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Monitored Retrievable Storage Facility Conceptual Design Report

November 30, 1992

U. S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington, DC

Prepared by:

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Under Contract Number DE-AC01-91RW00134

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APPROVED By:

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Associate Director
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Volume I - Executive Summary

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EXECUTIVE SUMMARY

This conceptual design report presents results of the monitored retrievable storage facility (MRS) conceptual design effort. Six design concepts were investigated for handling and storing spent nuclear fuel assemblies at the MRS and are presented in this report. All six of these design concepts satisfy program requirements and provide safe and efficient methods to handle and store spent nuclear fuel. This conceptual design is an important step towards furthering the civilian radioactive waste management system program. The executive summary provides an overview of the conceptual design, a discussion of the function and purpose of the MRS, a discussion of the basis for conceptual design, discussions of the six design concepts, cost and schedule information, and a brief summary.

ES.1 OVERVIEW

Since the early days of the nuclear industry in the United States, the federal government has accepted responsibility for permanent disposal of high-level radioactive waste generated by the nuclear industry. In 1982 the United States Congress enacted the Nuclear Waste Policy Act to provide for permanent disposal in an underground repository and required that the Department of Energy (DOE) receive and take title to spent nuclear fuel from commercial utilities beginning in January 1998, after completion of a repository. Recognizing the difficulty of this task, Congress also authorized evaluations of the need for a monitored retrievable storage facility (MRS) to receive and store spent nuclear fuel assemblies prior to shipment to a repository.

A conceptual design for an MRS, which would be located in Tennessee, was developed and presented to Congress in 1985 and was subsequently disapproved. Congress passed the Nuclear Waste Policy Amendments Act in 1987, which authorized DOE to site, construct, and operate an MRS, with the schedule linked to development of a mined geologic disposal system (the repository). The position of nuclear waste negotiator was created to contact state governments and American Indian tribes to find a volunteer host site for the MRS.

In February 1991 DOE awarded a contract to TRW, Inc., to act as management and operations contractor for the civilian radioactive waste management system. The scope of work includes the development of the MRS, the mined geologic disposal system, and the transportation and control systems serving these facilities.

The MRS is one element of the overall system for disposition of spent nuclear fuel. To properly integrate the MRS with other civilian radioactive waste management system program elements and to ensure that all requirements are defined and incorporated, the systems engineering approach is employed. This approach enables traceability of design to requirements beginning with those specified in *DOE/RW-0334P: Physical System Requirements—Overall System* (Revision 0) and *DOE/RW-0319: Physical System Requirements—Store Waste* (Revision 0).

As defined by DOE Order 4700.1, the MRS is a major system acquisition, consisting of the MRS, the transportation system, and waste acceptance. At key points in development, the MRS major system acquisition will be reviewed by the Energy Systems Acquisition Advisory Board. Unless specifically stated otherwise, the term MRS refers to the MRS facility and not the entire MRS major system acquisition.

The MRS consists of three major areas: receiving, handling, and packaging; storage; and support and industrial services. The receiving, handling, and packaging area contains the facilities necessary to receive, handle, package, and ship spent nuclear fuel assemblies. Space is also provided for expanding facilities. The storage area consists of the designated long-term location for the storage of spent nuclear fuel assemblies. The support and industrial services area consists of facilities necessary to support the receiving, handling, and storage functions performed at the MRS and to provide administrative and logistical support for MRS operations. Total acreage required for the MRS ranges from 300 to 500 acres, depending on the design concept and actual site conditions.

Fundamental objectives of this conceptual design are:

- To develop a project scope that satisfies program needs, operating needs, and statutory requirements.

- To ensure and validate project feasibility and attainable technical performance levels.

- To develop reliable cost estimates and realistic performance schedules.

- To identify and quantify project risks.

The purpose of this conceptual design report is to satisfy these objectives for the MRS facility portion of the MRS major system acquisition. By so doing, DOE can acquire an independent cost estimate and perform other steps leading to a review by the Energy Systems Acquisition Advisory Board and subsequent approval by the acquisition executive to proceed to the next step of project development. This approval is Key Decision 1.

This conceptual design report describes the results of activities performed during the conceptual design of the MRS. It presents several storage mode alternatives, shows the feasibility of design concepts, and documents cost and schedule baselines. Each design concept is described in terms of configuration items, or systems, buildings, and facilities, with minimal repetition. The concepts evaluated are summarized along with a cost and schedule estimate for each concept.

DOE determined that the conceptual design report is a quality affecting document. The management and operations contractor general manager designated the conceptual design report as Quality Assurance Classification 5, Mission Critical, because of its importance to the success of the civilian radioactive waste management system mission. Because the conceptual design report is a quality assurance record, it complies with certain management and operations contractor Quality Administrative Procedures (QAPs). The conceptual design report is reviewed according to QAP 3-1 (Technical Document Review), distributed according to QAP 6-1 (Document Control), and maintained according to QAP 17-1 (Program Records Management).

ES.2 FUNCTION AND PURPOSE

As an integral part of the civilian radioactive waste management system, the mission of the MRS is to accept spent nuclear fuel assemblies from civilian reactor sites until the mined geologic disposal system becomes operational. After that time, the MRS will act as a staging facility to manage the flow of spent nuclear fuel assemblies to the mined geologic disposal system. Functions of the MRS include receiving, storing, and monitoring spent nuclear fuel assemblies and retrieving them for shipment to the mined geologic disposal system. These operations increase overall flexibility and reliability of the civilian radioactive waste management system by providing a flexible link between reactor sites and the mined geologic disposal system.

The MRS is designed to:

- Receive spent nuclear fuel assemblies from civilian nuclear facilities.
- Safely handle and store spent nuclear fuel assemblies.
- Permit continuous monitoring and management of spent nuclear fuel assemblies.
- Retrieve spent nuclear fuel assemblies and prepare them for shipment to the mined geologic disposal system.

