XA9745283

Presentation at the IAEA Workshop to Review Waste Inventories, Waste Characteristics and Reference Candidate Site, Shanghai, China, July 7-9, 1997

RADIOACTIVE WASTE MANAGEMENT AND DISPOSAL IN AUSTRALIA

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1. INTRODUCTION

A national near-surface repository at a remote and arid location is proposed for the disposal of solid low-level and short-lived intermediate-level radioactive wastes in Australia. The repository will be designed to isolate the radioactive waste from the human environment under controlled conditions and for a period long enough for the radioactivity to decay to low levels.

Low-level and short-lived intermediate-level waste is defined under the new IAEA waste classification scheme as *short lived low and intermediate level waste (LILW-SL)* (IAEA 1994a). LILW-SL classification includes those wastes suitable for disposal in simple landfills, engineered surface facilities or near-surface facilities at depths of, typically, a few tens of metres. The concentration of long-lived radionuclides in LILW-SL is limited to low levels consistent with the radiotoxicity of the radionuclides and the requirements set by national authorities.

Compared to countries that have nuclear power programs, the amount of waste in Australia is relatively small. Nevertheless, the need for a national disposal facility for solid low-level radioactive and short-lived intermediate-level radioactive wastes is widely recognised and the Federal Government is in the process of selecting a site for a national near-surface disposal facility for low and short-lived intermediate level wastes.

Some near surface disposal facilities already exist in Australia, including tailings dams at uranium mines and the Mt Walton East Intractable Waste Disposal Facility in Western Australia which includes a near surface repository for low level wastes originating in Western Australia.

2. INVENTORY OF RADIOACTIVE WASTES

The amount of LILW-SL radioactive waste in Australia was estimated to be about 3,400 m^3, Table 1.

Table 1. Existing solid low level radioactive wastes for repository

Organisation	Volume m^3	Description
ANSTO	900	Compacted wastes in 205 L drums
		Dried sludges from treatment of low-level liquids
	200	Uncompacted solid items
	100	HEPA filters
Defence	60	Electronic valves, watches, etc
States and Territories	100	Sealed sources, etc
CSIRO	2000	Soil contaminated with uranium process tailings
Total	3400	

The existing generation rate of LILW-SL radioactive wastes in Australia is less than 50 m^3 per year. Over 50 years this generation rate would correspond to less than 2,500 m^3. However, this generation rate does not include such potential additional sources as those that could arise from the decommissioning of the HIFAR and Moata research reactors, from increased use of consumer products, and from the mining and use of naturally-occurring radioactive materials. It is estimated that decommissioning HIFAR could generate about 2500 m^3 of LILW-SL waste and about 150 m^3 intermediate-level waste assuming that the reactor is dismantled soon after it ceases operation. The amount of waste from site remediations will depend on regulatory clean-up criteria and acceptable disposal options.

Based on the amount of low-level and short-lived intermediate-level radioactive waste already in various storage facilities around Australia, the repository might only need a capacity of 10,000 m^3 over a 50-year period. However, as there could be other sources of radioactive wastes it has been suggested that the repository have space for 100,000 m^3 of waste.

Table 2. Other radioactive wastes in Australia

Type	Volume	Comments
Intermediate level solid	300 m^3	Research reactor operation, production of radioisotopes, medical radium sources.
	15 m^3	Processing of research reactor fuel
Intermediate level liquid	6 m^3	Production of molybdenum-99. These wastes are to be solidified
Uranium process tailings	~ 2 million tonnes per year	Disposal at mine sites
Spent research reactor fuel	1600 elements	0.25 tonnes heavy metal

The mining of uranium and mineral sands also produces wastes containing elevated levels of naturally occurring radionuclides. The two Australian uranium mines now operating produce over 2 million tonnes of uranium mill tailings a year and most of these tailings are disposed of in near surface facilities at the mine sites. Although uranium mill tailings are controlled by different regulations, the requirements for their disposal are consistent with disposal criteria for near surface disposal of radioactive wastes. The processing of mineral sand concentrates can produce wastes with elevated levels of thorium.

Australia also has intermediate level wastes that are unsuitable for near surface disposal. These include numerous radium sources, wastes from the production of molybdenum-99 and intermediate level wastes resulting from the overseas reprocessing of research reactor spent fuel. Consideration is being given to establishing a national store for intermediate level wastes pending the establishment of deep geological repository that would be suitable for intermediate level waste.

Small quantities of very low level radioactive waste from medical and research activities are disposed of in municipal tips, by incineration or to the sewer. Limits of these disposals are specified in the Code of Practice for the disposal of radioactive wastes by the user (NHMRC 1985).

