Submission
No 213

Submission to the Joint Select Committee on the Transportation and Storage of Nuclear Waste
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This submission is presented under the following headings:

1. **General**
2. **Why are we having this Inquiry?**
3. **Regulations governing transport and storage.**
4. **Transport of LLW and ILW : What is involved?**
5. **The physical condition of radioactive wastes will minimise the effects of accidental exposures to the wastes during both transport and storage.**
6. **The Transportation Record**
7. **Location of the ILW Store**
8. **Terrorist Attacks and "Dirty" Bombs**
9. **Radioactive wastes must be seen in perspective.**
10. **Postscript**

Abbreviations used:

ANSTO	Australian Nuclear Science and Technology Organisation
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
DWMF	Dedicated waste management facility
GSR	Greater Sydney Region, embracing Inner Sydney, Macarthur, Northern Sydney, Southern Sydney, Western Sydney, Central Coast, Hunter, and Illawarra.
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste. Waste containing intermediate levels of radioactivity classified as unsuitable for disposal but requiring on-going storage until

radioactivity levels permit controlled disposal. For full and quantitative definition see reference 1.

ILWS	Intermediate level waste store; the national store proposed by the Federal Government.
LLW	Low level waste. Waste low in radioactivity, herein considered as any wastes classified as suitable for disposal by near surface burial and hence, disposal in the National Waste Repository. For full and quantitative definition see reference 1.
Radwaste	Waste material that is radioactive
UIC	Uranium Information Centre

1. General

1.a The **need to transport wastes** from urban areas to waste management facilities is perceived by some, and promoted by others, as involving risks that are so great as to over-ride the positive gains (see below), from dedicated waste management facilities (DWMFs). **Members of the Select Committee must decide is whether this is -**

- truthfully so, or
- an uninformed and unsubstantiated concern held by the public (and promoted by opponents to the proposed DWMFs), or
- an avenue towards reaching a political objective of restricting nuclear activities in Australia, particularly prevention of operating nuclear reactors in this country.

This submission makes no explicit recommendations but **attempts to put realistic perspectives on the issues of storage and transport** to assist the committee to make a truly **objective** judgement.

The submission in no way expresses support for the construction of a replacement reactor at ANSTO's establishment at Lucas Heights but strongly opposes the use of this inquiry as a covert means of preventing its construction which, in the process, could subvert the proper management of radwastes that already exist and will continue to arise even if the reactor is not completed.

1b. Radioactive wastes, both LLW and ILW, already exist in Australia. LLWs are currently stored in over 100 locations spread through all states and territories. Most ILWs are stored at the ANSTO site at Lucas Heights about 1.6 km from the residential suburb of Engadine.

1c. Positive factors in establishing stores and repositories in dry remote locations, whether they be federal or state operated, are:

- Wastes will be removed from within and near to inhabited communities to remote areas where contamination accidents, if any, will have much reduced, if not negligible impact on residential and industrial communities, and clean-up operations will be more simply effected.
- The proliferation of long term storage sites will be avoided.
- Hundreds of users of radioactive materials will be relieved of the on-going responsibility of safeguarding their wastes.

- The bureaucratic policing and control of waste management will be concentrated in two centres (if federal) or a handful of centres (if state).

2. Why are we having this Inquiry?

The underlying reason for this inquiry is that the public has been led to fear ionising radiation and to believe that even very small levels of radiation are dangerous. Real life experience has shown that this is quite incorrect, and that when due care is taken, even higher radiation doses can be managed safely.

2.a Managing Accidental Exposures:

Radiation exposures **can** be handled safely, even in accident conditions. In the case of waste handling and transport, should accidental release of waste items occur and exposure to radiation intensities higher than the legislated safe levels occurs, **conditions can be made safe by teamwork management** which will keep radiation doses to recovery workers and public at safe levels. This would be the case both on the road/rail during transport and in ILW store operations.

It has been a successful practice over the last 40-50 years of dealing with radioactivity, that the safety of radiation workers can be ensured by limiting the dose they receive (as opposed to the radiation intensity to which they are exposed), by limiting their time of exposure so that the actual radiation dose (intensity multiplied by exposure time), does not exceed safe limits. Furthermore, the physical form of the wastes – all massive solids as opposed to powders, liquids and gases, (see section 4 and tables A3 and A4) – ensures that items released in an accident can be quickly and totally recovered without significant contamination of the surroundings.

2.b Are small radiation doses really harmful?

Some people argue that all radiation doses to the human body are harmful no matter how small the dose. This has been one of the cornerstone arguments used by anti-nuclear groups in promoting fear among the public that even very small levels of radiation are dangerous. The concept has been a contentious issue because

- the real effects at low doses are extremely hard to observe and measure and,
- many practical examples strongly suggest that low doses are easily tolerated by the human body and that there must be a threshold above which radiation exposures do become harmful *, and
- low doses to some organisms have been observed to have beneficial rather than harmful effects.

