# DISPOSAL CONCEPTS FOR RADIOACTIVE WASTES IN CLAY OR TILL DEPOSITS

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## ABSTRACT

Two generic schemes for disposal of low and intermediate level radioactive wastes at shallow to intermediate depths in clay/till geomedia are discussed in this paper. Engineered trenches, tunnels and augered boreholes are the technical concepts used in these schemes. Both schemes are constructable at direct construction costs of 377-392 $\$/m^3$ for low level and up to 1734 $\$/m^3$ for intermediate level wastes, using well proven construction methods and technologies.

## INTRODUCTION

Disposal methods could range from land-based methods (such as burial in shallow, intermediate and deep geologies), to lake, sea or ocean disposal methods. However, land-based methods are generally favoured from technical, economic and socio-political considerations.

Ontario Hydro, as part of an option study for disposal of its low and intermediate level wastes evaluated a number of land-based technical concepts. These are listed in Table 1. Among these technical concepts, the least engineered - and therefore the least expensive - concepts such as landfills and cut and cover trenches and boreholes are susceptible to degradation events such as collapse of earth covers into the waste, water ponding etc, potentially leading to the need for remedial work. These methods could, however, be suitable to wastes classified as of insignificant risk or sufficiently low in radioactivity such that destablilization of the system in time is not a radiological or a safety concern. On the other hand, the deep disposal concept in geological formations has superior isolation characteristics; but, due to its generally high cost, may not be justified for low and intermediate level wastes. Thus, detailed design studies concentrated on engineered concepts at shallow to intermediate depth either in rock media[1] or in suitable soil formations.

In this paper, two generic schemes for the disposal in soil deposits are presented. These schemes incorporate three basic burial concepts i.e. trenches, tunnels and augered boreholes.

For the low level waste, considering the nature of the waste (i.e. bulk volumes, ease of handling etc.) disposal can be easily facilitated in trenches (Scheme A) or in tunnels (Scheme B). For the intermediate level waste, however, the shielding and handling requirements favour disposal in augered boreholes although it is conceivable that these wastes can be disposed of in trenches or tunnels as well, along with low level Waste.

TABLE 1

| |
|---|
| Technical Concepts Initially Evaluated |
| Engineered Landfills |
| Cut and Cover Trenches/Boreholes - Shallow Depth |
| Engineered Trenches/Boreholes - Shallow Depth |
| Mined Cavern - Shallow to Intermediate Depth |
| Deep Disposal - in Deep Geological Formations |
| Technical Concepts Selected For Development |
| Caverns in Rock Media |
| Trenches in Soil Media |
| Tunnels in Soil Media |
| Augered Boreholes in Soil Media |

The schemes are developed such that they are constructable mostly with commercially available techniques and equipment. A modular approach is used to facilitate simultaneous construction and operation. Thus, the facility in each scheme is divided into a number of independent disposal units, although with a common access.

The reference quantities assumed in the scheme development are 50,000 $m^3$ of low level waste and 3,000 $m^3$ of intermediate level waste.

## GEOLOGICAL AND HYDROGEOLOGICAL CONSIDERATIONS

The disposal facility requires to be located in a geological and hydrogeological setting that meets the requirements not only for isolation and retardation of radionuclides but all other siting requirements. The soil types that can potentially meet these requirements are clay or till materials with low hydraulic conductivity and good radionuclide retardation capacity. Such deposits are common in many areas of Ontario.

Given the conditions in Ontario, where the water table is relatively high, it is assumed that the disposal units would be located below the water table. However, because of low conductivity of the soil types, ground water velocities would be slow enough that any backed, migrating radionuclides would decay significantly before reaching the biosphere. Engineered barriers further assist in delaying ground water flow into and through the disposal units, thus delaying potential leaching and transport of radionuclides.

The clay/till medium is assumed to be thick enough (more than 15 m) to host the underground facilities with an upper weathered zone in the order of 2 m. The unweathered clay/till is assumed to be free of major imperfections such as water bearing sand seams connected to major aquifers although isolated pockets of sand or silt can be tolerated. Thicker deposits would be more advantageous particularly for the tunnel scheme. It is stressed, however, that no attempt is made here at specifying site selection criteria as we believe that each site must be assessed on its own merit.

trench cover system made of natural materials is designed to minimize infiltration of surface precipitation into the trench as well as to protect the trench from other forms of intrusion (e.g. burrowing animals)[2]. The cover system is shaped to form a mound or a series of longitudial mounds to promote quick runoff, and minimize the amount of water penetrating the till/clay hydraulic barrier.

