CO-DISPOSAL FACILITY FOR HAZARDOUS 
AND LOW-LEVEL RADIOACTIVE WASTES

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ABSTRACT

To meet the requirements of the RCRA regulations and the Code of Federal Regulations for waste disposal, six conceptual designs for the co-disposal of hazardous and low-level radioactive wastes were developed based on an annual generation of 300,000 ft$^3$ ($8,495$ m$^3$) of wastes for a 25 year period. This paper discusses those designs, summarizing their potential as a secure landfill disposal facility, and presents the plan, facility description, and recommended operations for the management of such a facility.

INTRODUCTION

In the latter part of 1980, a client requested the siting and conceptual alternative designs for a secure landfill disposal facility for solid hazardous (HZW) and low-level radioactive (LLRW) wastes. Estimated quantities of solid waste that would be generated annually in the two categories were approximately 30,000 ft$^3$ ($850$ m$^3$) of HZW and 270,000 ft$^3$ ($7,646$ m$^3$) of LLRW annually. The facility was sized to contain the total solid waste accumulated during a 25 year period in the future.

Our evaluation of the characteristics and quantities of the two types of waste streams led us to conclude that a segregation of these waste streams at a common facility would be the optimum solid waste management system. This would provide single point control and facilitate the handling and treatment of leachate.

DESIGN CRITERIA

The criteria used to develop six alternative designs were based on the following regulations as promulgated by the Resource Conservation and Recovery Act (RCRA) and the Code of Federal Regulations (CFR):

D. 40 CFR 265 — Interim Status (Facility) Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities.

DISPOSAL FACILITY DESIGN

FOR ABOVE GROUND OR BELOW GRADE BURIAL DESIGNS 1 THROUGH 6, FIG. 1

The concept developed for the hazardous and low-level waste disposal facility which is discussed in this paper, is a 130 acre (52.61 ha) site composed of two major areas. One area of 54 acres (21.85 ha) contains 24 LLRW disposal cells; the second area of 15 acres (6.07 ha) for disposal of HZW and metal wastes has 30 cells. The remaining area, approximately 60 acres (24.28 ha), serves as a buffer zone and contains the
FIG. 1 SITE PLAN, HAZARDOUS AND LOW LEVEL RADIOACTIVE WASTE (SCALE 1 = 300)

FIG. 2 ABOVE GROUND WITH CONCRETE, HAZARDOUS/LLRW SECURE LANDFILL CONCEPT (NO SCALE)

FIG. 3 ABOVE GRADE WITHOUT CONCRETE, HAZARDOUS/LLRW SECURE LANDFILL CONCEPT (NO SCALE)
groundwater interceptor system (for bypassing groundwater around a below grade operation), the surface runoff collection and holding systems, the leachate collection systems, and ancillary facilities which include office and laboratory building, weigh station, truck washing and decontamination area, garages and support equipment. Two surface runoff holding basins are provided within the groundwater interceptor system. The groundwater trench extends 5 ft (1.524 m) deeper than the proposed cell depth. Separate leachate handling and treatment facilities are provided for the LLRW and the HZW. The LLRW leachate system includes the collection system throughout the cells, a holding/flow equalization pond and disposal to either on-site or off-site treatment facilities. The hazardous leachate system consists of the collection grid, a holding pond, chemical treatment stabilization, clarification (if necessary for solids removal), filtration, and adsorption with granular activated carbon. Finished effluent is spray irrigated on-site within the buffer zone.

DESIGN 1

ABOVE GROUND BURIAL WITH CONCRETE LINER, FIG. 2

The above ground hazardous waste concrete lined landfill is a constructed pit built up above the existing grade using suitable soil (from the site, if available). The elevated pit has a base liner of 5 ft of crushed and compacted shale topped with an asphalt seal. Above this is 2 ft (0.61 m) of sand and gravel. An 80-106 mil (2.032-2.692 mm) high density polyethylene liner rests on the sand and gravel. This liner is topped with 6 in. (15.24 cm) of reinforced concrete. Leachate interceptors are located at the shale and sand/gravel interface on
either side of the landfill. Leachate collectors are located in trenches in the concrete liner on either side of the landfill. All leachate drains to these collectors since the center of the landfill is crowned to induce such drainage by gravity. The landfill is sloped to one end to induce drainage from the leachate collection and interceptors to flow by gravity to the leachate collection facilities. The landfill is capped with 3 ft (0.914 m) of clay followed by 5 in. (12.7 cm) of sand, 6 ft (1.829 m) of common borrow and 6 in. of topsoil. The lowest shale liner is 10 ft (3.048 m) above the expected groundwater table. The landfill is graded to promote surface runoff. A surface water runoff collector is provided around the landfill. Monitoring wells are located beyond these collectors.