The low-dose beneficial effects are a phenomenon known as "hormesis", an effect which is known to occur with numerous other hazardous and toxic compounds. An explanation of the hormesis **dose-effect relationship** was published in the prestigious scientific journal "Nature" in early 2003 [7] and drew media publicity and comment in the scientific press [9,10] but no contentious comment. It supports the concept of a threshold dose (below which biological effects cannot be distinguished from the raft of other effects to which humans are subjected), and it weakens the argument of anti-nuclear groups who claim that all levels of radiation are harmful. A comment on this study from the Australian National University is given in Appendix 4 [8].

Over the past 40-50 years nuclear industry workers have been permitted to work continuously in areas where radiation levels can be consistently and significantly above the normal background level. Several studies of these groups have been done but none have shown that the groups exhibit an incidence of radiation effects greater than that in the normal population. In fact, Cameron [11], in his review of the study on American nuclear shipyard workers, has observed that *" the . . . results are in general agreement with reductions in overall mortality from other studies of workers in nuclear facilities and radiology practice in the United States, United Kingdom, Canada, and Australia (Smith and Doll 1981; Smith and Douglas 1986; Fraser et al. 1993; Gilbert et al. 1993; Luckey 1994, 1997; Boice et al. 1995; Rodriguez et al. 1997; Doody et al. 1998; Berrington et al. 2001; Sont et al. 2001; Habib 2002). Most of these studies also demonstrated reductions in all-cancer mortality of the radiation workers."*

3. Regulations governing transport and storage.

All transport and storage of radioactive wastes in Australia must be undertaken according to regulations promulgated, and enforced through licensing, by ARPANSA in agreement with relevant codes of practice. The codes covering disposal of LLW [1] and transport of radioactive materials [2] are already gazetted but the *Code of Practice for the Pre-disposal Management of Radioactive Waste* [3] is still under development by ARPANSA. Since this code will set out requirements on the physical condition and packaging of wastes for both transport and storage, particularly for ILW, it may not be possible to address completely all matters within the terms of reference of this inquiry. Pending the completion of this code, it should be expected that it will be based on, and embody best current international practice but, until such a code of practice is available **it could be argued that this inquiry is premature.**

The codes are (and the new code can be expected to be equally so), extremely comprehensive and explicit and leave no scope for error on the part of competent and responsible operators. The licensing procedures required by the codes maximise the likelihood that competent operators will be appointed, and the actions of the operators will be under the constant scrutiny of ARPANSA.

4. Transport of LLW and ILW : What is involved?

The following paragraphs of this section are copied from a briefing paper from the Uranium Information Centre (UIC) [6] and give a good summary of what has been the practice for the past forty or so years in overseas countries where quantities of LLW and ILW are far greater than in Australia. (The full document is available at *http://www.uic.com.au/nip51.htm.* and a partial copy, with less relevant sections deleted to conserve space, is included here as Appendix 3.)

> "Low-level and intermediate-level wastes (LLW and ILW) are generated throughout the nuclear fuel cycle. The transport of these wastes is commonplace and they are safely transported to waste treatment facilities and storage sites.
>
> "Low-level radioactive wastes are a variety of materials that emit low levels of radiation, slightly above normal background levels. They often consist of solid materials, such as clothing, tools, or contaminated soil. Low-level waste is transported from its origin to waste treatment sites, or to an intermediate or final storage facility.
>
> "A variety of radionuclides give low-level waste its radioactive character. However, the radiation levels from these materials are very low and the packaging used for the transport of low-level waste does not require special shielding.
>
> "Low-level wastes are moved by road, rail, and internationally, by sea. However, most low-level waste is only transported within the country where it is produced.
>
> "Low-level wastes are transported in drums, often after being compacted in order to reduce the total volume of waste. The drums commonly used contain up to 200 litres of material. Typically, 36 standard, 200 litre drums go into a 6-metre transport container.
>
> "The composition of intermediate-level wastes is broad. Much of it comes from nuclear power plants and reprocessing facilities.
>
> "Intermediate-level wastes are taken from their source to an interim storage site, a final storage site (as in Sweden), or a waste treatment facility. They are transported by road, rail and sea.
>
> "The radioactivity level of intermediate-level waste is higher than low-level waste. The classification of radioactive wastes is decided for disposal purposes, not on transport grounds. The transport aspects of intermediate-level waste take into account any specific properties of the material."

5. The physical condition of radioactive wastes will minimise the effects of accidental exposures to the wastes during both transport and storage.

The nature of LLW and ILW wastes are shown in Tables A3 and A4 in Appendix 2. Table A3 shows clearly that **all the constituents are solids** and, apart from the ANSTO wastes, comprise items that were in widespread use within the community and industry when they would have been more radioactive than they are as waste. The LLW from ANSTO comprises common items that were in use in laboratories specially declared as radiation areas where (as is common in all countries), paper towels, discarded protective clothing and equipment etc. are declared as radioactive wastes **even though they may not be contaminated and may not be radioactive at all. Furthermore, much of the material originally classified as radioactive is medical radioisotopes which decay rapidly and will no longer be radioactive under the definition of a radioactive substance.**

At Lucas Heights, ANSTO has an on-going program for solidifying liquid ILW resulting from radioisotope production and is preparing a process plant to immobilise these solid wastes for long-term storage [5].