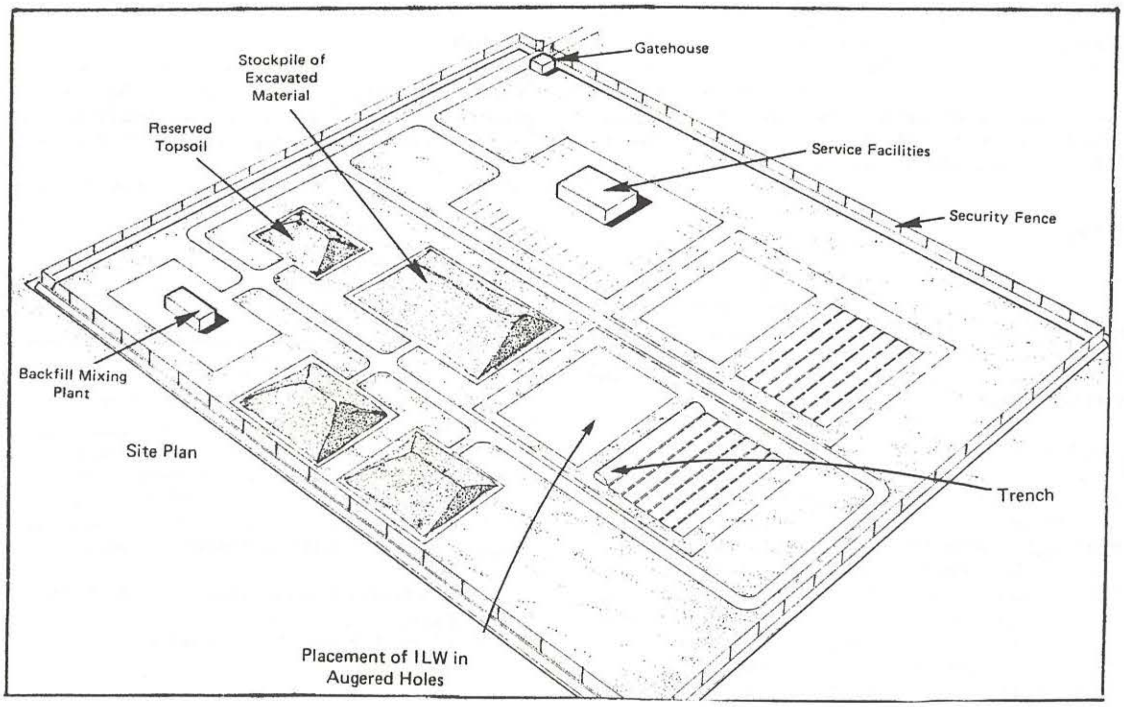


FIGURE 1: LAYOUT OF TRENCHES AND AUGERED BOREHOLES IN CLAY OR TILL

## DESCRIPTION OF SCHEMES

### Trenches and Augered Boreholes (Scheme A)

An artist's presentation of Scheme A is shown in Figure 1. For the reference quantities, assuming a 55 percent volume efficiency, the waste would be placed in 14 trenches which measure 10 m x 107 m in plan with 6 m depth of waste. Each trench (Figure 2) specifically designed to minimize potential for "bathtub" type failures consists of an underground structure with a structural roof supported on walls. The roof, together with the walls provide the support to the earth cover above the trench. Thus, any settlement of the waste does not affect the stability of the soil cover. The roof slab also provides an additional intrusion protection below the earth cover. All voids between the waste containers are filled with a fluidized cement-based backfill, to minimize the long-term settlement of the waste past the lifetime of the structural components of the trench. A

The structure of the trench can be a concrete box constructed in an open cut excavation. However, a minimum disturbance of the surrounding clay/till is achieved with a diaphragm-type wall or with tangent caissons. Initially, the weathered zone is excavated and the caissons are augered starting at the top of the intact clay/till. When the perimeter of a trench is completed, the earth inside the trench is excavated. The perimeter caissons are 0.8 m diameter and 13 m deep and act as a cantilever wall when the earth inside the trench is excavated. Depending on the quality of the bedrock at the site, some caissons (about one in five) must extend to bedrock to transfer the structural loads from the slab, earth cover and any potential surcharge.