Acceptance of spent nuclear fuel assembly shipments at the MRS is scheduled to begin in January 1998. MRS operation is based on an initial license period of 40 years, after which the license may be renewed. Design of the MRS places a priority on protecting the health and safety of the public and operating personnel and on protecting the environment. The MRS can be decommissioned once the mined geologic disposal system is in full operation and the stored spent nuclear fuel assemblies have been removed. Design of the MRS permits the entire site and surrounding areas to be returned for unrestricted use consistent with terms negotiated by a host and the federal government.

ES.3 BASIS FOR CONCEPTUAL DESIGN

A critical part of the MRS project development is selection of a design concept. To meet program goals and ensure conformance with schedule requirements for the receipt of spent nuclear fuel assemblies, only proven or high-confidence technologies will be used at the MRS. Design concepts have focused on spent nuclear fuel assembly storage designs that are already licensed by the Nuclear Regulatory Commission (NRC) or proven designs that have a high probability of being licensed within a reasonable period of time.

Dry storage facilities developed in the United States and Europe are the principal basis for candidate design concepts considered for the MRS. Multiple design concepts have been examined to take advantage of new and evolving technologies. Five basic dry storage technologies meet the requirement for using proven or high-confidence technologies and were selected for evaluation in MRS conceptual design. DOE also requested the evaluation of an underwater storage system. Wet transfer and storage of spent nuclear fuel assemblies has been licensed by the NRC at numerous commercial nuclear power facilities and has been used for many years throughout the United States. The following six technologies for storing spent nuclear fuel assemblies form the basis for MRS conceptual design:

- Vertical concrete cask storage
- Horizontal module storage
- Metal cask storage
- Vault storage
- Transportable storage cask storage
- Wet storage.

Conceptual design work scope normally evaluates and selects from various design concepts. Since a site has not been selected for the MRS, many factors are not available for determining layouts, sizes, and types of facilities. In addition, the 1991 Mission Plan Amendment invites candidate host communities to participate in selection of the storage design concept. Therefore, the design concept will not be selected until after selection of a site.

Technical baseline requirements for MRS conceptual design are presented in DOE/RW-0334P and DOE/RW-0319. In several key areas, especially those related to performance requirements and external interface requirements, DOE/RW-0319 does not specify requirements to adequately define all design inputs. The MRS Systems Requirements Document and associated interface specifications are currently under development by the management and operations contractor. When completed and approved, the System Requirements Document will specify all necessary MRS system-level requirements and will become the technical baseline for Safety Analysis Report design. Until then, some system-level assumptions have been made to allow completion of a conceptual design. These assumptions may be changed during final development of the System Requirements Document, but represent a consistent set of reasonable assumptions for conceptual design. In cases where DOE/RW-0319 does not specify detailed design codes and standards applicable to the MRS, a set of major codes and standards has been assumed to provide a consistent set of criteria for development of the MRS conceptual design.

Since a host site for the MRS has not been identified, a set of generic characteristics has been assumed for the MRS site. These characteristics include criteria for natural phenomena, soil and site conditions, and availability of local infrastructure and utilities. Criteria assumed cover a broad range of conditions that permit locating the MRS in most areas of the continental United States. When an actual site is identified, the adequacy of these criteria will be verified, and appropriate design updates will be made. The construction schedule will be re-evaluated to determine any impacts resulting from actual site terrain, weather conditions, and availability of supporting infrastructure. Facility designs must be reviewed to ensure they can accommodate actual site seismic loads, tornado loads, temperature extremes, precipitation quantities, groundwater levels, soil conditions, and other physical site features. Services available to the actual site location will affect MRS designs for water supplies, heating fuel type, on-site medical facilities, and many other items, and therefore, must be evaluated. Locations of facilities on the site may need to be modified to interface properly with existing infrastructure items and to accommodate the terrain. Facility layouts and architectural features may also be modified to enhance site aesthetics and conform to the desires of the host community.

DOE/RW-0319 does not currently specify the acceptance rate for spent nuclear fuel assemblies at the MRS; therefore, information provided in *DOE/RW-0331P: Annual Capacity Report* (December 1991) is used as a guide for establishing MRS spent nuclear fuel assembly acceptance rates. To size facilities for the MRS, it is assumed that the MRS receives and stores 3,000 metric tons of uranium (MTU) per year using Office of Civilian Radioactive Waste Management (OCRWM) Phase 2 (Initiative 1) shipping casks for the years 2010 and beyond. Before that date, it is assumed that 400 MTU will be delivered in 1998, 600 MTU in 1999, and 900 MTU each year beginning in 2000 and continuing through 2009, in OCRWM Phase 1 shipping casks which are similar to the current fleet of casks but have substantially expanded capacity. Figure ES-1 provides a graphical representation of assumed spent nuclear fuel throughput rates for the MRS.

Simulation modelling is used to confirm the adequacy of MRS facilities. Studies performed for conceptual design indicate that the size of systems for transferring spent nuclear fuel assemblies from shipping casks to storage modes is primarily controlled by the number of shipping casks handled, rather than by the number of spent nuclear fuel assemblies handled. These studies show that the MRS can accommodate uncertainties in shipping cask type in the early years of its operation. Operating efficiency improves in later years of operation as new, larger capacity shipping casks are put in service. This improvement parallels expected increases in spent nuclear fuel receipt rate and results in full utilization of systems throughout the life of the MRS.

Once the mined geologic disposal system becomes operational, the MRS can directly transfer incoming spent nuclear fuel assemblies to shipping casks for transport or can handle spent nuclear fuel assemblies retrieved from storage at a total rate of 3,000 MTU per year. Direct transfer of incoming spent nuclear fuel assemblies from truck casks to rail shipping casks for transport away from the MRS, known as pass-through operations, is based on the assumption that only nominal amounts of spent nuclear fuel assemblies will be added to or removed from storage at the MRS. In addition, direct flow-through of shipments received in rail casks, without any transfer of spent nuclear fuel assemblies, is planned for this period. These methods of operation were selected as a basis for conceptual design since final system requirements for the MRS cannot be identified at this time. Further system analysis based on an actual site location and other factors will provide clear definition of MRS functions and may require changes later.