Hence, in the event of accident in handling or transport, liquid radioactive materials will not be released. The fact that all wastes are, and will be, in solid form means that accidental breaching of containments during handling and transport, should that occur, will expose or release solid materials only. This will greatly facilitate recovery and clean-up actions. This situation should be compared to the handling and transport of non-radioactive poisonous and hazardous materials such as liquid pesticides, chlorine, explosives, petroleum, oil, combustible gases, etc., which are transported routinely on our road and rail systems.

It is relevant also to view this situation in the light of the daily transportation of radioactive sources, many of which are in liquid form, occurring by road, rail and air. (Although the volumes of liquid sources are very small, they are highly radioactive). See the following paragraph.

6. The Transportation Record

The transportation of radioactive materials has an excellent safety record and gives enormous confidence in the ability of society to handle such operations both technically, administratively, securely, and safely. About 30,000 shipments of radioisotopes are made within Australia each year.

The briefing paper from the Uranium Information Centre (UIC) referred to in Section 4 above, gives an excellent and factual summary of the history of the transport of radioactive materials. Its opening summary is as follows:

- **About twenty million* packages of all sizes containing radioactive materials are routinely transported worldwide annually on public roads, railways and ships.**
- **These use robust and secure containers. At sea, they are generally carried in purpose-built ships.**
- **Since 1971 there have been more than 20 000 shipments of spent fuel and high-level wastes (over 50 000 tonnes) over more than 30 million kilometres.**
- **There has never been any accident in which a container with highly radioactive material has been breached, or has leaked.**

(* The IAEA estimate is "over ten million" per annum [12], but half a very large number is still a very large number)

7. Location of the ILW Store

Intermediate level waste is currently produced and stored within New South Wales and further production will occur in NSW. If attempts by opposition groups succeeded in preventing construction of the ILWS, existing and future waste would remain in NSW. In such case, a choice would have to be made whether to keep the material in is present location adjacent to residential suburbs or move it to a state operated store in a more remote location (see section 1.c above).

Regardless of the eventual outcome of the store issue, each state and territory has a moral obligation to be responsible for an amount of the ILW in proportion to the amount of radioactive materials used within and to the benefit of that state, its industries, and its residents.

8. Terrorist Attacks and "Dirty" Bombs

Security in this age of terrorist threat is likely to be seen as a major concern.

Terrorist attack would be directed either at stealing radioactive material for use in dirty bomb manufacture or at causing the dispersion of radioactivity into the air by conventional explosion at a storage facility or transport vehicle. Both cases fall within the definition of a "dirty bomb" (see section 7.c below on the real effects of dirty bombs)

8.a Theft of material

In the case of wastes, the preferred target would be ILW but radioactive material cannot be transported without shielding to protect the carriers, and in general terms, the greater the radioactivity, the greater the amount of shielding required and the more difficult carriage becomes.

For maximum bomb effect and ease of carriage, theft would be targeted on material of high specific activity (reduction of bulk), making disused sources a high priority. These, however, would be low in activity, and possibly less accessible, compared to sources still in use in industrial plants (for radiography, level measurement, etc.), and hence, probably less attractive targets.

Perceptions on the ease of theft and carriage are probably greatly exaggerated as a consequence of incorrect press reporting of a recent incident in Thailand where a traveller was apprehended carrying a *reported* 32 kg of caesium-137 (Cs-137) in a suitcase. This is an impossible amount to carry in a suitcase as the amount of lead shielding required would be enormous. It is probable that the item was, in fact, a source of 32 gigabequerels, a typical size for a Cs-137 industrial source which, coincidentally, would, weigh about 32 kg with its packaging and shielding,

8.b Bomb attack on a waste store

Owing to the amount of material held in a store, a bomb attack or explosion at the store has potential to release far more radioactivity than a dirty bomb.

The effect of such an attack would depend on the location of a store and its proximity to habitation, industrial areas, or farmland. Bearing in mind that the bulk of ILW in Australia is currently held at ANSTO about 1.5 km from Sydney's southern suburbs, an attack there would have greater impact both psychologically and in contamination effects, than on an ILW store in a remote area.

Farmland adjacent to the store could, of course, be contaminated by such an attack but population density would be low and crops and livestock could be immediately isolated and monitored until assessed as safe.

In the current climate of terrorism, it is clearly preferable to store ILW away from urban areas.

8.c Is a dirty bomb really an effective terrorist weapon?

This question is effectively answered in the negative by the Australian Radiation Protection Society (an association of professionals who have studied, and qualified in, the nature and effects of radiation and the theory and design of safety measures) in a paper [9] reproduced here as Appendix 5.

The conclusion of these experts is that "*the health impacts of (the) airborne radioactive dust can easily be shown to be minor . . . (and) . . . are doses similar to those incurred in medical CT scans or in nuclear medicine procedures.*"

9. (Revised) Radioactive wastes must be seen in perspective.

The logistics of transport and storage/disposal of radioactive wastes are minute when compared to those of non-radioactive domestic and industrial waste management. In **volume and weight terms the quantities of radioactive wastes for the whole of Australia are trivial** relative to those of non-radioactive wastes for the Greater Sydney Region (GSR) alone, see Appendix 1 (revised 26 August 2003).