The waste is emplaced in layers in the trench. After each layer, a low strength concrete or fly ash concrete backfill is introduced to fill the voids and form a 100 mm cover over the containers prior to placing the next layer of waste. The trench depth (6 m in our case) would be selected

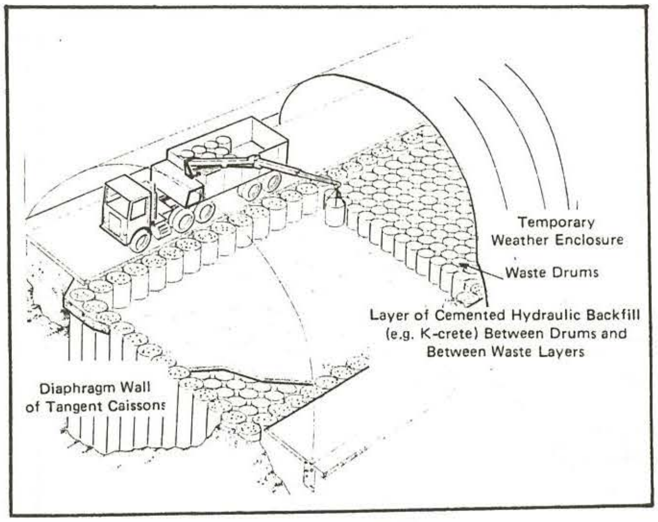


FIGURE 2: OPERATION OF AN "ENGINEERED" TRENCH FOR LLW DISPOSAL

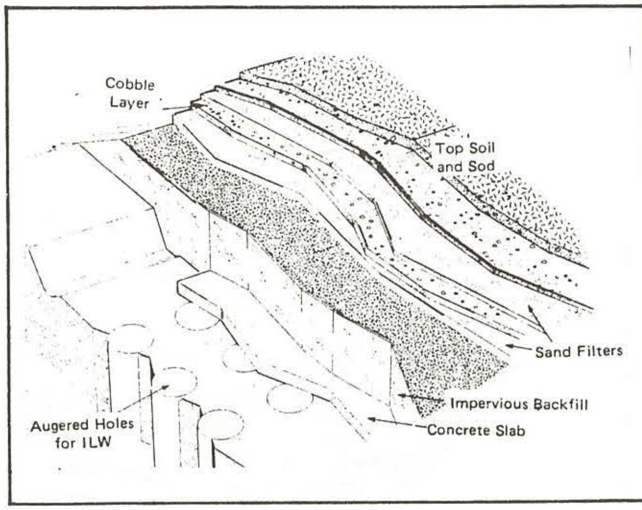


FIGURE 3: AUGERED BOREHOLE AND EARTH COVER FEATURES

based on the structural strength of the waste containers upon stacking, the shear strength of the clay and the thickness of the clay layer. Figure 2 is an illustration of the trench features and operations.

The intermediate level waste is placed in 3 m diameter augered boreholes, 8.5 m deep. As for the trenches, site preparation consists of first removing the weathered zone, then augering the holes and placing the waste. Waste emplacement is done by bottom unloading of waste into the augered boreholes through a temporary shielding cover and all voids are backfilled with a low strength concrete. Finally, a concrete slab is poured over the augered boreholes and a multi-layered earth cover is placed and compacted as for the trench cover. Figure 3 illustrates the augered borehole and the earth cover features.

Tunnels and Augered Boreholes (Scheme B)

The basic layout of the tunnel scheme is shown on Figure 4. Augered boreholes complement tunnels for the purpose of intermediate level waste disposal as in Scheme A. The scheme consists of parallel tunnels driven between two access ramps and trenches. This layout allows flexibility in simultaneously carrying out construction of new tunnels and disposal operation in completed ones, while keeping both activities totally separated. The tunnel depth, diameter, type of access and the distance between parallel tunnels will be controlled by site characteristics such as general topography, thickness and strength of the clay, thickness of the weathered zone, as well as other factors such as the size and shape of waste containers, type of tunnelling equipment and tunnelling method.

Tunnel Access. In a generally flat topography, access to the facility could be through a shaft or a ramp. While a shaft access reduces the potential contamination pathways, it introduces complications in the handling of the waste and general operation of the facility. For this reason, and because this concept is for relatively shallow depths, a ramp access is favoured. A concentrated effort is required to seal the accesses during the backfilling and closure of the facility in order to limit ingress of surface water.