A conservative strategy of MRS spent nuclear fuel assembly receipt has been assumed for conceptual design. *DOE/RW-0184-R1: Spent Fuel Characteristics Database* has been used as the basis for this assumption. Bounding burnup and decay conditions have been selected for shielding and effluent analyses. Requirements placed upon MRS by the mined geologic disposal system are also still being developed. The MRS will primarily handle intact spent nuclear fuel assemblies.

The MRS design complies with criteria specified in 10CFR72 to minimize potential radiation exposures to the public off site and to workers on site. Preliminary analyses confirm that potential exposures to members of the public and MRS workers will be below regulatory limits for all design concepts considered. The MRS is basically a passive facility for safely transferring spent nuclear fuel assemblies between shipping and storage casks and for storing the assemblies in heavily shielded storage modes. All spent nuclear fuel assemblies handled and stored at the MRS will have cooled for a minimum of five years before arriving at the MRS. For purposes of conceptual design, it has been conservatively assumed that off-site exposure is the maximum normal operating exposure that could be received by an individual located immediately adjacent to the owner controlled MRS site boundary, 24 hours a day for a full year. The normal operating exposure is assumed to be made up of direct and effluent (liquid and gaseous) release paths. All applicable Environmental Protection Agency regulations will be met for effluents from the MRS. Results of preliminary analyses indicate that the normal operating direct exposure will be primarily from the storage area, and the effluent exposure will be from normal permissible liquid and gaseous discharges from the transfer facility.

Off-site exposure during normal MRS operations was found to be below the allowable 25 mrem per year limit specified in 10CFR72. In addition, potential off-site exposures from a design basis fuel handling accident (the occurrence of which is judged to be extremely remote) were found to be significantly below the 5 rem allowable limit specified in 10CFR72. Occupational exposures were estimated for personnel dose received during daily MRS operations. The primary contributors were found to be cask receiving and preparation activities, radwaste processing and handling activities, and storage mode operations. Occupational exposures to MRS workers were found to be consistent with the 1 rem per year goal established by DOE regulations.

For purposes of conceptual design, the cask maintenance facility is collocated but not integrated with the MRS. Cost estimates for the cask maintenance facility are based on a feasibility study performed by Oak Ridge National Laboratories (*Feasibility Study for a Transportation Operations System Cask Maintenance Facility*, ORNL/TM-11019, ORO/TOPO-5404.0, January 1991). During later design phases, the cask maintenance facility may be developed as an integral part of the MRS.

The MRS is assumed to be located in a state that is part of a low level radioactive waste compact. After appropriate treatment and packaging, low level radioactive wastes generated at the MRS will be periodically shipped off site. This assumption will be further evaluated as a part of MRS siting activities. Facility design requirements, regulatory guidance, and operational practices will be applied to minimize generation of low level radioactive waste.

Flexibility is provided in the MRS design for incorporating additional or alternate features in later stages of design or after the start of operations. Changes may be necessary as a result of specific characteristics of the site selected, such as unique physical attributes of the site or available infrastructure surrounding the site. Flexibility is provided in the designs for the types of shipping casks received and the type of storage mode used at the MRS. Future program decisions may require the addition of spent nuclear fuel assembly handling or storage capacity. Sorting of spent nuclear fuel assemblies may become necessary as a result of decisions in other elements of the civilian radioactive waste management system. The conceptual designs presented allow flexibility for making such changes and for expansion of the facility after start of operations. Incorporation of design flexibilities also provides some margin for making key program decisions related to shipping cask types, storage mode design, and SNF receipt rates.

The MRS construction schedule was developed assuming that the NRC issues a license to build and operate the MRS in September 1996. In addition, it was necessary to assume that the NRC will issue a limited work authorization for nonpermanent construction prior to September 1996. An aggressive construction schedule is required to meet the January 1998 date for acceptance of spent nuclear fuel. For each design concept investigated, a phased construction approach is necessary to meet this objective. The phased construction approach allows acceptance of spent nuclear fuel in January 1998. Phased construction philosophies and schedules have been developed and are presented for each design concept.

During development of the various design concepts, an overall plan for MRS operations has been developed. Personnel resources needed to support each design concept are developed based on the functions and processes involved. The initial facility staff varies from about 500 to 540 employees, depending upon the design concept selected. These resource estimates are based on a 5-day work week with two shifts a day for handling spent nuclear fuel assemblies received at a rate of 900 MTU per year. For a 3000 MTU throughput, the facility staff would be from 675 to 740 employees. Staffing requirements include operating personnel, maintenance personnel, quality assurance inspectors, administration and support personnel, security personnel, public outreach staff, and site management. The majority of site staff consists of operations and maintenance technicians. Operations and maintenance positions include control room operators, mechanics, welders, millwrights, crane operators, electricians, computer technicians, procedure writers, and general maintenance workers. Personnel for these positions and for security, administrative, and clerical positions are primarily trained on site. Some positions require more highly trained personnel, such as engineers for support operations and maintenance activities and business personnel for management and accounting positions. Job categories and definitions will be refined as the design progresses. A large portion of the MRS staff can be locally hired individuals.

ES.4 DESIGN CONCEPTS

Six design concepts have been evaluated to determine feasibility of each for handling and storing spent nuclear fuel assemblies at the MRS. Five of these design concepts utilize dry transfer and storage of spent nuclear fuel assemblies, and the other concept utilizes wet transfer and storage operations. The six design concepts investigated are as follows:

- Dry transfer and vertical concrete cask storage (reference design concept)
- Wet transfer and storage
- Dry transfer and vault storage
- Dry transfer and horizontal module storage
- Dry transfer and metal cask storage
- Dry transfer and transportable storage cask storage.

The five dry transfer and storage concepts under consideration share many similar interface and support requirements in terms of receipt and handling facilities. The dry transfer and vertical concrete cask storage design concept has been designated as a reference for conceptual design, and the other design concepts are evaluated by considering required differences from the reference design concept.