If the comparison was made against non-radioactive waste for the whole of Australia rather than just the GSR, the ratio would be smaller by a factor of ten or more. The figures show that in **volume and weight terms** the quantities of radioactive wastes for the whole of Australia are about **one two-hundred-and-sixty-thousandth; 1/260,000** (see Appendix 1 Revised).

It follows directly that the number of transport vehicles, the number of transport operations, and the size of storage and disposal facilities, etc., will also be trivial in comparison with those required for non-radioactive waste management. Hence, the demands on land acquisition and on existing road and/or rail systems will be minimal. In volume terms this will remain true despite the additional packaging and radiation shielding measures required for ILL because their volumes will also be minimal.

The factor of **1/260,000** is an extremely large one. Taking into account all the technical factors of waste transport and disposal/storage, road/rail accidents, release to the environment of toxic materials (poisons, heavy metals, decay products, methane etc.), and the like, the committee must consider the following question and come to an objective conclusion based on technical factors rather than a subjective one deriving from political factors and/or unsubstantiated perceptions.

Bearing in mind that potential hazards are, inter alia, proportional to quantity, one must ask **are the real (not the perceived) hazards associated with the radioactivity in the small quantity of ILL (and LLW) held and to be generated in Australia, sufficient in reality to make the transport and storage of ILW (and LLW) a problem equal to or greater in magnitude than that of the transport and disposal of the nation's non-radioactive wastes?**

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10. Postscript

Each year in Australia, about 21,500* tonnes of tobacco are discharged into the air as carcinogen-bearing smoke [10].

(* The tonnage is for 1997. In subsequent years quantities were given in units rather than weight).

References:

1. *Code of Practice for Near Surface Disposal of Radioactive Waste in Australia (1992),* ARPANSA Radiation Health Series No.35,
2. *Code of Practice (for the) Safe transport of Radioactive Material (2001),* ARPANSA Radiation Protection Series No.2.
3. *Code of Practice for the Pre-disposal Management of Radioactive Waste, ARPANSA* in preparation
4. *Radioactive Waste Management in Australia,* Department of Science Education and Training (http://www.dest.gov.au/radwaste/default.htm)
5. ANSTO Annual Report 2002.
6. *Transport of Radioactive Materials,* Nuclear Issues Briefing Paper No. 51, Uranium Information Centre, February 2002
7. *Toxicology rethinks its central belief,* Calabrese, E.J. & Baldwin, L.A.. *Nature*, 421, 691 - 321, (2003).
8. National Research Centre for occupational Health and Safety Regulation, ANU, Canberra, Vol.2 Issue 1, March 2003 (http://www.nature.com/cgitaf/DynaPage.taf?file=/nature/journal/v421/n6924/full/421691a_fs.html.
9. *Statement on Potential Impacts of "Dirty Bombs",* Press Release, Australasian Radiation Protection Society, July 10 2002
10. Article on smoking in Australia, the Quit Organisation, 2002 http://www.quit.org.au/quit/FandI/fandi/c02.htm
11. *Nuclear Shipyard Workers Study (1980-88): A large cohort exposed to dose-rate gamma radiation,* R Sponsler and J.R. Cameron, Depts. of Medical Physics and Radiology and Physics, University of Wisconsin-Madison, http://www.medphysics.wisc.edu/~jrc/

12. *Nuclear Transport Fact File,* World Nuclear Transport Institute, http://www.wnti.co.uk/pages/faq.html

Appendix 1 (Revised): Comparison of LLW and ILW with non-radioactive waste quantities

Table A1. Quantities of radioactive wastes currently held in storage in Australia [4]

	LLW		ILW	
	Volume	Weight*	Volume	Weight*
Volume now held in storage	3200 m^3	8750 Te	500 m^3 #	1250 Te

* Estimated assuming a (compacted) density of 1.5 tonne/ m^3 (greater than water and sand but less than rock)

\# 35 m^3 of this is currently stored in the Woomera Prohibited Area.

Table A2. Comparison of projected annual rates of production of radioactive and non-radioactive wastes

	Projected annual production rates					
	LLW		ILW		Non-radioactive waste, from Greater Sydney Region #	
	Volume	Weight*	Volume	Weight*	Volume*	Weight
2000-2005	50 m^3	75 Te	2.5 m^3	4 Te	3,350,286 m^3	5,025,430 Te
After 2005	(50 m^3)	(75 Te)	4 m^3	6 Te	<3,350,000 m^3	<5,000,000 Te

* Estimated assuming a (compacted) density of 1.5 tonne/ m^3 (see footnote to Table A1)

Compared to the volume of household garbage and industrial wastes produced in Australia, the volume of ILW produced per annum (see Appendix 2) is extremely small. For the period 2000-2005, the ratio

$$\frac{\text{total volume of radioactive waste produced per annum in Australia (Table A2, 2000-2005)}}{\text{volume of domestic and industrial waste produced per annum in the Greater Sydney Region}}$$

$$= \frac{50 + 2.5}{3,350,286} = \frac{1}{63815}$$ = 0.000016 for the Greater Sydney Region alone.

