DEVELOPMENT OF THE CENTRAL WASTE DISPOSAL FACILITY*

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ABSTRACT

The Central Waste Disposal Facility is a proposed facility for shallow land burial of low-level radioactive waste on the Department of Energy Oak Ridge Reservation near Oak Ridge, Tennessee. The facility development has proceeded through site characterization, facility design, assessment of environmental impacts via pathways analysis, and preparation of an environmental impact statement. The worst-case pathways analysis indicated that expected performance of the facility was within the performance goal of 25 mrem/year maximum off-site exposure as defined in the Code of Federal Regulations (10 CFR Part 61). Similar exposure calculations were also completed for an alternative aboveground disposal option. Due to comments regarding the applicability of the stated performance standard as well as related questions on the facility design, philosophy, and siting, further development of the facility has been delayed pending resolution of these issues.

INTRODUCTION

The Central Waste Disposal Facility (CWDF) is a proposed solid low-level waste disposal facility currently under development by Oak Ridge National Laboratory (ORNL). As burial space in existing disposal areas on the Department of Energy Oak Ridge Reservation (ORR) is depleted or removed from service to implement remedial actions, it is necessary to develop new facilities for all the plants on the ORR. This includes not only the Oak Ridge National Laboratory but also the Y-12 Defense Plant and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Centralization of waste management activities is unique on the ORR. In the past, due to different needs, waste types, and sources of funding, as well as physical separation, each of the three plants has provided for its own waste disposal capacity. The centralization of these activities will provide not only economies of scale, but will also allow for utilization by all plants of the best available resources of the ORR to meet the demanding requirements for waste disposal in a humid environment.

STATUS

The CWDF is currently delayed pending additional study and alternatives evaluation including the options of storage and greater confinement disposal. The potential for implementation of interim storage measures on the ORR is also being evaluated consistent with expected delays in the CWDF project.

The CWDF was originally conceived as a disposal facility utilizing the technology of shallow land burial. Guidance was obtained from the DOE Order on Waste Management, 5820.2[1], and to the extent feasible, the Nuclear Regulatory Commission (NRC) Rule 10 CFR 61[2]. Initial work on the facility was begun in 1981 with the selection of the site and initial characterization activities. Major activities were initiated in 1983 with the facility design, preoperational planning, and preparation of the Draft Environmental Impact Statement (DEIS)[3]. The DEIS was formally issued for public comment on September 14, 1984, with the expectation of completing the National Environmental Policy Act (NEPA) process and constructing an initial (partial) facility for Beneficial Occupancy by August 1985 with follow-up construction activities for facility completion continuing through 1989 concurrent with operations.

During the public review of the DEIS, comments of significant concern were received from the Tennessee Department of Health and Environment (TDHE), the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), and private citizens, resulting in the aforementioned delay to review the alternatives and technology for the proposed facility. This activity is currently underway. The purpose of this paper is to present briefly the activities which were completed and the concerns which were raised in the hope that the experience gained from these interactions will be useful in the development of other facilities under similar conditions.

THE PROPOSED SITE

A site selection study[4] was conducted as the first step in the development of the CWDF. Due to DOE policy which restricts off-site disposal of generated wastes, this study was restricted to potential sites on the ORR. The study resulted in the identification of five candidate sites which are identified in Table I and are located with respect to major ORR features in Fig. 1.