ES.4.1 Design Concept Overview

Dry transfer and vertical concrete cask storage was selected as the reference design concept because it has enveloping requirements for cask weight, cask size, and storage area space when compared to other design concepts. The reference design concept has used many features of the previous MRS conceptual designs, such as concrete casks and dry transfer of fuel assemblies. Multiple vendors are available to provide information and competitive bids for vertical concrete cask storage modes; therefore, this design concept could be selected as the reference without focusing on a single cask supplier.

Designation of dry transfer and vertical concrete cask storage as the reference design concept is not intended to represent preference for this design concept over any other competing design concept. All six design concepts are considered viable. The wet transfer and storage and dry transfer and vault storage alternate design concepts differ significantly from the reference design in their approach to spent nuclear fuel assembly transfer or storage. The dry transfer and horizontal module storage, dry transfer and metal cask storage, and dry transfer and transportable storage cask storage alternate design concepts resemble the reference design, except that different type storage casks are used.

Differences between the six design concepts occur primarily in the receiving, handling, and packaging areas and in the storage areas. Support and industrial services areas change little between design concepts. The transfer facility is the largest and most complex building for the reference design concept. This facility is a shielded concrete structure that is used for dry transfer of spent nuclear fuel assemblies from shipping casks to storage modes. For the reference design, storage of casks containing spent nuclear fuel assemblies is provided in an open area of the site, away from the transfer facility. The wet transfer and storage alternate design concept utilizes a single, large building for both transfer and storage of spent nuclear fuel assemblies. The wet transfer and storage design concept is the only design concept that uses water for shielding and cooling spent nuclear fuel assemblies. Transfer of spent nuclear fuel assemblies in the dry transfer and vault storage alternate design concept takes place inside a transfer facility similar to the transfer facility in the reference design. A major difference from the reference design is that the dry transfer and vault storage alternate design concept provides for storage of spent nuclear fuel assemblies inside a large vault structure connected directly to the transfer facility. The dry transfer and horizontal module storage, metal cask storage, and transportable storage cask storage design concepts all use the same type transfer facility as the reference design, although the size of the transfer facility for several of these concepts varies from the reference design. The storage areas for these concepts and the reference design are similar, but vary in size and the type of storage cask used.

Priority has been placed on using proven technologies to the extent practical in all conceptual designs. Designs for two types of vertical concrete casks have been developed by vendors for similar applications. One of these cask designs has been licensed for storing pressurized water reactor fuel. Using pools to transfer and store spent nuclear fuel assemblies is a proven design that has been licensed by the NRC and is in use at numerous commercial reactor facilities. Though spent nuclear fuel assembly handling concepts and pool arrangements at the MRS are different from existing pool designs, there are no significant differences in the designs of structures, systems, and components as compared to licensed facilities. A vault storage facility has been licensed by the NRC and is currently in use at a reactor site. Horizontal storage modules have been licensed by the NRC and are in use at several reactor facilities in the United States. A variety of metal storage casks have been demonstrated at sites in the United States. Transportable storage cask designs, though currently not licensed, are similar to metal storage casks, and the aspects of their design are well known. Dry transfer facilities have been used in several locations in the United States and abroad. Structures, systems, and components for MRS dry transfer facility designs are similar to those used in nuclear facilities throughout the United States. None of the six conceptual designs presented for the MRS should have major design or licensing barriers to overcome.

ES.4.2 Design Concept Descriptions

The dry transfer and vertical concrete cask storage design concept (reference design concept) uses dry, shielded transfer cells to transfer spent nuclear fuel assemblies from shipping casks into vertical concrete storage casks. Spent nuclear fuel assemblies are received at the MRS by either truck or rail. On-site tractors and rail engines move spent nuclear fuel assembly shipments to a queuing area or to the transfer facility for handling. Located within the transfer facility are three transfer cell modules, which accommodate spent nuclear fuel assembly handling functions. These functions include removing assemblies from shipping casks, providing temporary lag storage for assemblies, canistering any damaged assemblies, placing assemblies into or removing them from storage casks, and preparing assemblies for transport to the mined geologic disposal system. Each transfer cell module incorporates two inload ports and one outload port for mating shipping and storage casks to the cell. All operations in the transfer cells are performed in dry, heavily shielded compartments. A radwaste area is provided in the transfer facility in a location that minimizes transport distances for radwaste. Figure ES-2 shows the steps involved in handling spent nuclear fuel assemblies using this design concept. Figure ES-3 shows the configuration of a typical transfer cell, as well as the arrangement of the control and monitoring areas of the transfer facility.

The wet transfer and storage design concept uses underwater transfer of spent nuclear fuel assemblies from shipping casks to storage baskets that are placed in water-filled storage pools. Transfer pits and storage pools are located inside a large, concrete structure. Spent nuclear fuel assemblies are retrieved by transferring the assemblies in baskets under water from storage pools to from-MRS shipping casks. Figure ES-4 shows the steps involved in handling spent nuclear fuel assemblies using this concept. Figure ES-5 shows additional details of the transfer operations and the control and monitoring areas for this design concept.

The dry transfer and vault storage design concept provides for transfer of spent nuclear fuel assemblies from shipping casks to canisters inside dry, shielded transfer cells. Two transfer cell modules are provided in the transfer facility for this design concept. Each transfer cell module incorporates three inload ports for mating shipping casks to a transfer cell and two outload ports for mating storage canisters to the cell. Canistered spent nuclear fuel assemblies are moved out of the transfer facility for storage in dry, vertical vault compartments. The vault compartments are located in large concrete enclosures adjacent to the transfer cells and are passively cooled to remove decay heat from the spent nuclear fuel assemblies. Spent nuclear fuel assemblies are retrieved by taking the canisters back through the transfer cells to transfer the assemblies to from-MRS shipping casks.

Vault storage design is the only concept which requires canisterization of individual spent nuclear fuel assemblies. Canisterization was considered necessary due to the large number of spent nuclear fuel assemblies handled and the resulting potential for contamination of the fuel assembly handling machine and other vault areas.

The dry transfer and vault storage design concept and the wet transfer and storage design concept require less area than the reference design concept. Both of these design concepts have site size requirements of less than 400 acres, compared with 500 acres for the reference design concept.

