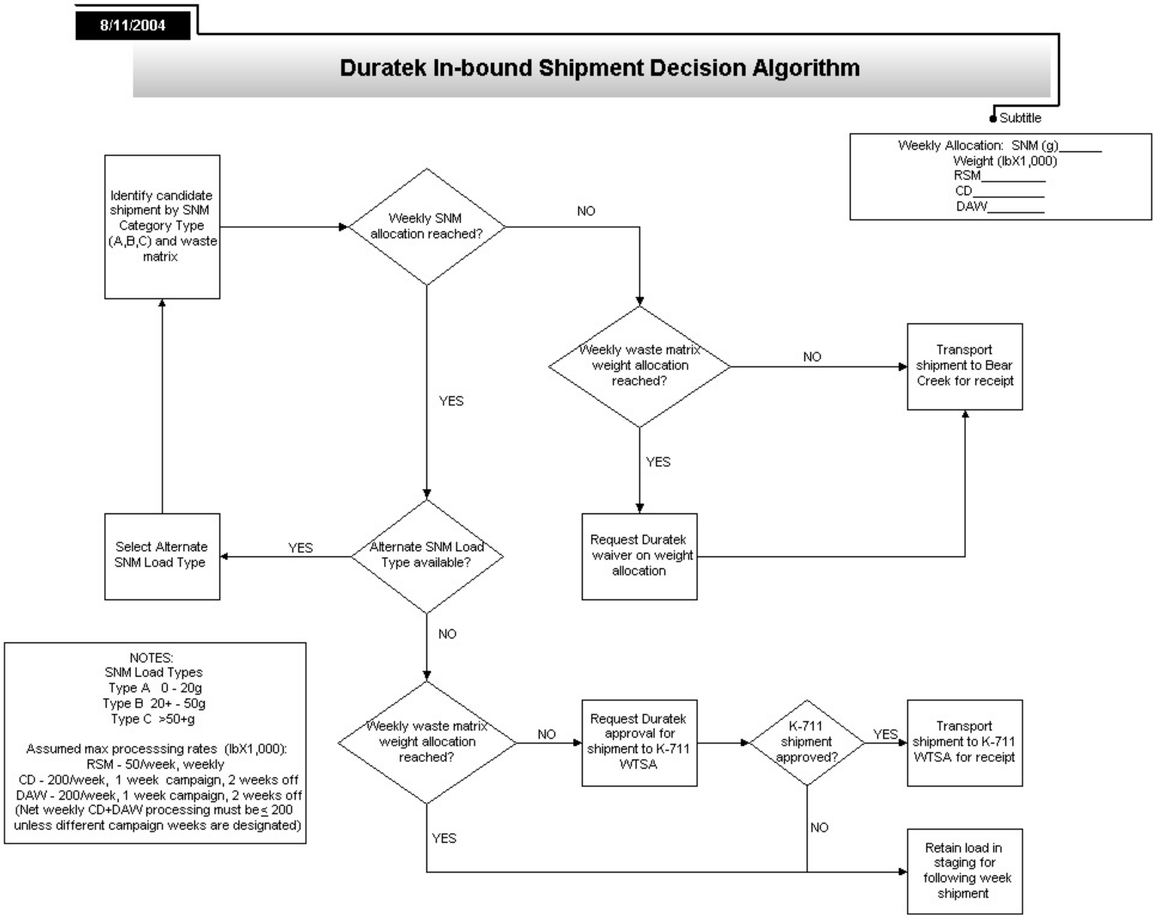


Fig. 3. Duratek inbound waste shipment decision algorithm

Waste Processing Throughput Impacts

The discussion above establishes the close correlation between sorting facility throughput rates and waste SNM inventories. The connection is based on the need to optimize use of the available waste processing capacity in the sorting facilities by maximizing the quantities of waste received for processing. Processing capacity is based on waste mass moved through the facilities while the amount of waste that can be made available (processing backlog) to support sustained operations is affected by the density of SNM contained within the waste mass with which it is associated. Higher per-container SNM densities translate accordingly into lower backlog available for processing at any given time.