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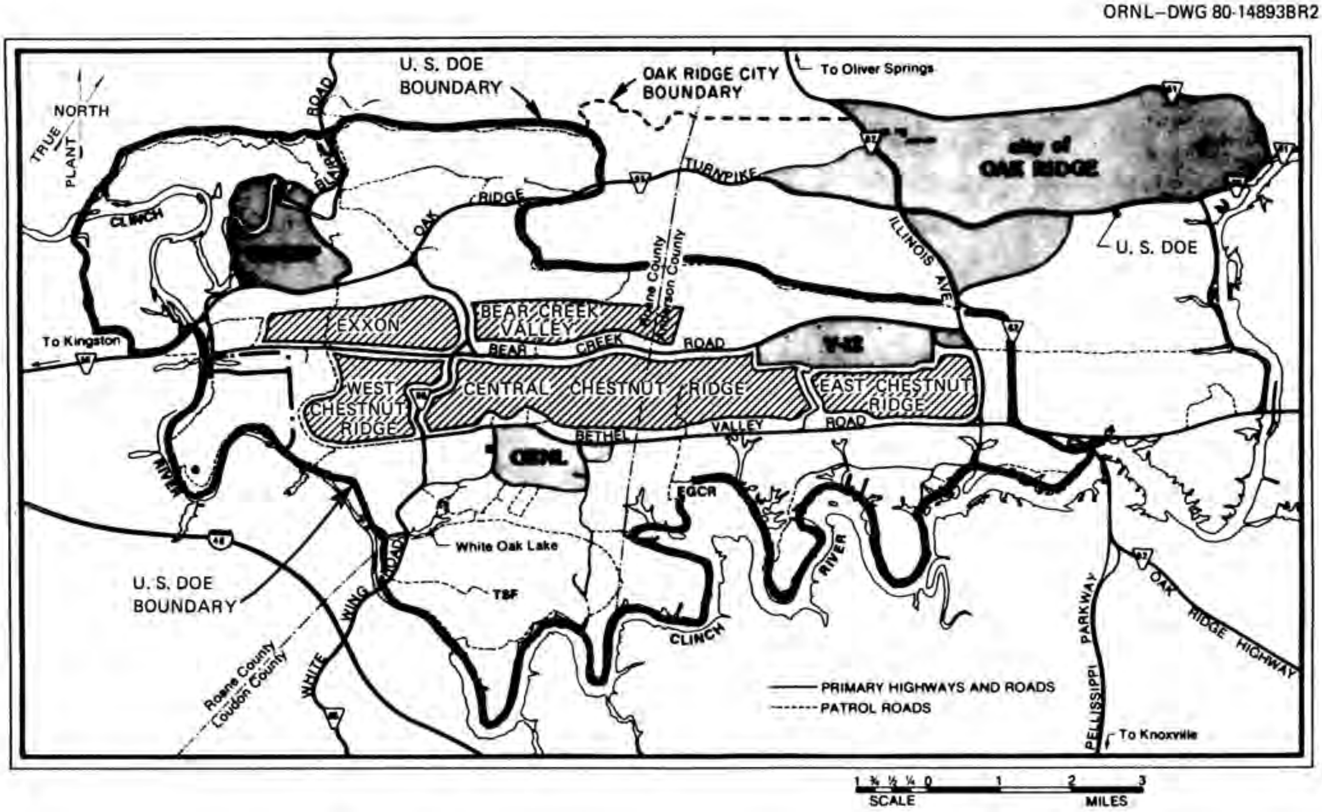

Fig. 1. Location of candidate sites on the ORR.

TABLE I

Candidate Sites Within the Oak Ridge Reservation

Candidate Site	Geologic Unit
Exxon	Conasauga Group
Bear Creek Valley	Conasauga Group
West Chestnut Ridge	Knox Formation
Central Chestnut Ridge	Knox Formation
East Chestnut Ridge	Knox Formation

Conasauga group sites, which have been extensively utilized in previous shallow land burial activities on the ORR, were known to consistently exhibit a shallow water table which allows burial operations only within a few meters of the surface. Extensive remedial actions were already underway in areas of the conasauga which had been used for such operations due to leaching into the shallow groundwater. This led to the identification of the Knox formation as the preferred geologic formation. It was recognized that this choice represented some limitations due to the potential long-term instability (karst topography) of the Knox sites. This was not felt to be an exclusionary consideration due to the relatively low hazard of the proposed wastes which were restricted to the equivalent of the NRC-defined Class A wastes[2] and the ability to engineer the facilities to minimize the creation of karst conditions. Due to the availibility of large contiguous land areas, the West Chestnut Ridge (WCR) site was chosen over the Central and East Chestnut Ridge sites for detailed characterization.

During 1983 and 1984, the WCR site was subjected to an extensive characterization program[5]. Both deep and shallow drilling and sampling activities[6] provided information on the site soil composition, permeability, water table profiles, etc. The site was found to have large masses of soil necessary for excavation of large trenches and depths to groundwater of from 15 to 30 m (50 to 100 ft). Seismic profiling of the bedrock under the site indicated approximately 30 m (100 ft) to bedrock in the proposed burial areas[7]. Laboratory testing of WCR soils[8] provided information on the excellent radionuclide retardation properties of the site and provided input parameters for the subsequent pathways analysis work. Surface hydrology was investigated[9,10] with the installation of five temporary flumes and one permanent flume as well as collection of rainfall and other meterological data. A tracer test[5] was conducted to help define the subsurface flows and provide a greater understanding of the existing karst features on the site. In general, the site was found to present no significant obstacles to the acceptable performance of a shallow land burial facility.