3. THE SITE SELECTION PROCESS FOR AN AUSTRALIAN NATIONAL REPOSITORY

In 1992, the Federal Government with support from the States, started a site selection process for a national near-surface disposal facility at a remote and arid location (Davoren et al 1996). Selection criteria are based on the requirements in a code of practice for a near-surface facility in Australia issued in 1992 (NHMRC, 1992). The national repository will be designed to isolate the radioactive waste from the human environment under controlled conditions and for a period long enough for the radioactivity to decay to near-background levels.

In Phase 1 of the site selection process, the National Resource Information Centre (NRIC) developed a methodology to identify a suitable site using the site selection criteria of the NHMRC Code of Practice as previously described. A discussion paper on the methodology and the near-surface concept for the repository was issued (NRIC 1992).

In Phase 2, NRIC assembled more detailed information and applied the GIS methodology again on a country-wide basis (NRIC 1994). Based on the assessment and suggestions from public comment, NRIC identified eight regions for further assessment. The eight identified regions had areas ranging between 11,000 and 67,000 square kilometres, and were characterised by low population density, low annual rainfall (mainly less than 500 mm), high pan evaporation, generally local and low productivity aquifers and no intensive agriculture. Detailed digital data were assembled for each region on a 250 m grid. The themes used for the regional analysis were geology, faults, drainage features, standing water levels, supply rate and water quality in water bores, tenure and transport.

The public comments were sought on both the Phase 1 and the Phase 2 discussion papers (DPIE 1993, 1995). A National Repository Advisory Committee has been formed to advise the Minister.

Phase 3 of the site selection process is the identification of a suitable site. The Federal Government will nominate one of the eight regions for detailed field investigations. A comprehensive public consultation process is planned during the selection and investigation of a preferred site.

4 DESIGN CRITERIA

The Australian National Health and Medical Research Council (NHMRC) developed a *Code of Practice for the Near-Surface Disposal of Radioactive Waste in Australia* that specifies requirements for site selection, design criteria, safety assessment, operation, regulation, and rehabilitation for a near-surface facility (NHMRC 1992). This code is expected to form the basis for regulations governing operation of the repository.

Three categories of radioactive waste (A, B and C) are defined in the NHMRC Code as suitable for near-surface disposal and one category (S) as unsuitable. Category C waste is bulk materials with similar activity concentration limits to Category B. The minimum cover thickness for Category A material is 2 m between the top of the waste and the top surface of the cover, and for Category B and C materials the minimum cover thickness is 5 m.

Design criteria for the Australian repository will be based on the requirements of the NHMRC Code of Practice for the Near-Surface Disposal of Radioactive Waste in Australia and the IAEA RADWASS recommendations. The design will also depend on the amounts and types of radioactivity waste for disposal, the climate and geology of the site, the design dose constraint for any release, the level of access control that can be imposed while the site is operational and the institutional control period for which land use limitations can be maintained after the site has closed. At the end of the institutional control period (100 –300 years) the residual levels of radioactivity should be low enough that foreseeable human and biological activity will not result in unacceptable doses.

The lowest level of wastes, Category A, must be treated to reduce the waste volume and to minimise voids. The next level of wastes, Category B or Category C, must in a form which will maintain its physical dimensions and properties under the anticipated conditions of disposal, including the compressive effects of overburden and compaction equipment, and the structural changes caused by chemical reaction or biodegradation. Category B or C wastes must be structurally stable for a design period of at least 300 years. Stability could be provided by the waste form itself, by processing the waste into a stable form, by placing the waste into a disposal container, or by placing it in a structure such as a lined trench or a bore hole.

Under the Australian NHMRC Code, Category B waste must be at least 5 m, and Category A waste at least 2 m, below the top surface of the cover. If Category A and B wastes are buried in the same trench, the Category A wastes must be stabilised to the same standard as required for Category B wastes

5. REPOSITORY SITE CONDITIONS

The site for the repository is expected to be in an semi arid or arid climate. The site will have an average annual rainfall less than 500 mm and an average annual pan evaporation greater than 2500 mm. Storm intensity will be medium, i.e. a maximum rainfall over 3 days of 300 mm for a 50 year average recurrence interval.

The site is expected to have low vertical relief with clearly defined surface water flow paths and slopes low enough to ensure erosion is not significant over the life of the repository. Ideally the repository will be on elevated land where no off-site water flows onto the site. The facility will be designed to ensure there is no accumulation of surface waters in the vicinity of the buried wastes both during operations and after closure.