For the whole of Australia (which will feed to the proposed national DWMFs), the volume of non-radwaste would be over four times greater (based on population), than for the GSR and the value of the **ratio would reduce to 0.0000038 (or, one two-hundred-and-sixty-thousandth; 1/260,000).**

* This ratio is based on 1996 data for non-radwastes and its value would be higher if waste reduction measures have been effective since then in the domestic and industrial area.
But even a 90 per cent reduction (inconceivable), would not greatly alter the implication in this comparison.

\# Source: NSW Waste Boards (1998)

Appendix 2: Quantities and types of materials requiring disposal/storage

Table A 3. Nature (with quantities) of LLW wastes currently stored in Australia [4]

Source	**Typical Waste**	**Estimated Current Volume (m^3)**	**Estimated Annual generation (m^3)**
ANSTO	Contaminated clothing, paper and glassware *	1080	30
State/Territories	Industrial gauges, exit signs, smoke detectors, medical sources, hospital waste including clothing, paper, glassware	100	5-10
CSIRO	Contaminated soil from research into treatment of radioactive ores 40 years ago *	1950	-
Defence	Electron tubes, radium painted watches, compasses, sealed sources	60	<5
Other Commonwealth Agencies	Used sources	10	-
Totals		3200	40 – 50

* These two categories attract the greatest attention because of their volumes but are, in fact, the least radioactive.

Table A4. Nature (with quantities) of ILW wastes currently stored in Australia [4]

Source	**Typical Waste**	**Estimated Volume (m^3)**
ANSTO-radioisotope production, reactor operation and research	Target cans, alumina columns, used control arms, aluminium end pieces, solidified liquid waste.	205
Historical waste from industry	Thorium and uranium residues from mineral sands processing	165
State/Territories	Used sources from medical, industrial and research equipment #	100
Other Commonwealth Agencies	Used sources from medical and research equipment #	35
Totals		505

Used sources are disposed of with their shielding which will be part of the estinmated volume and not, itself, radioactive.

Appendix 3: Transport of Radioactive Materials

Nuclear Issues Briefing Paper # 51, February 2002

Note: To reduce the material bulk of this submission the text, but not the headings, of certain sections of this paper have been deleted. The full document can be viewed on the internet at http://www.uic.com.au/nip51.htm

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- **About twenty million packages of all sizes containing radioactive materials are routinely transported worldwide annually on public roads, railways and ships.**
- **These use robust and secure containers. At sea, they are generally carried in purpose-built ships.**
- **Since 1971 there have been more than 20 000 shipments of spent fuel and high-level wastes (over 50 000 tonnes) over more than 30 million kilometres.**
- **There has never been any accident in which a container with highly radioactive material has been breached, or has leaked.**

About 20 million transports of radioactive material (which may be either a single package or a number of packages sent from one location to another at the same time) take place around the world each year. Radioactive material is not unique to the nuclear fuel cycle and most transports of such material are not fuel cycle related. Radioactive materials are used extensively in medicine, agriculture, research, manufacturing, non-destructive testing and minerals' exploration.

The regulatory control of shipments of radioactive material is independent of its intended application and the same safety procedures are employed, whatever the intended end-use.

Nuclear fuel cycle facilities are located in various parts of the world and materials of many kinds need to be transported between them. Many of these are similar to materials used in other industrial activities. However, the nuclear industry's fuel and waste materials are radioactive, and it is these 'nuclear materials' about which there is most public concern.

Nuclear materials have been transported since before the advent of nuclear power over forty years ago. The procedures employed are designed to ensure the protection of the public and the environment. For the generation of a given quantity of electricity, the amount of nuclear fuel required is very much smaller than the amount of all other fuel. Therefore, the conventional risks and environmental impacts associated with fuel transport are greatly reduced with nuclear power.

Materials being transported

Transport is an integral part of the nuclear fuel cycle. There are some 430 nuclear power reactors in operation in 32 countries but uranium mining is viable in only a few areas. Furthermore, in the course of over forty years of operation by the nuclear industry, a number of specialised facilities have been developed in various locations around the world to provide fuel cycle services. It is clear that there is a need to transport nuclear fuel cycle materials to and from these facilities. Indeed, most of the material used in nuclear fuel is transported several times during its 'life'. Transports are frequently international, and are often over large distances. Nuclear materials are generally transported by specialised transport companies.

The term 'transport' is used in this document only to refer to the movement of material between facilities, i.e. through areas outside such facilities. Most transports of nuclear fuel material occur between different stages of the cycle, but occasionally a material may be transported between similar facilities. When the stages are directly linked (such as mining and milling), it is sometimes advantageous to construct facilities for the different stages on the same site and no transport is then required.

With very few exceptions, nuclear fuel cycle materials are transported in solid form. The following table (deleted for this submission), shows the principal nuclear material transport activities:

Although some waste disposal facilities are located adjacent to the facilities that they serve, utilising one disposal site to manage the wastes from several facilities usually reduces environmental impacts. When this is the case, transport of the wastes from the facilities to the disposal site will be required.

Packaging

The principal assurance of safety in the transport of nuclear materials is the design of the packaging, which must allow for foreseeable accidents. The consignor bears primary responsibility for this. Many different nuclear materials are transported and the degree of potential hazard from these materials varies considerably. Different packaging standards have been developed to recognise that increased potential hazard calls for increased protection.