Similar in concept to the reference design, the dry transfer and horizontal module storage design concept provides for transfer of spent nuclear fuel assemblies from shipping casks to sealed canisters inside dry, shielded transfer cells. Spent nuclear fuel assembly canisters are placed horizontally into modular, dry storage receptacles on the MRS site, separate from the transfer facility. Spent nuclear fuel assemblies are retrieved by taking the sealed canisters back through the transfer facility to repackage the assemblies in from-MRS shipping casks.

The dry transfer and metal cask storage design concept is similar to the reference design concept, except that metal storage casks are used in place of concrete storage casks. The transfer, storage, and retrieval functions closely resemble those described for the reference design concept.

The dry transfer and transportable storage cask storage design concept is based on the assumption that many spent nuclear fuel assemblies are received at the MRS in transportable storage casks. Because some utilities cannot accommodate rail shipments of transportable storage casks, some spent nuclear fuel assemblies are shipped in truck casks. Loaded transportable storage casks are inspected and taken directly to the storage area. Truck shipping casks are taken into the transfer facility, where spent nuclear fuel assemblies are transferred into transportable storage casks. The transfer facility for this design concept is smaller than that for the reference design concept. As in the reference design concept, spent nuclear fuel assembly transfer takes place inside dry, shielded transfer cells. Transportable storage casks are placed vertically on concrete storage pads on the MRS site. Spent nuclear fuel assemblies are retrieved by loading the transportable storage casks onto rail cars for shipment to the mined geologic disposal system. Regardless of the design concept selected, receipt of some transportable storage casks is planned at the MRS, since some utilities are expected to use transportable storage casks for at-reactor storage. These casks can be shipped to the MRS and stored without transferring spent nuclear fuel out of the casks. Additionally, transportable storage casks offer an option for timely receipt of spent nuclear fuel assemblies in the event of delays to completion of the MRS.

ES.4.3 Design Concept Support Facilities and Services

Supporting facilities essential to the safe handling, packaging, site transport, storage, and monitoring of spent nuclear fuel assemblies are provided for all design concepts. Road tractors and railroad engines transport shipping and storage casks throughout the MRS network of roads and rail lines. Staging and holding areas accommodate surges in cask shipments and temporarily store railroad cars and truck trailers. Required levels of security for the MRS are ensured by providing fencing around the site, site illumination, alarm and monitoring systems, inspection areas for shipments into and out of the MRS site, and guard houses for observing and controlling activities on and near the site. Low level radioactive wastes generated during spent nuclear fuel assembly handling operations are collected in a radwaste facility. Solid low level radioactive wastes are treated and packaged for off-site disposal in a regional low level radioactive waste compact. Any liquid wastes discharged off site will be properly filtered, treated, and monitored in accordance with federal regulations before being released.

A cask maintenance facility is collocated with the MRS to support maintenance activities for the shipping cask fleet. Major repairs and maintenance tasks performed on shipping casks in the cask maintenance facility include inspecting casks, changing cask baskets, replacing cask lid seals, and welding and repairing casks damaged during shipping or handling. Providing a cask maintenance facility for major cask maintenance and repair activities allows the MRS transfer facility to proceed uninterrupted with spent nuclear fuel handling operations. The cask maintenance facility is located outside the protected area of the MRS site and has not been designed within the scope of this conceptual design. Information from a study performed by Oak Ridge National Laboratories (ORNL/TM-11019) has been used to ensure proper interface of the cask maintenance facility with the MRS and to provide a basis for the cost estimate and construction schedule. Conceptual design concepts for the MRS provide the flexibility to fully integrate the cask maintenance facility with other site facilities if required.

Utility services are provided throughout the MRS site to support spent nuclear fuel assembly handling operations and other site activities. An electrical power distribution system supplies the continuous electrical demands of all systems and components for normal spent nuclear fuel assembly handling operations, support activities, and administrative areas. For emergency electrical power needs, on-site diesel generators are provided. Potable and process water supply systems are provided to meet MRS water demands. The centralized sanitary and conventional waste treatment systems are provided to service all MRS facilities. Refinements to these systems may be appropriate to properly interface with the host community infrastructure once a site is selected.

Additional services supporting the MRS mission include a site fire protection system that protects structures, systems, and components related to radiological aspects of the facility and provides personnel safety and investment protection for the MRS. This system services MRS facilities through a centralized network of underground piping. Instrumentation and control systems are provided to ensure proper control of MRS spent nuclear fuel assembly handling operations, to monitor spent nuclear fuel assemblies in storage, and to ensure protection of the public, MRS workers, and the environment. In addition, a communications system provides for proper coordination of spent nuclear fuel assembly handling activities and efficient interfaces with other civilian radioactive waste management system elements.

Several conventional buildings are provided for accommodating support personnel, storing materials, providing maintenance activities associated with operation of the MRS, and interfacing with the community surrounding the MRS site. A warehouse within the protected area stores spare parts and materials needed for spent nuclear fuel assembly handling activities. Space is provided outside the protected area for storing materials necessary for MRS support activities. Administrative office space and site service facilities are located in a conventional building outside the protected area. A vehicle maintenance facility is also provided.

A visitors and media center is located near the main entrance to the MRS and outside the security fence. The center is architecturally designed to blend the MRS into the environment of the host community and to welcome visitors to the MRS site. The purpose of this facility is to accommodate outreach activities and programs of interest to MRS visitors. The center contains a reception area for greeting visitors, a display of an MRS project model, exhibits, information booths, and a canteen. An auditorium is provided in the visitors and media center for presenting films and hosting speakers. Community meeting rooms are also provided.

In support of outreach activities, the receiving, handling, packaging and storage facility designs will consider visitors' access to the facility and viewing of MRS operations to the extent practical and in a safe manner consistent with NRC requirements.

ES.5 COST AND SCHEDULE

The MRS is affected by a number of programmatic requirements that impact the cost and schedule, including the following items.

- The site will be selected through a process of negotiation between the Office of Nuclear Waste Negotiator and the host state governor or Indian tribe leaders.