**DESIGN 2**

**ABOVE GROUND BURIAL WITHOUT CONCRETE LINER, FIG. 3**

The above ground hazardous waste landfill without concrete liner is similar to the previous described landfill with concrete liner. It consists of a constructed pit above the existing grade; it has a base liner of 5 ft of clay, crushed and compacted shale, with asphalt seal; 2 ft of sand and gravel layer to support an 80-106 mil high density polyethylene liner. The bottom liner is completed with an additional 2 ft of sand and gravel. Leachate interceptors are located at the clay/shale/sand interface. Leachate collectors are located immediately above the polyethylene liner. The top of the landfill is as before with 3 ft of clay, 6 in. of sand, 6 ft of borrow, and 6 in. of topsoil. Surface water runoff collection is provided, as well as monitoring wells.

**DESIGN 3**

**BELOW GRADE BURIAL WITH CONCRETE LINER, FIG. 4**

The below grade hazardous waste secure landfill without concrete liner is similar to the previously described landfill with concrete liner. It consists of an excavated lined pit located to a depth of 25 ft (7.62 m) above the area groundwater. The base lining consists of 5 ft of clay or crushed and compacted shale with an asphalt seal. Above this is 2 ft of sand and gravel liner supporting an 80-106 mil high density polyethylene liner. This liner is topped with 6 in. of reinforced concrete. Leachate interceptors are located at the clay/shale/sand, gravel interface. Leachate collectors are located in a trench in the reinforced concrete. The landfill is capped with 3 ft of clay, 6 in. of sand, 6 ft of borrow, and finished with 6 in. of topsoil.

Monitoring wells are provided around the landfill to monitor groundwater quality. A gas vent can be provided through the top coverage, if necessary.

**DESIGN 4**

**BELOW GRADE BURIAL WITHOUT CONCRETE LINER, FIG. 5**

The below grade hazardous waste landfill without concrete liner is similar to the previously described landfill, with the following exception. In place of the 6 in. of reinforced concrete, 12 to 18 in. (30.48 to 45.72 cm) of sand and gravel is provided. The leachate collectors are located in this layer of the liner. The landfill is capped and finished as before.

**GROUNDWATER DIVERSION FOR DESIGNS 3 AND 4, FIG. 6**

In areas where the groundwater table is too high to allow the proper separation of the below grade landfill and the groundwater, the groundwater could be lowered by the use of interceptor trenches on wells. The groundwater would be lowered to maintain a 20 ft to 30 ft (6.096 m to 9.144 m) minimum separation. The groundwater interceptor trenches would be to a depth of 30 ft (9.144 m) to the projected lowered groundwater elevation. The groundwater would collect in the trench and drain by gravity to an outfall point downgradient of the landfill. The groundwater could also be controlled by well pumping which would produce a draw down as shown on Fig. 6 (Well Point Section). Site conditions and land availability will determine the alternative groundwater control.

**DESIGN 5**

**ABOVE GRADE BURIAL, EPA DESIGN I, FIG. 7**

EPA Design I hazardous waste landfill has a soil liner which is at least 1.5 m (5 ft) in thickness and composed of natural in-place soil or emplaced soil which as a permeability less than or equal to $1 \times 10^{-7}$ cm/sec. It has a leachate collection and
removal system overlying the soil liner which is at least 30 cm (12 in.) in thickness and composed of permeable soil capable of permitting leachate to move rapidly through the system and into the leachate collection sump(s). The liner system therefore has a slope of at least one percent at all points, and is connected to all low points to one or more leachate collection sumps so that leachate formed in the landfill will flow by gravity into the sumps from where it can be removed, treated and/or disposed.

The design as depicted in Fig. 7 includes the capping as specified for low-level radioactive waste disposal in 10 CFR 61.