The institutional control period limits the activity concentration of wastes that can be disposed of in the repository. An institutional control period of 100 to 300 years is being considered.

6. FACILITY DESIGN OPTIONS

The performance of a near surface facility depends on the waste form, the waste package, the engineered barriers built into the repository design and the surrounding geology. The conditioning and packaging of the waste for disposal could involve a range of immobilisation techniques such as cement, polymer and bitumen and a range of packages such as polyethylene high integrity containers, steel drums, stainless steel drums, concrete lined steel drums, large steel boxes, prefabricated concrete containers, concrete vaults and monoliths. A balance needs to be maintained between the level of containment which forms part of the waste package and the level of need for engineered barriers built into the repository.

Because the Australian repository will have to accept many different types of radioactive waste, the facility design needs to be flexible and capable of accepting wastes of widely differing toxicity. The disposal facility is expected to be based on an excavated pit or trench into which are placed packaged wastes, modular canisters, and perhaps engineered structures.

Disposal Technologies

Direct disposal in 205 litre steel drums could be appropriate for the thousands of cubic metres of very low-level wastes, including cleanup wastes and very low-level laboratory wastes. The very low level wastes would be placed in trenches, the spaces between the wastes backfilled and a low infiltration cover installed.

In the case of direct disposal, steel drums cannot be considered to provide long term containment after wastes are buried. For direct disposal, the engineered cover and geology would need to be shown to provide adequate isolation. Individual items would be placed by fork lift and/or crane in ordered arrays. All packages should be numbered and positions of each item surveyed and recorded. Voids between each item should be filled with dry sand at the completion of each layer, with the fill extending to the sidewall of trench. If greater containment is required, mortar could be used as backfill.

Additional containment can be provided by modular canisters made of concrete or steel and able meet structural criteria. Containment can be provided by the canister itself, or by an inner package such as a polyethylene high integrity container. Modular canisters can be packed at the repository or at regional centres.

For some wastes, it might be appropriate to consider concrete vaults or concrete monoliths. For both vaults and monoliths, the waste is placed in an open concrete cell, which is backfilled with concrete/mortar to produce a concrete monolith or by sand/gravel, and fitted with a concrete lid.

Because different toxicity wastes have different containment and structural requirements, there can be advantages in using different disposal structures for the different types of wastes. However, if as in the Australian repository, the amount of waste is relatively small, there can be economic and operational advantages in limiting the number of disposal structures being used at any time.

Intermittent Operation

The low generation rate of radioactive waste in Australia means that disposal campaigns at the repository could be separated by extended periods of inactivity. At the end of each campaign, the facility will have to be closed and all waste securely contained to prevent intrusion by humans, animals and plants and to limit the ingress of rainwater. It would be advantageous to design the repository so that periodic monitoring and surveillance of the site during the closed periods would provide adequate security without the need for permanent staff on site.

Site Layout

As discussed above, the amount of wastes to be disposed of in the Australian repository is expected to be between 10,000 and 100,000 m^3. A waste volume of 100,000 m^3 would fit in a volume of 200 m x 200 m by 5 m deep, assuming the waste takes only half the volume with the balance for spacing and backfill.

The preliminary plans for the Australian repository are based on a notional site area of 25 ha (500 m x 500 m) surrounded by a buffer zone of about 500 m width where access is restricted and development controlled. With the buffer zone, the area of the site is about 1.5 km x 1.5 km. A further zone of restricted occupancy where land use is controlled and housing restricted could be advantageous.

Cover Design

A suitably engineered cover will be placed over the buried waste to limit infiltration of rainwater, discourage entry of animals, plant roots and humans, and inhibit erosion for the particular conditions at the site. In undisturbed soils in arid locations only a very small fraction of the annual rainfall percolates to depth. The design of the cover depends on the level of containment required, climatic conditions and local topography. The cover design must be designed to ensure it maintains its integrity during any consolidation of the wastes or backfill.. Voids should be filled and back-fill compacted to minimise consolidation

On-site Facilities

The Australian repository is expected to have minimal on-site conditioning facilities. However, there will be a need to be able to inspect wastes, to store and handle any waste that does not comply with acceptance criteria and has to be returned to the conditioner.