- An environmental assessment will be performed and will accompany the negotiated site agreement when submitted to Congress for approval.

- Multiple storage technologies are under consideration, and final selection will be made in consultation with the host community as part of negotiations with the Office of Nuclear Waste Negotiator.

- The facility will be licensed by the NRC, which in turn requires a detailed safety analysis report and environmental impact statement.

These requirements necessitate a compressed schedule to meet the January 1998 date for first receipt of spent nuclear fuel assemblies. Some program activities will be accelerated and will impact costs. Aggressive schedule assumptions and activity durations require innovation from all program participants and deviations from some of the normal methods of executing DOE projects.

ES.5.1 Cost Estimate

Cost estimates have been developed for each of the six design concepts and are presented in Section 4.0. Direct comparison of costs among design concepts is not appropriate because the estimates do not consider total life cycle costs for design, construction, and operations. Many other factors relating to cost and design must be evaluated to perform a rational comparison of design concepts. Data presented in Section 4.0 provides reliable costs for use in Energy Systems Acquisition Advisory Board deliberations leading to Key Decision 1 and approval to start the next phase of MRS design.

Costs have been generated for activities scheduled through the end of all phases of construction for all design concepts. For cost estimating purposes, the end of construction has been defined as completion of all facilities necessary to store 5,000 MTU of spent nuclear fuel assemblies. A three-phase program is planned for constructing MRS facilities. Phase 1 costs for the reference design concept include costs for all support facilities, one transfer cell module, civil portions of the storage area, and enough casks to begin operations. Phase 2 construction costs include completion of an additional transfer cell module and additional storage. Phase 3 construction costs include completion of the transfer facilities and cask maintenance facility and acquisition of the remaining storage needed for 5,000 MTU capacity. Estimated costs for each design concept are summarized in Table ES-1.

Table ES-1 - Summary Cost Estimate
Including Escalation & Contingencies
(Millions of Dollars)

Description Storage	Concrete Cask Storage	Wet Storage	Vault Storage	Horizontal Module Storage	Metal Cask Storage	TSC
MANAGEMENT & ENGINEERING						
Systems Engineering	17	17	17	17	17	17
MRS Design	117	117	117	117	117	109
CMF Design	13	13	13	13	13	13
Quality Assurance	9	9	9	9	9	7
Project Management	26	26	26	26	26	22
Information Management	8	8	8	8	8	5
Support Services	8	8	8	8	8	8
Subtotals	198	198	198	198	198	181
CONSTRUCTION						
Construction Management	69	69	69	69	69	57
MRS Construction and Procurement without Storage	360	382	368	342	342	293
CMF Construction and Procurement	87	87	87	87	87	87
Storage Containers for 1000 MTU	46	14	95	66	124	200
Subtotals	562	552	619	564	622	637
TOTAL DEVELOPMENT COST	760	750	817	762	820	818
OPERATIONS						
Preoperations Test and Training	46	44	46	46	46	45
Initial Operations	98	92	96	98	98	94
Subtotals	144	136	142	144	144	139
DEVELOPMENT & OPERATIONS FOR 1000 MTU	904	886	959	906	964	957
Added Storage for 5000 MTU	195	57	407	279	528	801
DEVELOPMENT & OPERATIONS FOR 5000 MTU	1,099	943	1,366	1,185	1,492	1,758

Scope of cost estimates includes all elements of design, construction, and operation of the MRS. In past MRS studies and reports, storage casks were included in construction cost estimates to support operations until all phases of facility construction were complete. Additional casks for subsequent operations were included in operation cost estimates. DOE requested that a similar approach be used in developing costs for this conceptual design. Applying this approach for the vault and wet storage design concepts is more difficult. While staged construction can be accomplished for the vault and wet storage design concepts, the increments of storage capacity are much larger than for concepts that use storage casks or modules. DOE suggested that all design concepts be estimated to the lowest common denominator of capacity. The largest storage increment, and therefore the lowest common denominator, is 5,000 MTU for the wet storage design concept. As such, costs for all design concepts have been estimated based on 5,000 MTU of storage capacity.

ES.5.2 Schedule

The master schedule for the reference design concept is shown in Figure ES-6. The schedule is based on Document Change Proposal 57, which was written to change the schedule baseline. A departure from this baseline was necessary to ensure acceptance of spent nuclear fuel assemblies in January 1998. Primary departure from Document Change Proposal 57 is the early start of construction activities, which is reflected in schedules developed in detail for each of the design concepts.

Many assumptions were required to develop the MRS construction schedule. The critical assumptions are listed below.

- The site and design concept will be selected by December 1992.
- Collection of data necessary for developing the environmental impact statement can begin before approval of the site by Congress.
- NRC review of the license application will be completed in two years, based on submittal of the safety analysis report at the beginning of the review period and submittal of the environmental impact statement one year later.
- There will be minimal opposition and no delays for legal issues during the licensing process.
- The NRC will waive restrictions required in 10CFR72 that prohibit nonpermanent construction prior to issue of a full license.
- Congress will appropriate the necessary funds to proceed with construction in a timely manner.

Virtually all portions of the schedule present challenges. The critical path flows through all schedule elements relating to site identification, environmental assessment activities, Congressional approval, site characterization activities, environmental impact statement development, safety analysis report development, NRC license application review, and construction activities. Design activities, while not shown on the critical path, must proceed expeditiously to support other activities, such as development of the safety analysis report and environmental impact statement.

ES.5.3 Cost and Schedule Risks

Cost and schedule risks addressed within this conceptual design are limited to risks associated with design, construction, and initial operations of the MRS. The MRS Project Plan provides additional information concerning risks associated with the MRS project, including those associated with obtaining an approved site and performing regulatory and environmental reviews.

Proven technologies are utilized in design of the MRS to the maximum extent practical and do not present any foreseeable major design problems. Design activities are generally not on the critical path for the MRS and are not seen as a significant risk to the schedule. With the current scope, design cost growth is not regarded as a significant risk.