'Type A' packages are designed to withstand minor accidents and are used for medium-activity materials such as medical or industrial radioisotopes. Ordinary industrial containers are used for low-activity material such as U_3O_8.

Packages for high-level waste (HLW) and spent fuel are robust and very secure containers are known as 'Type B' packages. They also maintain shielding from gamma and neutron radiation, even under extreme conditions. There are over 150 kinds of Type B packages, and the larger ones cost some US$1.6 million each.

In France alone, there are some 750 shipments each year of Type B packages, among 15 million shipments classified as 'dangerous materials', 300 000 of these being radioactive materials of some kind.

Smaller amounts of high-activity materials (including plutonium) transported by aircraft will be in 'Type C' packages, which give greater protection in all respects than Type B packages in accident scenarios.

Radiation protection

Since nuclear materials are radioactive, it is important to ensure that radiation exposure of both those involved in the transport of such materials and the general public along transport routes is limited. Packaging for nuclear materials includes, where appropriate, shielding to reduce potential radiation exposures. In the case of some materials, such as fresh uranium fuel assemblies, the radiation levels are negligible and no shielding is required. Other materials, such as spent fuel and high-level waste, are highly radioactive and purpose-designed containers with integral shielding are used. To limit the risk in handling of highly radioactive materials, dual-purpose containers (casks), which are appropriate for both storage and transport of spent nuclear fuel, are often used.

As with other hazardous materials being transported, packages of nuclear materials are labelled in accordance with the requirements of national and international regulations. These labels not only indicate that the material is radioactive, by including a radiation symbol, but also give an indication of the radiation field in the vicinity of the package.

Personnel directly involved in the transport of nuclear materials are trained to take appropriate precautions and to respond in case of an emergency.

Environmental protection

Packages used for the transport of nuclear materials are designed to retain their integrity during the various conditions that may be encountered while they are being transported and to ensure that an accident will not have any major consequences. Conditions which packages are tested to withstand include: fire, impact, wetting, pressure, heat and cold. Packages of radioactive material are checked prior to shipping and, when it is found to be necessary, cleaned to remove contamination.

Although not required by transport regulations, the nuclear industry chooses to undertake some shipments of nuclear material using dedicated, purpose-built transport vehicles or vessels.

Regulation of transport

Since 1961 the International Atomic Energy Agency (IAEA) has published advisory regulations for the safe transport of radioactive material. These regulations have come to be recognised throughout the world as the uniform basis for both national and international transport safety requirements in this area. Requirements based on the IAEA regulations have been adopted in about 60 countries, as well as by the International Civil Aviation Organisation (ICAO), the International Maritime Organisation (IMO), and regional transport organisations.

The IAEA has regularly issued revisions to the transport regulations in order to keep them up to date. The main publication on which other IAEA transport regulations are based is Safety Series No. ST-l, Regulations for the Safe Transport of Radioactive Material.

The objective of the regulations is to protect people and the environment from the effects of radiation during the transport of radioactive material.

Protection is achieved by:

- containment of radioactive contents;
- control of external radiation levels;
- prevention of criticality; and
- prevention of damage caused by heat.

The fundamental principle applied to the transport of radioactive material is that the protection comes from the design of the package, regardless of how the material is transported.

Transport of uranium fuel assemblies

Uranium fuel assemblies are manufactured at fuel fabrication plants. The fuel assemblies are made up of ceramic pellets formed from pressed uranium oxide that has been sintered at a high temperature (over 1400°C). The pellets are aligned within long, hollow, metal rods, which in turn are arranged in the fuel assemblies, ready for introduction into the reactor. Different types of reactors require different types of fuel assembly, so when the fuel assemblies are transported from the fuel fabrication facility (where they are manufactured) to the nuclear power reactor, the contents of the shipment will vary with the type of reactor receiving it.

In Western Europe, Asia and the US, the most common means of transporting uranium fuel assemblies is by truck. A typical truckload supplying a light water reactor contains 6 tonnes of fuel. In the countries of the former Soviet Union, rail transport is most often used. Intercontinental transports are mostly by sea, though occasionally transport is by air.

The annual operation of a 1000 MWe light water reactor requires an average fuel load of 27 tonnes of uranium dioxide, containing 24 tonnes of enriched uranium. The assemblies containing this are normally supplied in one consignment occupying 4 to 5 trucks.

The fuel assemblies are transported in packages specially constructed to protect the precision-made fuel assemblies from damage during transport. Uranium fuel assemblies have a low radioactivity level and radiation shielding is not necessary.

Fuel assemblies contain fissile material and in some circumstances fissile material can spontaneously become critical, i.e. start a self-sustaining, nuclear chain reaction, releasing energy. Criticality is prevented by the design of the package, the arrangement of the fuel assemblies within the package, limitations on the amount of material contained within the package, and on the number of packages carried in one shipment.

Transport of LLW and ILW

Low-level and intermediate-level wastes (LLW and ILW) are generated throughout the nuclear fuel cycle. The transport of these wastes is commonplace and they are safely transported to waste treatment facilities and storage sites.