Tunnel Construction. For the reference waste quantities, and assuming a variety of waste containers, six tunnels with an inside diameter of 4.4 m and each 1030 m long are required. Except for the first 20 m which are hand mined and concrete lined, the tunnels are advanced from one access trench to another using a Tunnel Boring Machine (TBM). The TBM starts its operation by jacking against the concrete lining of this first hand mined portion. For the remainder of the tunnel, the support is the conventional system of steel ribs and timber lagging erected within the tail of the TBM. This system is traditionally used in soft ground tunnel construction as a primary support system. For other tunnel applications (e.g., transit, municipal), a secondary lining is installed within the primary one. This secondary lining can be of cast in-situ concrete, precast concrete segments, cast iron, steel, bricks, etc., and is usually required for aesthetic reasons or for its hydraulic flow properties. By the time the secondary lining is installed, the primary lining and the surrounding soil would have achieved equilibrium and the primary lining carries all the loads. While it does not contribute to the soil support, the secondary lining usually adds substantially to the tunnel cost. For the present application, it is considered that a secondary lining is not required. The waste containers are stacked in vertical rows to fill a length of

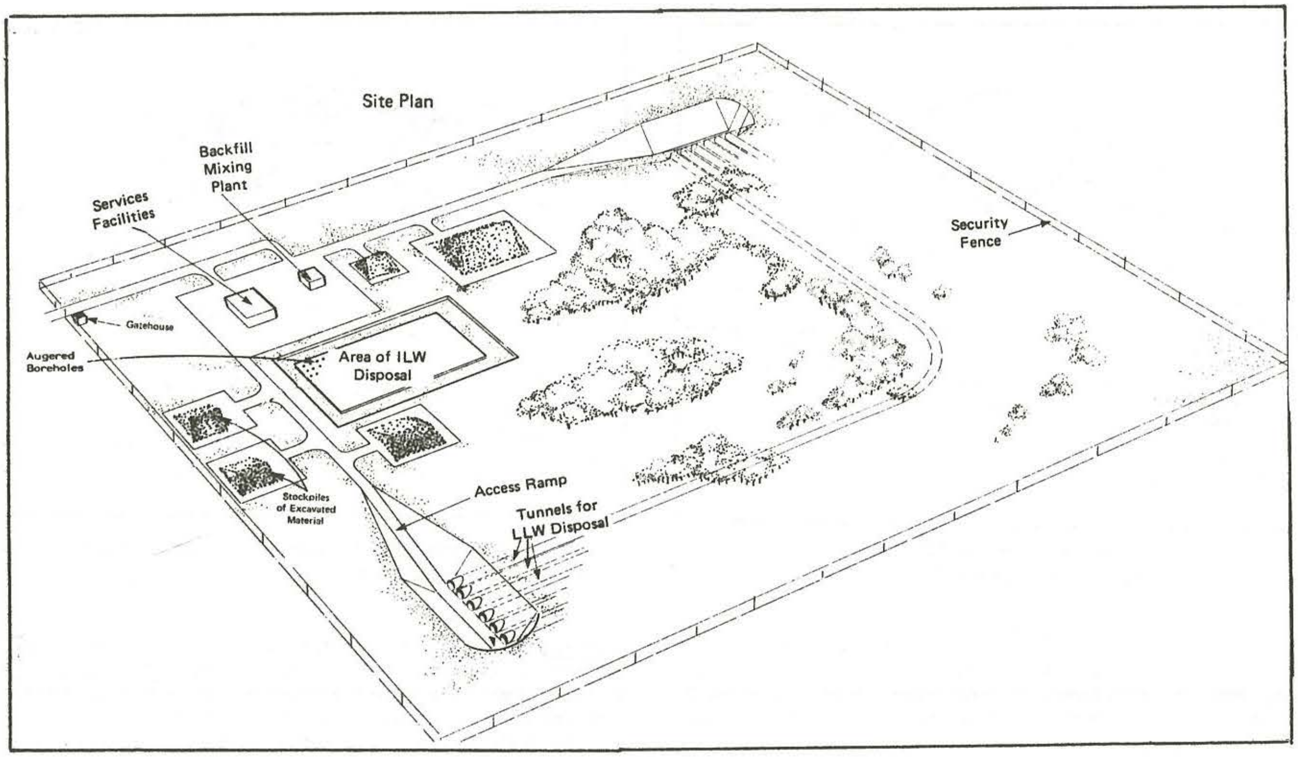


FIGURE 4: LAYOUT OF TUNNELS AND AUGERED BOREHOLES IN CLAY OR TILL

tunnel. A temporary bulkhead is then placed and a fluidized, cement-based backfill injected to fill all voids within the tunnel. Once the backfill has hardened, the waste container rows would be stabilized in a solid mass of backfill within the glacial till or clayey soil deposit.

Major ground water problems during construction are not anticipated in a clay or till site suitable for waste disposal. Minor seepage from localized sand pockets can be handled by local sump pumping at the tunnel invert. Perimeter interceptor ditches at the ground surface minimize surface water inflows into the trench access. Groundwater and precipitation in the trench can be handled by sump pumps.