While the inventory of Australia's waste that is not suitable for near surface disposal is still relatively small, proposals are being considered for a national storage facility where this waste can be stored pending establishment of a suitable geologic disposal facility. If a national storage facility for long-lived intermediate level wastes is to be established, one option would be to co-locate the intermediate-level storage facility at the site of the national low-level radioactive waste disposal repository. Because the site selection criteria for the two facilities are different, co-location will only become an option if the site selected for the disposal facility wastes is assessed and found to be also suitable for the storage facility. Co-location of a storage facility for long-lived intermediate level wastes would not imply that a deep geological facility for Category S wastes would be sited at the same site or in the same region.

Monitoring

A comprehensive site monitoring program will be undertaken beginning well before any radioactivity is taken to the site, and continuing through the operational and the institutional control periods.

7. CONCLUSION

International experience and practice shows that a range of different technologies are available to ensure that a near-surface repository can be established to dispose of Australian low and short-lived intermediate-level waste in a effective, safe and cost effective manner that meets international standards.

Site selection is proceeding, and design options are under consideration. Selection of packaging options and the disposal will be based on an engineering costing study to estimate comparative costs of different options, and a safety assessment using site specific data to select the technologies that meet radiological and environmental criteria.

8. REFERENCES

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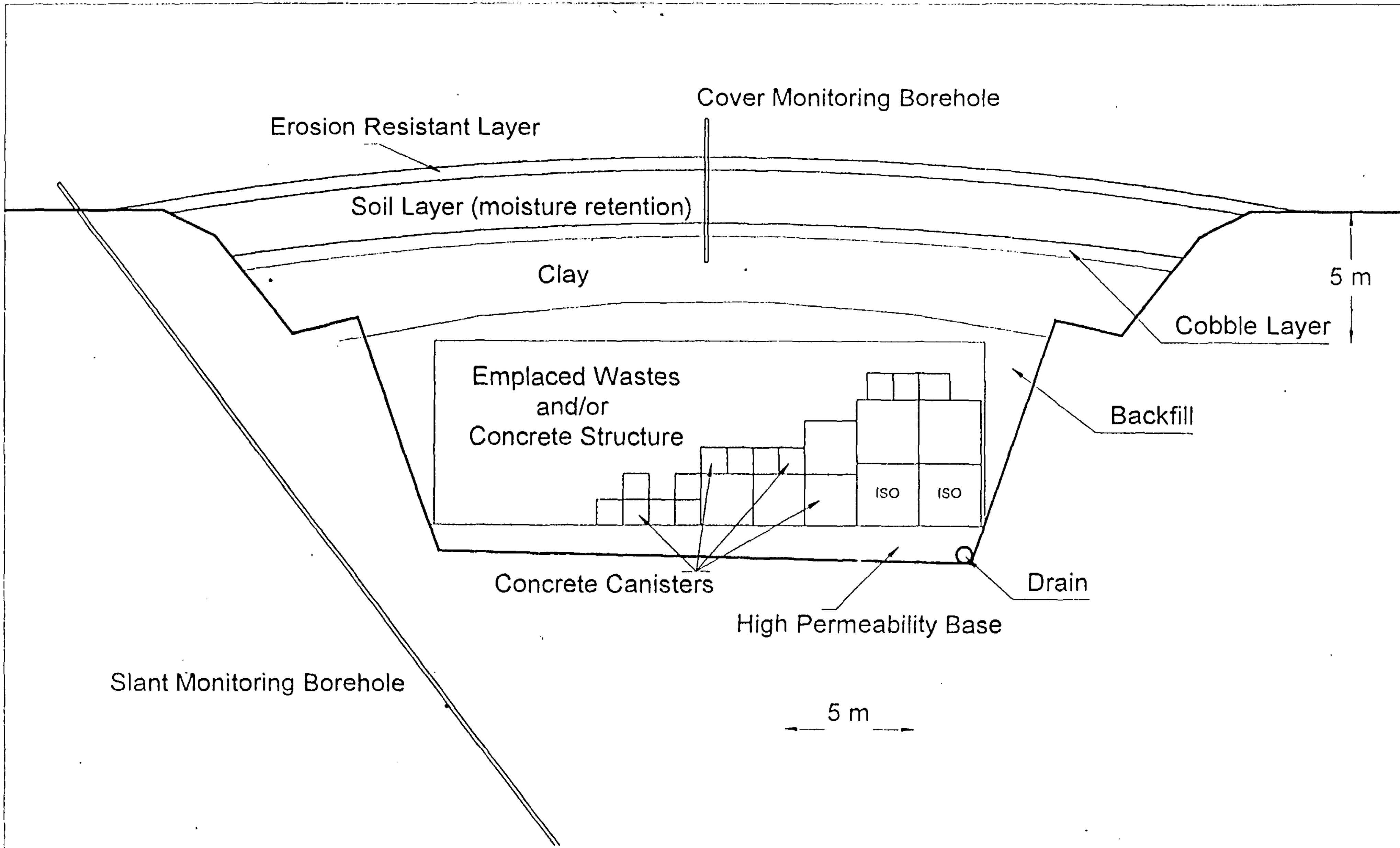

Figure . Schematic Diagram of Possible Near Surface Disposal Facilities for Low Level and short Lived Intermediate Level Wastes.