The processing backlog issue created major concerns in that fluctuations in this aspect of operations planning had the potential to completely disrupt processing and disposal schedules. The possible end result could be a missed DOE milestone commitment. It was widely felt that resolution of this issue lay in finding ways of reducing the timeline (cycle time) between receipt of wastes for sorting and repackaging and release of repackaged wastes for transport to the disposal sites. Detailed studies of the facility operations were undertaken to identify possible ways of shortening the processing cycle time and the accompanying on-site residence time for SNM inventories. The studies resulted in development of a conceptual scheduling histogram based on a standard 17-day cycle time between inbound waste receipt and outbound waste shipment events. The histogram was a tool that could provide much needed visibility on the total mass of SNM "in process" at any given time and could supply information vital to planning of inbound waste shipment schedules supporting optimal use of sorting facilities. A representation of the cycle time histogram is shown in ***Figure 4***.

A key component of the cycle time reduction strategy was an off-site waste transport staging area where repackaged containers approved for release and manifested to disposal facilities could be staged for consolidation and transloading. Wastes, once released to the staging area on outbound manifests, were considered to be in transit according to DOT criteria and could remain in the area on conveyances used for local transport until transloading to the long-distance conveyance was completed. Use of this outbound shipment staging area facilitated early release of on-site inventory capacity that could in turn be re-allocated to inbound shipments pending receipt. The staging process was considered to be most beneficial for rail shipments destined to Envirocare, primarily because it mitigated the longer lead times required to obtain shipping approvals and to finalize associated shipping documentation.

SUMMARY AND CONCLUSIONS

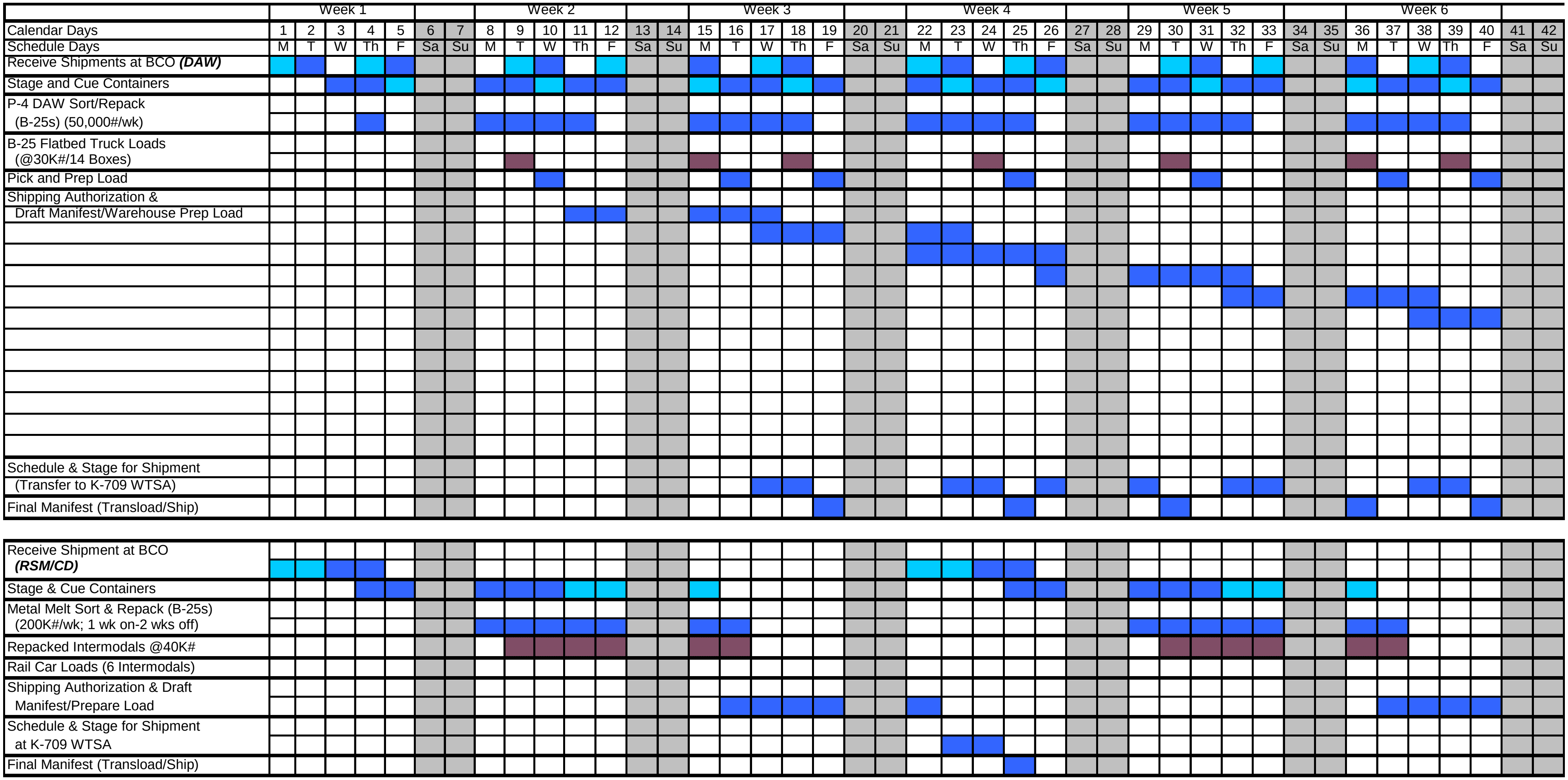
Bechtel Jacobs, the cleanup contractor for DOE in Oak Ridge, awarded Duratek a subcontract to participate in the processing and disposition of more than 22,000 cubic meters of low-level radioactive waste generated by decades of ORR operations. Bechtel Jacobs committed to DOE that the legacy waste population will be dispositioned off-site by June 30, 2005. Duratek has made its cadre of personnel and resources available to support Bechtel Jacobs in this endeavor and has placed the highest priority on exhibiting the teamwork required to achieve the objectives established for this project. The challenges encountered by the project team were consistently met with energy and enthusiasm and many innovative solutions were developed to address issues as they arose.