The construction schedule is aggressive and will require a dedicated effort to start MRS operations by January 1998. The schedule assumes the NRC will grant a limited work authorization allowing early start for nonpermanent construction at the site. Other assumptions are that the selected site will be in an area of moderate climate with minimal weather impacts on schedule and that site preparation work will not be complex or extensive. At this stage of design development, no schedule allowance for work activity congestion has been made for installation of mechanical and electrical equipment in the transfer facility. This will be further monitored as the design matures.

Because this is a conceptual design, details of the design concepts have not been finalized. As such, there are some uncertainties in inputs generated for cost estimates. The storage modes for all design concepts represent a major portion of the total construction cost. This portion of the costs was estimated on the basis of public information and some input from vendors. For the estimate, a 25% contingency was applied to storage costs. To allow for these and other uncertainties, an overall weighted average contingency of approximately 17% has been applied to the construction cost estimates. Since the facility is relatively simple with few unusual equipment requirements, the cost estimates are considered to be valid within 30% of the values given.

Operation costs can be significantly affected by changes in MRS facility staffing levels. Staffing levels presented for the design concepts reflect assessments of all MRS operation functions, including facility management, administration, support, and spent nuclear fuel assembly handling operations. Operation staff sizes are based on derived numbers of casks handled at the MRS, forecast throughputs of spent nuclear fuel in MTU, and assessments of times required to perform each task. These times are based on data from operating nuclear facilities and on analyses by experienced nuclear fuel handling operations personnel. Changes in the operation times assumed could significantly impact staffing levels and associated operating costs. Trade-off studies to assess benefits of additional automation in cask handling operations may show some opportunity to reduce operating costs.

ES.5.4 Risk Resolution

Schedules developed for the six design concepts indicate that the MRS can receive spent nuclear fuel assemblies by January 1998 for all design concepts. As addressed in Subsection ES.5.3, some risks are associated with meeting schedules for each of the design concepts. Analyses indicate that completion of the transfer facility is the critical path element for receipt of spent nuclear fuel assemblies for all design concepts. At least two contingency options are available that would allow the MRS to receive spent nuclear fuel assemblies before completion of the transfer facility and therefore alleviate schedule risks associated with MRS construction.

One option is for the MRS to receive all spent nuclear fuel assembly shipments in transportable storage casks prior to completion of the transfer facility. Transportable storage casks can be taken directly to the storage area without passing through the transfer facility. All of the design concepts considered in this conceptual design include provisions to handle some transportable storage casks. By scheduling the early deliveries from reactors that can handle transportable storage casks, a January 1998 receipt date for spent nuclear fuel assemblies can be achieved regardless of construction completion of the transfer facility.

Another option is to develop a system for dry cask-to-cask transfer of spent nuclear fuel assemblies, which could be utilized at the MRS for receipt of spent nuclear fuel assemblies prior to completion of the transfer facility. Such a system is currently under joint development by the Sacramento Municipal Utility District, the Electric Power Research Institute, and DOE. This system would be subject to review and licensing by the NRC.

ES.6 SUMMARY

A systems engineering approach has been used for developing the MRS conceptual design. This approach and appropriate management and quality assurance reviews have ensured that the project scope satisfies needs of the civilian radioactive waste management system, regulatory requirements, and DOE requirements. All requirements specified in *DOE/RW-0334P: Physical System Requirements—Overall System* (Revision 0) and *DOE/RW-0319: Physical System Requirements—Store Waste* (Revision 0) that are appropriate for conceptual design of the MRS have been met. In addition, criteria specified in 10CFR72 and other applicable NRC regulations have been fully satisfied to the extent possible for a conceptual design. Conceptual designs developed for the MRS can achieve their mission of safely receiving, storing, and monitoring spent nuclear fuel assemblies shipped from civilian reactor sites until a mined geologic disposal system becomes operational. MRS conceptual design concepts are also capable of safely retrieving spent nuclear fuel assemblies from storage and managing flow of assemblies to the mined geologic disposal system after it becomes operational. Designs that have already been licensed by the NRC or designs that have a high probability of being licensed have been utilized in all design concepts to the extent possible.

A primary emphasis has been placed on protecting the health and safety of the public and operating personnel and on protecting the environment in all aspects of the MRS conceptual design. Preliminary analyses have been performed, confirming that any potential exposures to members of the public and MRS workers will be below regulatory limits specified in 10CFR72 for all design concepts. Off-site exposure for normal operation is below the allowable 25 millirem per year for all design concepts. Off-site exposure resulting from any credible accident is substantially less than the allowable 5 rem for all design concepts. Radiation exposure to MRS workers from normal operations is consistent with the 1 rem per year goal established by DOE regulations. Facilities are provided to collect, treat, and monitor all wastes generated at the MRS to ensure protection of the environment in accordance with Environmental Protection Agency regulations.

Six design concepts have been developed for MRS conceptual design. Of these, five design concepts use dry transfer and storage of spent nuclear fuel assemblies, and the other concept uses wet transfer and storage. Storage modes for four of the design concepts (wet pool storage, vault storage, horizontal storage modules, and one type vertical concrete storage cask) are already licensed by the NRC. Metal storage casks have been demonstrated at several sites in the United States. Transportable storage casks are similar to metal casks, and aspects of their design are well known. All of these design concepts are feasible and can attain required performance levels for receipt, handling, storage, retrieval, and flow-through of spent nuclear fuel assemblies. The six design concepts are all viable as options for MRS design, and no major design problems or licensing barriers are anticipated. Structures, systems, and components used in the design concepts are proven technologies similar to those used in commercial nuclear and nuclear process facilities in the United States.

The six design concepts selected for MRS conceptual design offer a wide range of options for accomplishing the MRS mission. Once a site is chosen for the MRS, one design concept will be selected for final design. Some modifications to the design concept selected may be required to accommodate specific site characteristics. Any such modifications are expected to be minor because of flexibilities incorporated into each of the design concepts. Flexibilities are provided in the design concepts for receiving varying quantities of spent nuclear fuel assemblies, handling different types of shipping casks, and accommodating additions or alterations at the site. The designs also permit flexibility for fully integrating a cask maintenance facility with other MRS facilities.