Low-level radioactive wastes are a variety of materials that emit low levels of radiation, slightly above normal background levels. They often consist of solid materials, such as clothing, tools, or contaminated soil. Low-level waste is transported from its origin to waste treatment sites, or to an intermediate or final storage facility.

A variety of radionuclides give low-level waste its radioactive character. However, the radiation levels from these materials are very low and the packaging used for the transport of low-level waste does not require special shielding.

Low-level wastes are moved by road, rail, and internationally, by sea. However, most low-level waste is only transported within the country where it is produced.

Low-level wastes are transported in drums, often after being compacted in order to reduce the total volume of waste. The drums commonly used contain up to 200 litres of material. Typically, 36 standard, 200 litre drums go into a 6-metre transport container.

The composition of intermediate-level wastes is broad. Much of it comes from nuclear power plants and reprocessing facilities.

Intermediate-level wastes are taken from their source to an interim storage site, a final storage site (as in Sweden), or a waste treatment facility. They are transported by road, rail and sea.

The radioactivity level of intermediate-level waste is higher than low-level waste. The classification of radioactive wastes is decided for disposal purposes, not on transport grounds. The transport aspects of intermediate-level waste take into account any specific properties of the material.

Transport of spent fuel

When spent fuel is unloaded from a nuclear power reactor, it contains: 96% uranium, 1% plutonium and 3% of fission products (from the nuclear reaction) and transuranics).

Spent fuel looks the same as fresh fuel but when the fuel assembly is removed from a reactor it will be emitting high levels of both radiation and heat. It is stored in water pools adjacent to the reactor to allow the initial heat and radiation levels to decrease. Typically, spent fuel is stored for at least five months before it can be transported, although it may be stored there long-term.

From the reactor site, spent fuel is transported by road, rail or sea to either an interim storage site or a reprocessing plant where it will be reprocessed.

Spent fuel assemblies are shipped in Type B casks. These casks are shielded with steel, or a combination of steel and lead, and can weigh up to 110 tonnes each when empty. A typical transport cask holds up to 6 tonnes of spent fuel.

Since 1971 there have been some 7000 shipments of spent fuel (over 35 000 tonnes) over more than 30 million kilometres with no property damage or personal injury, no breach of containment, and very low dose rate to the personnel involved (e.g. 0.33 mSv/yr per operator at La Hague).

In the USA alone, one percent of the 300 million packages of hazardous material shipped each year contain radioactive materials. Of this, about 250,000 contain radioactive wastes from US nuclear power plants, and 25 to 100 packages contain spent fuel. Most of these are in robust 125-tonne Type B casks carried by rail, each containing 20 tonnes of spent fuel.

Transport of plutonium

Deleted

Transport of vitrified waste

Deleted

Sea shipments of wastes

Deleted

Accident scenarios

There has never been any accident in which a Type B transport cask containing radioactive materials has been breached or has leaked.

For the radioactive material in a large Type B package in sea transit to become exposed, the ship's hold (inside double hulls) would need to rupture, the 25 cm thick steel cask would need to rupture, and the stainless steel flask or the fuel rods would need to be broken open. Either borosilicate glass (for reprocessed wastes) or ceramic fuel material would then be exposed, but in either case these materials are very insoluble.

The transport ships are designed to withstand a side-on collision with a large oil tanker. If the ship did sink, the casks will remain sound for many years and would be relatively easy to recover since instrumentation including location beacons would activate and monitor the casks.

Sources:
BNFL, Cogema, JNFL, SKB and ANSTO publications and papers.

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Appendix 4: "Toxicology rethinks its central belief"

National Research Centre for occupational Health and Safety Regulation,
ANU, Canberra
Vol.2 Issue 1, March 2003

Re: E Calabrese and L Baldwin , "Toxicology rethinks its central belief", Nature **421**, p691-692, 13 February 2003

Regulatory agencies for OHS, environment, public health and other areas base their decisions and policies on toxicological predictions applying a dose-response model to extrapolate and predict responses to chemical substances, pharmaceutical's and other physical agents. After reviewing a wide range of toxicological experiments, Calabrese and Baldwin identified up to 5,000 examples of an alternative "hormetic response". They argue that a radical rethink is required of the traditional basis for toxicological risk assessment applying a model of hormesis. If accepted, this approach would have wide ranging implications for standard setting for chemical and other agents. Their commentary can be read at http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v421/n6924/full/421691a_fs.html.

Appendix 5: Statement on Potential Impacts of "Dirty Bombs"

AUSTRALASIAN RADIATION PROTECTION SOCIETY

PRESS RELEASE July 10 2002

Statement on Potential Impacts of "Dirty Bombs"

The threat of use by terrorists of 'dirty bombs' or 'radiological weapons' has been the subject of some news media speculation.

The threat presented is that a stolen radioactive source could be dispersed by an explosive device in a building or in the Central Business District of a city, thereby causing major disruption, potential health consequences, and public panic.

Several media portrayals, including some in popular science magazines which purport to give accurate information, are seriously lacking in balance inasmuch as they fail to point out the demonstrably low level of immediate health risk, apart from the direct effects of the blast, which such an attack would present.

This Statement is intended to give information to enable a more complete and more balanced assessment of the health risks, and a realistic appreciation of the decontamination task.