DESCRIPTION OF THE WASTES

The wastes to be disposed of in the CWDF will be generated by routine production and research and development activities of the three plants on the ORR. As mentioned previously, the wastes were restricted to activity levels consistent with the NRC 10 CFR 61 Class A definition with two exceptions. Consistent with the Order DOE 5820.2, transuranics would be accepted up to a concentration of 100 nCi/g and, secondly, the wastes orginating from the production operations of the Y-12 and ORGDP plants contain concentrations of the uranium isotopes which are uncharacteristic of the commercial Class A wastes for which 10 CFR 61 was written.

The wastes considered for CWDF will consist of either bulk contaminated trash or grout material formed by solidification of contaminated sludges, incinerator ash, etc. The grout materials were included for consideration contingent on future delisting of the hazardous materials, as defined by the Resource Conservation and Recovery Act of 1976 (RCRA), known to be contained in those wastes. Based on this, plus uncertainty on the extent of volume reduction activities for the bulk waste, the facility was designed to be flexible in disposal rate. In general, a disposal rate of 8,500 to 14,000 m^3 (300,000 to 500,000 ft^3) per year was assumed. The total facility was estimated to be capable of providing nominally 40 years of capacity at these rates dependent on more detailed site characterization and design considerations.

The bulk wastes will consist of contaminated paper, cloth, plastics, rubber, wood, metals, glass, concrete, soil, baled miscellaneous materials, scrap metal, and decontamination and decommissioning (D&D) wastes. Table II lists the major isotopes and the maximum average concentrations for each radionuclide which would be expected from any particular source. The isotopic content of individual waste streams will vary depending on their origin and none would be expected to contain all the listed isotopes at the quoted maximum concentrations. In general, waste from the Y-12 Defense Plant and the ORGDP would contain the uranium and technetium, ORNL wastes would contain the fission products, and ORNL D&D wastes would contain the major transuranic activity.

TABLE II

Isotopic Characteristics of Solid Debris Low-Level Waste

Isotope	Max. Avg. Isotopic Conc., Ci/m^3
H-3	1×10^{-1}
C-14	1×10^{-3}
Co-60	1×10^{-3}
Sr-90	2×10^{-2}
Zr-93	1×10^{-3}
Tc-99	3×10^{-3}
Sn-121	6×10^{-4}
Cs-134	1×10^{-3}
Cs-137	5×10^{-3}
Sm-151	1×10^{-3}
Ir-192	2×10^{-3}
U-234	7×10^{-5}
U-235	6×10^{-5}
U-238	2×10^{-3}
Pu-238	3×10^{-5}
Pu-239	9×10^{-6}
Am-241	4×10^{-5}
Cm-244	4×10^{-5}
Mixed TRU (mostly Pu-239)	9×10^{-5}

FACILITY CONCEPTS AND DESIGNS

A conceptual[11] and detailed design[12] for a shallow land burial facility on WCR was completed. The design utilized the site information generated during the characterization effort as well as information from previous operating experience on the ORR and the wealth of data and experience resulting from research and development activities related to improving performance in existing operating and closed facilities on the ORR. The objective of the design was the utilization of natural and engineered features to isolate the waste from both ground and surface waters. A simplified sketch of the proposed trench design is shown in Fig. 2.