Cost estimates have been developed for each of the six design concepts through the end of all phases of construction, including enough storage capacity for 5,000 MTU of spent nuclear fuel. Cost estimates include all elements of design, construction, and operation of the MRS. The resultant construction cost for each design concept is provided in Table ES-1. Cost estimates do not consider total life cycle costs; therefore, direct comparison of costs among design concepts is not recommended.

Aggressive construction schedules are provided for each of the six design concepts. These schedules are attainable with the provisions identified for phased construction and timely site selection and regulatory review. Schedules developed indicate that each of the design concepts can accommodate receipt of spent nuclear fuel assemblies by January 1998. This satisfies spent nuclear fuel receipt requirements of the Nuclear Waste Policy Act.

Use of proven technologies results in minimizing design risks associated with any of the design concepts. Some risks are inherent with any conceptual design because designs are not final and details have not all been resolved. Costs estimated for the design concepts are within the 30% range normally associated with a conceptual design. Cost and schedule risks are associated with basic assumptions made concerning site selection, NRC licensing time requirements, NRC permit authorization, weather impacts, site conditions, and work activity congestion for an accelerated schedule. These items present risks for meeting the January 1998 date for acceptance of spent nuclear fuel assemblies at the MRS. Thus, the project risks are related primarily to schedule, with minimum risks associated with cost and technical issues. Contingency options have been identified to alleviate schedule risks associated with development of the MRS.

The performance requirements of the MRS can be met. Technically, there are at least two acceptable methods for transferring fuel, dry and wet, and six suitable methods for storing spent nuclear fuel assemblies. Requirements identified in NRC regulations and DOE orders can be met with application of existing technology. Risks of radiation exposure to the public and to the MRS staff are significantly below guidelines stated in NRC regulations and DOE orders.

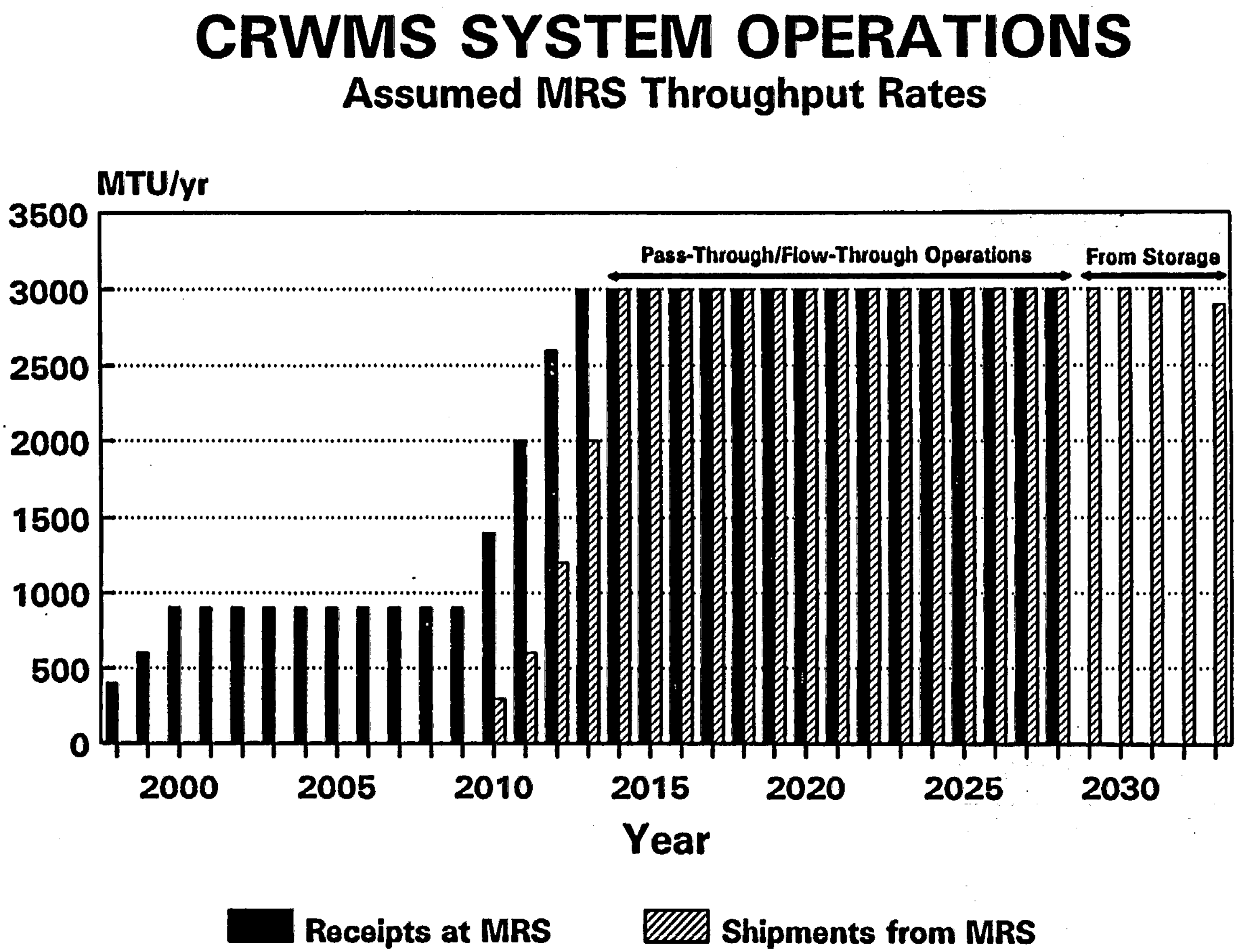
CRWMS SYSTEM OPERATIONS
Assumed MRS Throughput Rates
MTU/yr
3500
3000
2500
2000
1500
1000
500
0
Pass-Through/Flow-Through Operations
From Storage
2000
2005
2010
2015
2020
2025
2030
Year
Receipts at MRS
Shipments from MRS

Figure ES-1