Radioactive material used in a "dirty bomb" would most likely to be obtained by theft of a medical or industrial source. The source might be, for example, an iridium-192 source used in industrial radiography for gamma-ray weld testing of pipelines or pressure vessels. These sources generally contain a quantity (or 'activity') of radioactive Iridium of something like a few thousand gigabecquerels. An alternative potential source might be an industrial gauge containing possibly up to 20 gigabecquerels of caesium-137. *

In both these cases, the source would need to be removed from its lead shield and wrapped with explosive, and the constructor would receive a substantial but not incapacitating nor lethal dose during the assembly.

The detonation of such a device in a crowded shopping mall, office block or railway station would produce damage and injuries from the blast, and would spread radioactive material as dust in the air and on surfaces.

However, the health impacts of this airborne radioactive dust can easily be shown to be minor. Using activity-to-dose factors from publications of the International Commission on Radiological Protection (ICRP) or from the International Atomic Energy Agency's Basic Safety Standards and reasonable estimates of the volume into which the radioactive dust gets distributed, the dose received from inhalation of the dust can be calculated. Over a period of an hour, and assuming both that the dispersed radioactive material is all of respirable size and that it remains suspended during this time, the dose generally will be no more than 10 to 50 millisieverts, for these scenarios.

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*Sources of up to 30 GBq are, in fact, used (G L Hanna)

These are doses similar to those incurred in medical CT scans or in nuclear medicine procedures.

The total gamma radiation dose to someone evacuating the area, from dust which has fallen out on surfaces, can be shown to be negligible in comparison with the already low doses discussed above, incurred from inhalation.

The implication of this is that emergency response personnel involved in lifesaving actions or in firefighting can freely enter such areas without specific attention to respiratory protection. Trapped victims will not incur life threatening radiation doses while awaiting rescue. [Emergency response workers may be allowed to receive doses up to 500 mSv if saving lives (NHMRC Radiation Health Series No. 32)].

And even the simplest respiratory protection, such as breathing through a moistened doubled handkerchief, will reduce the dose further.

After exiting a contaminated area, decontamination of skin and clothing can be accomplished by washing with soap and water. (Just like uranium miners and mineral sand miners do at the end of shift every day.)

The biggest threat is that arising from uncontrolled panic, particularly if there is a perception that a large area is affected. Risks taken during disorderly evacuation, traffic accidents, and the like, are by far the biggest hazards, other than injuries resulting from the initial blast, and resultant structural damage and fire.

Decontamination of the target building will most probably be long and costly, with the cost ultimately depending on the acceptable level of residual activity; the more demanding the final cleanup criterion, the longer and more costly the process will be.

Even in a more extreme scenario of a bomb made with a substantially larger source, such as a stolen cancer therapy source (up to 100,000 Gigabecquerels of caesium-137), the situation will not be immediately hazardous to life for victims caught in the target building or for rescuers entering the area.

However, in this case the hazard to the bomb constructor would be serious. The very high doserate received while assembling the source with the explosive, and packaging it, and then while transporting it to the target location, would be a major impediment to a terrorist, since a lethal and rapidly incapacitating dose from the concentrated and unshielded source is likely.

If the more extreme scenario is considered improbable, then the remaining simpler possible dirty bomb scenario is of a 'weapon of mass disruption' rather than one which can be capable of widespread death and destruction.

Examples of accident situations which parallel these 'dirty bomb' scenarios are given below, and show (as expected from basic principles) that extended exposure times and intimate contact were the main contributors to high radiation doses.

About 20 years ago, there was a major incident in the city of Goiania in Brazil in which a stolen cancer therapy source was taken apart in a backyard scrap metal business. Children played with the caesium powder, smearing it on their faces because it glowed in the dark. Tragically there were several deaths. Public panic was extreme, and some 100,000 people presented at the local soccer stadium for contamination checks.

At a junkyard in Juarez in Mexico, in the early 1980's, a stolen cancer therapy unit was dismantled to recover its lead, and the cobalt source container was cut open. The two workers who carried out this operation admitted themselves to hospital some days later and were subsequently discharged having recovered.

Some months ago, an iridium source, while in use for weld testing at an oil refinery in the US, was contacted by an uninsulated high voltage conductor, and exploded. The workers who were in the vessel at the time, and carried out the initial emergency response activities, were subsequently estimated, following whole body monitoring, to have received doses of a few millisieverts.

The possibility of delayed cancer induction in populations exposed to radiation also needs to be addressed, however the estimated doses are so low that there is no certainty that any excess cancer risk actually exists.

Any such cases of cancer that might eventuate would occur some 4 to 40 years after exposure and would not be identifiable as having been caused by radiation. Although some individuals might incur larger doses, the estimated average doses are so low that there would almost certainly be no discernible increase in the incidences of cancers.

According to the assumptions made by ICRP for the purpose of radiation protection, for example, 200 people exposed to 50 millisieverts might at worst ultimately suffer one additional cancer over and above the normal average number of about 40 cancer deaths usual for this size group.

Dr A C McEwan
President
Australasian Radiation Protection Society

Contact the ARPS Secretariat for more information