Because legacy operations at the Oak Ridge site often resulted in inadequate waste segregation practices, the actual contents of waste containers arriving at Bear Creek for processing have sometimes differed significantly from the available characterization data. Duratek’s waste

processing personnel completed rigorous training programs in hazard awareness, material segregation, disposal facility waste acceptance criteria, and decontamination procedures to ensure safety while processing these waste streams.

As one of three subcontractors initially selected for this project, Duratek has set the standard for safe, high-quality performance and customer satisfaction under constant regulator and stakeholder scrutiny. In setting the standard, Duratek recorded a number of “firsts” among its subcontractor peers to include the following:

- First to complete all Bechtel Jacobs readiness approvals and receive a waste shipment for processing (17 days after contract award),
- First to begin sustained waste sorting and segregating operations,
- First to ship processed wastes from this project to EMWMF for disposal,
- First to process and ship more than 1 million kilograms of waste,



Calendar Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
DAW Grams on Site	30	60	60	90	120	120	120	120	150	180	180	210	210	210	240	240	240	240	240	240	240
CD/RSM Grams on Site	20	40	60	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Total LLW Grams on Site	50	100	120	170	200	200	200	200	230	260	260	290	290	290	320	320	320	320	320	320	320

Calendar Days	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
DAW Grams on Site	240	240	270	270	240	270	270	270	270	240	270	300	270	270	270	270	300	300	300	300	300
CD/RSM Grams on Site	80	80	100	40	60	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Total LLW Grams on Site	320	320	370	310	300	350	350	350	350	320	350	380	350	350	350	350	380	380	380	380	380

Fig. 4. Bear Creek Operations cycle time histogram.

- First to develop State-acceptable protocols for disposition of non-conformers segregated from processed wastes, and
- First to ship processed wastes from this project to Envirocare of Utah.

These achievements were made in the face of conditions that required a delicate balance of knowledge and expertise in implementing operations under stringent regulatory criteria while adopting proactive and innovative approaches to resolving issues that have arisen during project execution. Duratek's support of this important project is significant because it reaffirms the Company's determination to aggressively support Bechtel Jacobs in meeting its Accelerated Closure Program commitments to DOE. Duratek continues to look for innovative ways to help Bechtel Jacobs accelerate the schedule for processing and disposal of the remaining ORR legacy waste streams.

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FOOTNOTES

***** Bechtel Jacobs Company, LLC with the U.S. Department of Energy under Contract No. DE-AC05-98OR22700.