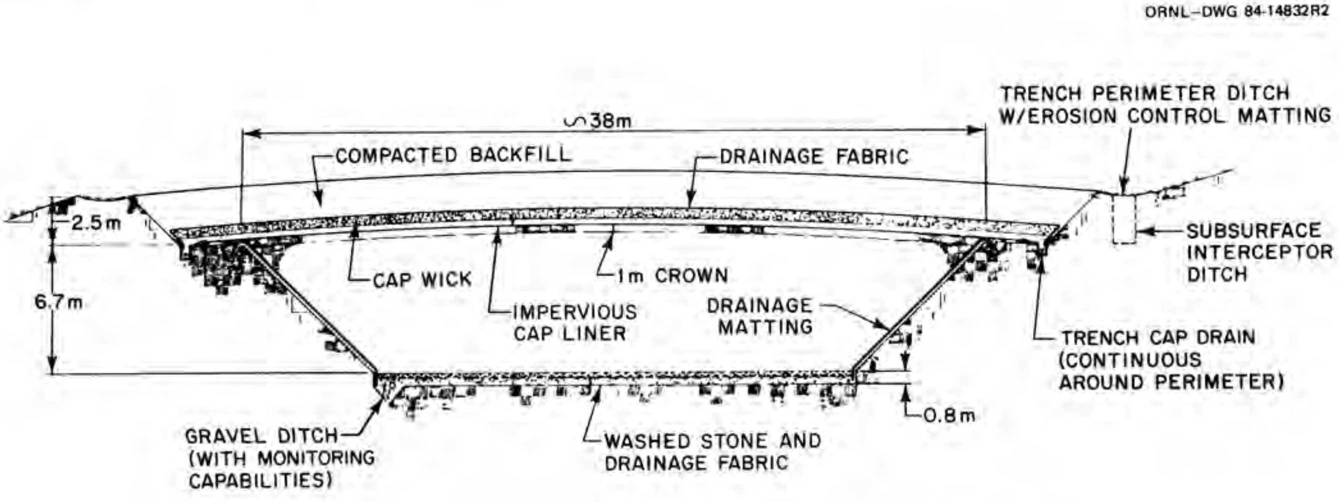

Fig. 2. Principle design features of the proposed trench for the CWDF.

The active trench areas on the WCR site were located on the ridge tops to eliminate the possibility of significant lateral flow of groundwater through the trench areas from nearby topographic features. In addition, this quickly diverts rainfall away from the trench areas and maximizes isolation between the wastes and the subsurface aquifer. An extensive surface drainage system with appropriate erosion control measures diverts rainwater around the trenches and minimizes the available moisture for infiltration into the trench cap. A system of subsurface drainage ditches diverts subsurface water flow to an exit point down gradient from the trench areas.

The features of the trench design provide isolating enclosure of the trench top and all sides. The sides of the trench are lined with a synthetic drainage mat material which diverts any lateral flow downward to the trench bottom for percolation into the soil. The trench bottom consists of approximately 0.8 m (2.5 ft) of a composite stone-drainage fabric hold-up zone. The thickness of this permeable layer is based on the percolation rate of the trench bottom and sized to provide capacity for possible storm conditions while the trench is open. The trench bottom is sloped in two directions to collect water in a sump constructed along one side of the trench. If the capacity of this layer is exceeded, standpipes installed in the sump area, which will also provide monitoring and sampling capability when the trench is closed, are provided to pump water from the trench. This water would subsequently be treated through an existing ion exchange processing system at ORNL.

The final trench cap will consist of a 2.5 m (8 ft) thick composite of an impervious liner (100 mil polyethylene), a wick system composed of stone and drainage mat, and the remainder of compacted backfill. In addition, a trench cap drain which circles the perimeter of the trench will divert water which is wicked from the cap to an exit point down gradient. The cap is installed with a 1.0 m crown to eliminate possible ponding on the cap after subsidence. A possible variation being considered for capping of the trench may be the installation of a temporary cap when the trench is filled. This temporary cap would consist of compacted backfill with an impermeable surface cover. Settling monitors would be installed in the temporary cap with monitoring of subsidence and active cap maintenance continuing until all major subsidence had occurred. At this point, the temporary cap would be removed and the permanent cap, described previously, installed in its place. Experience will provide an indication of the effectiveness of this procedure in reducing damage to the permanent cap from subsidence as well as the nominal time necessary prior to installation of the permanent cap.

Wastes will be emplaced in the trenches utilizing a layered landfill approach. Wastes will be covered with approximately 0.3 m (1 ft) of compacted backfill on a daily basis. This provides contamination control and also reduces subsidence although at the expense of trench utilization. Monitoring capability will be provided at each trench and throughout the site. The individual trench will be the primary monitoring point utilizing the standpipes mentioned previously to provide an indication of trench water and sampling capability if water is detected. In addition, soil lysimeters will be installed in each trench bottom to provide an indication of radionuclide movement under unsaturated conditions.