Sealing of the Access Trenches. Sealing of the access trenches will begin upon completion of waste emplacement and backfilling of all the tunnels. This operation is critical in the success of this disposal concept. The major steps of this operation are as follows:

(a) Completely remove all surface covers placed over the natural soil of the ramp/trench during the construction and waste emplacement phases of the facility. These covers could include paving, granular material, slope protections, etc., which if left in place would become a potential pathway for surface water into the closed facility.

(b) Shape the sides of the access trenches/ramps in stepped configuration to allow better quality compaction and blending with the natural soil.

(c) Backfill by placing the previously excavated clay or till in shallow layers, observing moisture and compaction control to achieve a pre-determined permeability close to that of the surrounding natural soil.

(d) Use a blend of bentonite and natural clay/till in a horizontal layer near the top of the ramp/trench to achieve a watertight seal.

(e) Reshape the ground surface over the access openings to prevent water ponding.

A preliminary performance assessment of the tunnel scheme[3] concluded that under suitable geological and hydrogeological conditions, the scheme is viable and has a potentially good containment capability.

COST ESTIMATES

The estimated direct construction costs in 1986 Canadian dollars are summarized in Tables 2, 3 and 4. In summary, the total direct construction costs are 24 M$ for scheme A (trenches and augered boreholes) and 24.8 M$ for Scheme B (tunnels and augered boreholes). These costs amount to 377-392 $/m$^3$ for low level and up to 1734 $/m$^3$ for intermediate level wastes.

TABLE 2

Cost of Concrete Trenches
(Capacity 50,000 $m^3$)

(Scheme A)

| | Item | Cost (K$1986) |
|---|---|---|
| 1. | Site Preparation (Excavation of Weathered Zone) | $ 828 |
| 2. | Caisson Walls | 6,581 |
| 3. | Trench Excavation | 1,105 |
| 4. | Weather Enclosure | 715 |
| 5. | Drainage | 122 |
| 6. | Trench Backfill | 4,449 |
| 7. | Trench Cover System (Includes Concrete Slab) | 3,909 |
| 8. | Miscellaneous (Security, Surface Roads, Fence, Gate-house) | 1,258 |
| | TOTAL | $18,877 |

TABLE 3

Cost of Tunnels
(Capacity 50,000 $m^3$)

(Scheme B)

| | Item | Cost (K$1986) |
|---|---|---|
| 1. | Two Access Ramps and Trenches | $ 1,387 |
| 2. | Tunnel Boring Machine | 2,490 |
| 3. | Excavation, Drainage, Electric Components, Steel Ribs and Lagging | 8,918 |
| 4. | Backfill (Tunnels and Accesses) | 5,610 |
| 5. | Miscellaneous (Security, Surface Roads, Fence, Gatehouse) | 1,228 |
| | TOTAL | $19,633 |

TABLE 4

Augered Holes for ILW
(Capacity 3,000 $m^3$)*

| | Item | Cost (K$1986) |
|---|---|---|
| 1. | Site Preparation (Excavation of Weathered Zone) | $ 502 |
| 2. | Augering, Spoil Disposal and Miscellaneous | 972 |
| 3. | K-crete Backfill | 1,385 |
| 4. | Concrete Slab and Earth Cover | 2,344 |
| | TOTAL | $5,203 |

* Common for Schemes A and B

## CONCLUDING REMARKS

Two generic schemes for shallow disposal of low and intermediate level wastes in clay/till geomedia have been developed consisting of trenches, tunnels and augered boreholes. Under suitable site conditions, both schemes are constructable with well proven construction methods and technologies. The design of the engineered trenches is aimed at avoiding problems due to the destabilization of the earth cover. The tunnel cost compares well to the cost of engineered trenches. In addition, tunnelling operations are far less disruptive to the environment at the site. The soil cover over the tunnel remains undisturbed which eliminates one major contamination pathway inherent to the trench method. Also, given a sufficient thickness of clay/till, tunnel can be constructed at greater depth than would be practically achievable with trenches.

Finally, augered boreholes, while the most practical alternative for disposal of intermediate level waste from shielded containers, are costlier. In addition, to some extent, like trenches, measures are required to be taken to prevent failure by destabilization of the earth cover.

## ACKNOWLEDGEMENT

The authors are indebted to several of their colleagues in the various departments of Ontario Hydro who contributed to this study and to those who critically reviewed the work and provided useful comments and suggestions. Thanks are due in particular to Mssrs. P.J. Armstrong, E.M. Taylor and Dr. C.F. Lee.

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