NOTES ON LOW-LEVEL DISPOSAL FACILITIES AROUND THE WORLD

John Harries, Australian Nuclear Science and Technology Organisation, 4 July 1997

Site	Operating	Technology	Design Volume	Rate	Rainfall	Evaporation
Australia, National Repository	Proposed	Near Surface	10,000 m^3		< 300 mm/y	~ 2500 mm/y (pan)
Australia, Mt Walton East, WA	Operating	Near Surface: concreted shaft, concrete ISO container		125 m^3 to 1997	220 mm/y	2800 mm/y (pan)
Canada, Chalk River	Proposed	Near Surface: below ground concrete vault	4,000 m^3		800 mm/y	500 mm/y (actual)
China, Northwest	Under Construction	Near Surface: below ground vaults (no concrete floor)	60,000 m^3 (later 200,000 m^3)		< 70 mm	
Czech, Dukovany	Operating	Near Surface: below ground concrete vault	310,000 m^3		~ 500 mm	
Finland, Olkiluoto	Operating	Excavated Rock Cavity	15,000 m^3		~~600 mm/y	
France, L'Aube	Operating	Near Surface: concrete vault/monolith	1,000,000 m^3	20,000 m^3/y	870 mm/y	650 mm/y actual?
France, La Manche	Closed	Near Surface: tumulus and concrete vault/monolith	525,000 m^3		1000 mm/y	630 mm/y actual?
Germany, Morsleben	Operating	Salt Mine (500 m)	40,000 m^3		~ 600 mm/y	
Japan, Rokkasho	Operating	Near Surface: below ground monolith	40,000 m^3		1200 mm/y	
Norway, Himdalen	Construction	Rock Cavern	2,000 m^3		~ 700 mm/y	
S Africa, Vaalputs	Operating	Near Surface: simple & concrete canister		800 m^3/y	74 mm/y	
Slovak, Mochovce	Operating	Near Surface: concrete trench	220,000 m^3		~ 500 mm/y	
Spain, El Cabril	Operating	Near Surface concrete vault/monolith	50,000 m^3	3,000 m^3/y	452 mm/y	1800 mm/y (pan)
Sweden, SFR Forsmark	Operating	Excavated Rock Cavity	60,000 m^3	2,500 m^3/y	~ 550 mm/y	
UK, Drigg	Operating	Near Surface: below ground concrete vault	1,000,000 m^3	6,000 m^3/y	~ 1000 mm/y	
USA, Barnwell (commercial site)	Operating	Near Surface	800,000 m^3 [720,000 m^3 cum thru 1994]	20,800 m^3 (1994)	1200 mm/y	~ 1600 mm/y (pan)
USA, Beatty (commercial site)	Closed	Near Surface	137,000 m^3 (cum thru 1992)		100-125 mm/y	~ 2000 mm/y (pan)
USA, Hudspeth, Texas	Proposed	Near Surface: modular concrete canisters			300 mm/y	~ 2600 mm/y (pan)
USA, Nevada Test Site (DOE site)	Operating	Near Surface:	481,000 m^3 (cum thru 1994)	22,900 m^3 (1994)	100 mm/y	~ 2000 mm/y (pan)
USA, Pennsylvania	Proposed	Near Surface Tumulus		6,700 m^3/y	~ 800 mm/y	~ 1200 mm/y (pan)
USA, Richland (commercial site)	Operating	Near Surface	1,500,000 m^3 [358,000 m^3 cum thru 1994]	3,500 m^3 (1994)	150-200 mm/y	~ 1400 mm/y (pan)
USA, Savannah River (DOE site)	Operating	Near Surface	676,000 m^3 (cum thru 1994)	11,400 m^3 (1994)	1200 mm/y	~ 1400 mm/y
USA, Hanford (DOE site)	Operating	Near Surface	615,000 m^3 (cum thru 1994)	13,700 m^3 (1994)	150-200 mm/y	~ 1400 mm/y
USA, Ward Valley	Proposed	Near Surface	300,000 m^3		130 mm/y	2500 mm/y