For comparison, the alternative of aboveground disposal was also analyzed in the DEIS. The concept of aboveground disposal (tumulus concept) has been developed by the French at the Centre de la Manche facility[13]. Figure 3 illustrates this concept. A

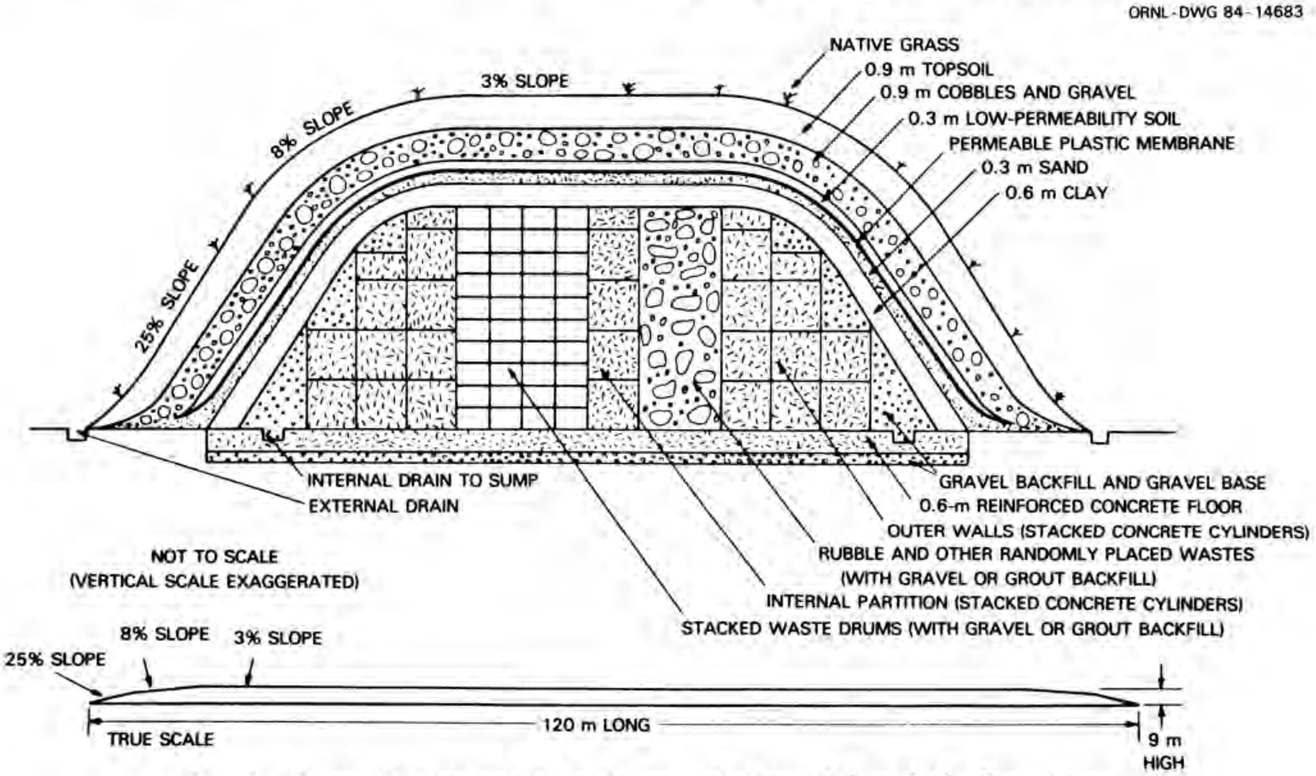

Fig. 3. Schematic diagram of the aboveground disposal (tumulus) alternative.

concrete pad is constructed to collect and provide monitoring capability for leachate. Waste is stacked on the pad in an organized fashion. Larger stable waste forms such as concrete cylinders are placed around the perimeter with drums and other loose material placed inside this enclosure. Lower activity wastes can be used to shield higher activity wastes. The structure is then covered with a composite cap similar to shallow land burial. With the exception of being above grade, the concept is not significantly different from the proposed shallow land burial option. The tumulus concept has the advantage of enhanced monitoring due to the concrete base pad and enhanced retrievability. Disadvantages include increased erosion losses due to exposure of the cap and the possible release of leachate to the surface environment which provides an immediate exposure pathway and eliminates the advantage provided by soil retardation during movement to the aquifer.