**DESIGN 6**

**ABOVE GRADE BURIAL – EPA DESIGN II – FIG. 8**

EPA Design II hazardous waste landfill has a liner system which is also sloped at least one percent for leachate collection as EPA Design I, however, the liner must be a synthetic membrane liner. The EPA Design II liner system, therefore, consists of the following:

1. A leachate detection and removal system, placed on the natural base of the landfill, which consists of a minimum of 15 cm (6 in.) of permeable soil capable of permitting leachate to move rapidly through the system and into the leachate collection sumps;

2. A membrane liner system overlying the leachate detection and removal system composed of a 15 cm (6 in.) layer of clean permeable sand or soil overlaid with a synthetic membrane liner which is overlaid with a 15 cm (6 in.) layer of clean permeable sand or soil;

3. A soil liner overlying the membrane liner system which is at least 1 m (3 ft) in thickness and composed of soil which has a permeability less than or equal to $1 \times 10^{-7}$ cm/sec.

4. A leachate collection and removal system overlying the soil liner which is at least 30 cm (12 in.) in thickness and composed of permeable soil capable of permitting leachate to move rapidly through the system and into the leachate collection sumps.

The design as depicted in Fig. 8 includes the capping as specified for low-level waste radioactive waste disposal in 10 CFR 61.

Further details of the design criteria for EPA Designs I and II can be found in the December 18, 1978 issue of the Federal Register, pages 59009 to 59011.

**EVALUATION**

**ABOVE GROUND BURIAL – DESIGNS 1 AND 2**

Multiple lined landfills provide means for containment and leachate control. Leachate can permeate the upper porous layers to the impervious
membrane and be conveyed to the leachate collector. Interceptors are provided below the leachate collectors to provide a backup system should the high density polyethylene liner fail.

Above grade burial provides the maximum natural buffer between the landfill and water table. It can eliminate the need for lowering the ground water and for providing ground water interceptors. It affords additional protection from flooding and can promote rainfall runoff. Leachate from the facility can generally be handled by gravity flow without the expense or need for pumping.

Above grade burial, however, requires large amounts of borrow soil for the construction of the banks and additional soil for berms within the facility and capping. The above ground facility can be significantly more costly than the below grade facility, depending on the cost of groundwater control for the below grade facility. In addition, erosion could be a problem due to the elevated nature of the facility and its slopes. Furthermore, the combination of hazardous and radioactive waste in one facility requires more borrow for capping than if the materials were handled separately. The depths of linings and cap will raise the above grade landfill to almost 20 ft without considering waste material placement. The concrete lining in a multi-lined landfill provides a more stable base during the landfill operation and permits greater ease of waste retrieval if it is desired at a later time. It gives greater protection to the polyethylene liner than the sand and gravel liner cover during operations and later recovery. It also provides an additional barrier for radiation.

**BELOW GRADE BURIAL — DESIGNS 3 AND 4**

Below grade burial in a multi-lined landfill affords the same protection for leachate control as stated for above grade landfills.

Below grade burial will, however, require means
for groundwater control to produce the required 10 to 25 ft (3.048 to 7.62 m) of buffer zone. Groundwater control should be passive if topography permits to minimize operation failure. Below grade landfills does yield better erosion control but could be susceptible to flooding if land availability has dictated that the landfill be located on a floodplain site.

Below grade landfills do not require the extensive amount of borrow material required by above grade landfills. In addition, the material excavated for the landfill can be used for dike building and capping. Combining of hazardous and radioactive waste requires extensive capping material; however, diking within the facility could be used to separate the material to lessen final cover requirements and allow for less complicated leachate treatment systems.

The advantages of concrete lined facility versus a facility without concrete lining are as previously stated in the evaluation for the above ground facility.

GROUNDWATER DIVERSION – FOR BELOW GRADE DESIGNS

Effective groundwater diversion should rely on passive interceptor trenches rather than well pumping to ensure control at all times. These trenches, sited to utilize the available topography, would divert the groundwater around the facility to a disposal point downgradient. If elevations did not permit a gravity system, pumping and backup could be provided for dewatering; however, this should be considered only when alternative gravity systems are not possible.

EPA DESIGNS I AND II

Design I does not provide a double liner system which allows for some measure of protection if the inner liner fails or is breached by an accident. It is the writer's opinion that future revisions of RCRA may require double liners for refractory organics and certain trace metals. In addition, double lined systems may be required in areas where maximum protection of underlying water supplies is required. The double liner requirement could come about as a secondary insurance to prevent the migration of hazardous substances and nuclides via water pathways.

Design I and II require a maximum subgrade permeability of $1 \times 10^{-4}$ cm/sec. Because of the variability of the subgrade permeability, it is of paramount importance that site specific soil evaluation be made before deciding the design of the facility. Design I may be appropriate in situations where there is a uniformity of waste streams and where relatively little or no waste segregation or berming is required within the facility.