PREDICTION OF ENVIRONMENTAL IMPACTS

A dose-to-man pathways analysis[14] was performed to evaluate the impacts of the proposed alternatives. Analyses were completed for both the proposed option of shallow land burial and the alternative tumulus concept. The exposure pathways concentrated on demonstrating compliance with the off-site performance criteria of 25 mrem/year but also considered the intruder scenario. The off-site pathway involves the migration and transport of radionuclides to the Clinch River which is a potential drinking water source. Movement of radionuclides for the shallow land burial option occurs through leaching of the disposed waste and subsequent movement of the leachate through the WCR site soils to the aquifer which then transports the material to the Clinch River. For the tumulus concept, the situation is similar with the exception that all leachate is conservatively assumed to be discharged to surface pathways for transport to the Clinch River. The intruder scenario considers inadvertant intrusion after the assumed 100-year period of institutional control has ended. The intruder scenario analyzes the situation where an intruder resides on the WCR site, inhales suspended particles of contaminated dust, ingests vegetables grown at the site, and receives direct exposure from the contaminated soil. In addition, the scenario assumes that the intruder consumes contaminated water from either an on-site well (shallow land burial) or from an on-site surface stream (tumulus concept).

The analyses performed utilized the "worst-case" philosophy. In areas of uncertainty, choices were made during the performance of the analyses which would result in conservative (high) estimates of dose. Thus, the analyses are not intended to provide a realistic prediction of routine releases from the facility, but is felt to provide an upper bound. The worst-case methodology is useful for demonstrating regulatory compliance with assurance of an adequate margin of safety. It is also helpful in identifying deficiencies in alternatives and providing a base for comparison.

The results of the analyses for the drinking water pathways are presented in Table III[14]. Impacts are summarized for whole body exposure as well as exposure to the major organs. Dose estimates for both shallow land burial and the tumulus alternatives are presented. The assumptions of the analyses include effective performance of the engineered features of the respective designs and active maintenance during the institutional control period assumed to be 100 years after closure. At the end of the institutional control period, all engineered features are assumed to fail resulting in immediate leaching of the disposed material. The estimates presented at 100 years after closure represent the maximum 50-year dose-equivalent resulting from the subsequent releases. This is obtained by summing the maximum dose contribution from each radionuclide at whatever point in time that peak occurs. The time of maximum concentration for individual radionuclides ranges from tens to thousands of years after failure; however, the major contributors to the overall dose estimates reach a maximum in less than 200 years. For comparison, dose estimates at 500 years after closure (400 years after failure) are presented. These estimates assume the same failure scenario at 100 years after closure.

Several conclusions can be drawn from Table III. The maximum dose commitment is estimated to be higher for the tumulus alternative due to the assumed worst-case release of the material through the surface-water pathway which does not allow for retention of

TABLE III

Maximum 50-Year Dose Commitment[a] from Drinking Water from a Potential Public Water Supply from the Clinch River

	Maximum Individual Dose (mrem/year)			
	100 Years After Closure		500 Years After Closure	
Organ Exposed	Below-Grade Trench	Above-Grade Tumulus	Below-Grade Trench	Above-Grade Tumulus
Whole Body	0.08	1.4	0.009	3×10^{-7}
Bone	1.0	8.5	0.12	5×10^{-6}
Kidney	0.2	1.6	0.02	1×10^{-6}
Lung	0.008	1.6	0.009	1×10^{-8}

[a] The dose that an organ or tissue would receive during a 50-year lifetime as a result of intake of one or more radionuclides from one year's release.

the radionuclides in the WCR site soils. This retention results in a more even, continuous release for the shallow land burial alternative as evidenced by the relatively small decrease from the maximum dose after 500 years. Doses from the tumulus alternative, on the other hand, are higher in the near term but insignificant at 500 years due to the assumed rapid flushing of the aboveground source and almost instantaneous transport to the environment.

Estimated doses for the intruder scenario are presented in Table IV[14]. Estimates are presented for both the shallow land burial and tumulus alternatives although they differ only by the drinking water pathway. For purposes of worst-case analysis, differences in the other pathways are insignificant. For the drinking water pathway, the intruder is assumed to obtain his drinking water supply from contaminated water supplied by an on-site well in the case of shallow land burial, and from a surface stream (Ish Creek) in the case of the tumuli. The more rapid transport and decreased dilution in the surface stream pathways results in significantly higher doses. Again, the doses are estimated assuming occupation by the inadvertant intruder immediately following the assumed loss of institutional control 100 years after closure.