Design II provides a double liner system; however, because of the placement of the leachate detection system, the success of the system is dependent upon a subgrade permeability $1 \times 10^{-4}$ cm/sec. If the geologic formation under the burial site is part of the Conasauga Group, its permeability may preclude use of this design unless the subgrade is treated to attain the $1 \times 10^{-4}$ cm/sec permeability. The design shown on Figs. 2 through 5 provide for multi-liner protection and would not require the $1 \times 10^{-4}$ cm/sec permeability of the subgrade for success of the leachate interceptor should the high density polyethylene liner fail.

LEACHATE AND RUNOFF FACILITIES

The major benefit of separated waste streams within a co-disposal facility lies in the segregation of the resultant leachate allowing for optimum handling and treatment of each type (HZW or LLRW). For the facility as sized in this paper, the following leachate and runoff holding ponds were required based on a two days' storage during the month of maximum rainfall in order to attenuate flows to the treatment systems and receiving streams.

1. Hazardous Waste Leachate Pond - 42,000 gal (158.988 m$^3$) 5 ft D X 35 ft X 35 ft (approximate dimensions)
   2. Low-level Waste Leachate Pond - 160,000 gallons (605.559 m$^3$) 5 ft D X 65 ft X 65 ft (app. dim.)
   3. Runoff Pond for HZW and LLRW Disposal Site - 300,000 gal (1135.630 m$^3$) 5 ft D X 90 ft X 90 ft (app. dim.)

Items 1 and 2 are covered with a floating Hypalon cover to prevent increase in leachate volume due to rainfall.

Item 3 contents are disposed of by returning to available waterways.

LEACHATE MANAGEMENT

ONSITE TREATMENT (PHYSICAL/CHEMICAL)

Leachate from the radioactive landfill facility
drains along trenches to the landfill pond and from there is transported by pump to the storage hold tank in the leachate treatment plant facility. There are two storage tanks. When one is filled, the leachate will be processed, while the other tank will receive any leachate developed during the batch processing.

The on-site LLRW leachate treatment facility utilizes filtration and ion exchange demineralization operations to prepare leachate for discharge. The leachate drainage trench collects effluent from the landfill and delivers it to the leachate collection pond. The sump is sized to hold two days' accumulation of leachate during maximum flow conditions through the twenty-fifth year of landfill operation (approximately 160,000 gal). The pond pump transfers leachate to a transport truck or to the storage hold tank on a batch basis for pH adjustment through chemical addition. The storage tank pump transfers contents through a series arrangement of 50 μm and 25 μm etched disk filters to the mixed bed demineralizer. The filter and demineralizer systems are sized for a 104 gpm (0.394 m³/min) throughput to accommodate the average daily leachate flow through the twenty-fifth year of operation assuming a 50 percent equipment availability. Output from the demineralizer is held in the demineralizer water tank for sampling, then discharged to the nearest stream or river. When necessary, the filters are backwashed into the backwash and spent resin storage tank. Spent resins are also washed into this tank for dewatering and subsequent transfer for further processing prior to shipment to the landfill facility. The processing involves the solidification of spent resins with a suitable binder such as concrete or vinyl-ester resin in a specifically designed steel drum.

EVALUATION

Since the leachate is from the radioactive landfill facility, the radionuclides existing as insoluble particles are removed for the most part by the series filters, and the remaining ionic constituents in solution are removed from the filtrate by the mixed bed demineralizer. The distillate discharge from this filter-demineralizer system can be safely returned to the environment. The collected radioactive concentrates can easily be solidified and packaged in drums and returned to their point of origin, the landfill facility. The main objectives of pumping the leachate from the radioactive landfill facility for treatment are the reduction of the potential for migration of radionuclides via water pathways, and meeting the standards set by RCRA, 10 CFR 61 and the EPA.

CONCLUSION

In conclusion, co-disposal of HZW and LLRW is feasible with six secure landfill burial type facilities depending on the Topographic, Geologic and Hydrologic conditions of the selected site. The most important of the controlling design criteria is the prevention of groundwater contamination due to the migration of hazardous wastes and radionuclides via water pathways. Both CFR and RCRA Regulations emphasize the prevention of groundwater contamination and the return of clean water to the environment, therefore, the only solution is to provide positive control of leachate by containment and treatment.

Key Words
Co-disposal
Facility
Hazardous
Landfill
Operation
Treatment
Waste quantity

168