The pathways analyses, even in the worst case, demonstrate that disposal on WCR would provide adequate containment of the wastes. The shallow land burial alternative appears to provide lower releases due to the retentive properties of the WCR soils and would appear to adequately satisfy the performance criteria of 25 mrem/year to the maximally exposed off-site individual. The intruder scenario doses are obviously higher than the 500 mrem/year guideline which has been used in previous analyses of this type[15]. These doses, and in fact a large fraction of all the dose estimates presented herein, result solely from the significant quantity of the uranium isotopes contained in the wastes. The uranium, due to its extremely long half-life, presents a difficult problem which is not consistent with the intruder philosophy and is unique to DOE waste streams. These doses must be evaluated in view of several factors including the worst-case nature of the analyses, the questionable applicability of the intruder scenario to a Federal Reservation, and the unlikely event of such intrusions within the assumed 100 year time frame. In any event, the worst-case intruder doses are still below the 5 rem/year allowable exposure for radiation workers.

ISSUES AND CONCERNS

The preceeding sections have described the proposed action and the supporting work which was presented for public review and comment in the CWDF Draft Environmental Impact Statement. Several major issues arose in comments received on the document which provide a unique perspective of the regulatory environment within which this facility is being reviewed.

There is a very obvious lack of universal agreement on the performance criteria applicable to radioactive waste disposal facilities. In the case of CWDF, the 25 mrem/year performance guide recommended in 10 CFR 61, was rejected by the State of Tennessee (TDHE) as a sufficient criterion for determining the level of technology for such a facility with respect to groundwater contamination. The more widely understood philosophy promoted by the Resource Conservation and Recovery Act (RCRA) of zero release disposal and "best available technology" may be applied to disposal of radioactive waste and this philosophy is inconsistent with facility design to a given "acceptable" release rate.

The management of large quantities of uranium contaminated wastes presents a unique situation which is not clearly addressed by existing low-level

TABLE IV

Summary of Maximum Doses to the Intruder Living in the Disposal Area After Loss of Institutional Controls

	Dose (millirem/year)			
Pathway	Total Body	Bone	Kidney	Lungs
Ingestion of vegetables	2.1×10^{2}	9.2×10^{2}	2.3×10^{2}	1.3×10^{2}
Inhalation of resuspended particles	5.3	6.2	9.2×10^{-1}	1.3×10^{2}
External dose from contaminated soil	1.6×10^{2}	1.8×10^{2}	1.5×10^{2}	1.5×10^{2}
Drinking Water				
On-site well	1.9×10^{2}	2.5×10^{3}	5.4×10^{2}	1.7×10^{1}
(Ish Creek)	(3.0×10^{3})	(1.8×10^{4})	(7.6×10^{2})	(3.4×10^{3})
Total - Shallow Land Burial	5.6×10^{2}	3.6×10^{3}	9.2×10^{2}	4.3×10^{2}
(Tumulus)	(3.4×10^{3})[a]	(1.9×10^{4})	(1.1×10^{3})	(3.8×10^{3})

[a] Total for surface water pathway (tumulus disposal). Ish Creek is the assumed drinking water source.

legislation although uranium is defined, by default, as Class A waste.

Additional technical issues raised during the review include the question of long-term stability of the WCR site, the question of long-term storage versus disposal, the level of groundwater contamination (if any is allowed), concerns related to capability to adequately monitor performance related to groundwater contamination, and the ability/commitment to integrate new technology and techniques during the expected operating lifetime of the facility.

FUTURE ACTIVITIES

In order to define the best compromise between operational, environmental, and regulatory concerns, a Task Force study has been initiated to develop additional information regarding the above concerns prior to continuing with additional action on the DEIS. The major objectives of this Task Force will be:

- o To generate cost-benefit (disposal costs versus environmental impacts) comparisons for various alternatives applicable to the CWDF to provide a basis for establishing release criteria,
- o To apply systems analysis to the overall problem of disposal of LLW, mixed, and hazardous (RCRA) wastes on the ORR,
- o To investigate the desirability of waste stream segregation with specific treatment/disposal options for streams of differing characteristics,
- o To define funding scenarios and evaluate the need for interim storage methods to allow continued operations on the ORR until permanent disposal facilities are operational, and
- o To involve the appropriate regulatory agencies as an integral part of the planning process to ensure appropriate consideration and emphasis of the problems and issues and obtain mutual agreement on the solutions.

The above effort has just been initiated and results will not be available for some time. However, it is hoped that the above approach will produce decisions that will have a broad base of support and will provide an acceptable long-term solution for waste management on the ORR.

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