APPENDIX L: TRANSPORT ANALYSIS

This study, undertaken by Jacobs and MCM, assessed the risks and consequences that would result from possible adverse events during the transport of radioactive materials, both within Australia and internationally. Both potential 'accident' and 'attack' scenarios were considered for transport by road, rail and sea.

The assessment takes into account the engineering of radioactive material packages and the impacts in the event that an accident caused a release of radiation. It also considers the effectiveness of the response measures that would be in place during transport.

ASSUMPTIONS AND INPUTS

METHOD OF ASSESSMENT

The events were assessed considering the probability of an event occurring (using historical data) and, if it did occur, the likely radiological consequences (based on empirical study). In each case, the impact of likely protective measures was also taken into account.[1]

The risk analysis considered the following nine events[2]:

- four 'accident' scenarios involving feasible road, rail and sea transport modes
- four 'attack' scenarios which describe deliberate acts to either capture, or cause the uncontrolled release of, the radioactive material being transported
- one scenario involving low level waste movement on a public road, in an accident scenario and an attack scenario.

LIKELIHOOD OF EVENTS

The likelihood of transport accidents occurring was assessed using statistics both in Australia and around the world:

- for road accidents, one significant (fatal) collision per 18.5 billion tonne kilometres nationally[3]
- for rail accidents, one derailment per 1.04 million kilometres travelled nationally on shared/non-exclusive rail lines[4]
- for accidents at sea—being the longest transport stage in terms of distance and duration—the likelihood of there being a collision or fire is summarised in Figure L.1.

Additionally, in 40 years of low level waste transport in Australia, there have been no road accidents causing a significant release of radiation.[5]

While the likelihood of transport accidents occurring can be confidently estimated due to the existence of extensive transport statistics, the likelihood of deliberate attacks cannot be assessed in the same way. Therefore, the deliberate attack scenarios are assessed on the basis of potential courses of action which might be taken and the likely measures in place to mitigate them.

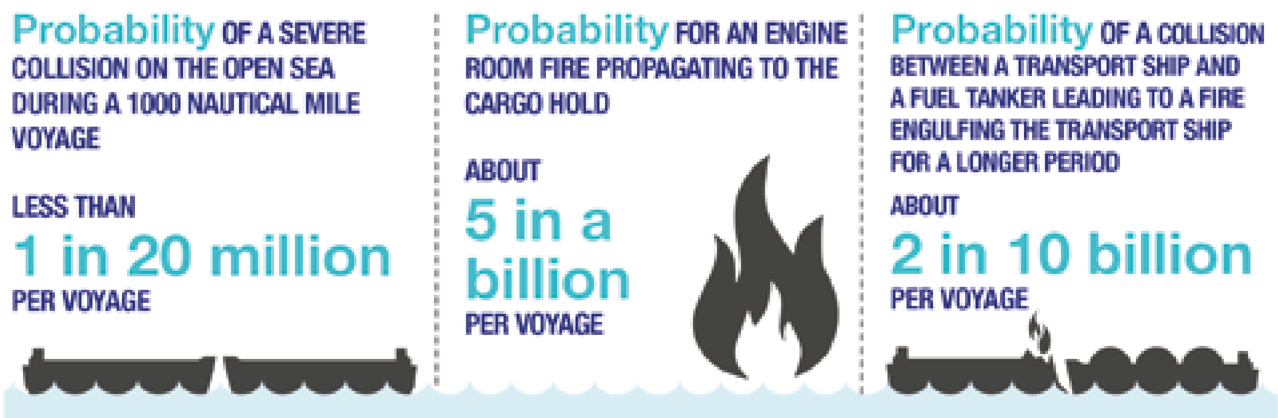

Figure L.1: Probability of accidents involving sea transport

Source: Jacobs & MCM

CONSEQUENCES OF ACCIDENT EVENTS

Casks used to transport used fuel are heavily engineered and undergo a strict testing regime to ensure that no radioactive material is released in the event of a credible accident scenario.[6] They contain solid waste that is physically and chemically stable, and not at risk of explosion.[7] Therefore, the primary consequence of concern is a scenario in which a cask is damaged to an extent where there will be a release of radiation that causes people and the environment to become exposed. The accident events that were analysed gave rise to three types of hazard to the transport casks: severe impacts, fire and immersion in water.[8]

In the context of marine transport, purpose-built vessels are used to transport casks of used fuel. These ships incorporate double reinforced hulls and fire detection and suppression capabilities.[9] It is considered unlikely that a collision or fire on these vessels would damage a cask to the extent that it would fail.[10] Even if a transport vessel was involved in a severe collision that initiated a severe fire while in port, the most exposed person to any possible release of radiation would receive a dose far below natural background levels.[11]

In the hypothetical event of a catastrophic ship collision, it is possible that a cask could be lost at sea. Recovery of the cask would be routine if it were lost within tens of kilometres from shore, with the recovery operation normally taking place before any significant release of radioactivity.[12] The cask is unlikely to be recovered from very deep waters and would eventually corrode to release some radionuclides. Assuming that the radioactivity affected people through the marine food chain, the maximum annual dose expected would be a thousandth to a billionth of natural background levels (depending on how far from shore the cask is lost).[13]

During rail transport of used fuel, the analysis considered hypothetical accidents subjecting a cask to impact damage, fire damage and damage resulting if an elevated portion of a freeway fell directly onto the cask. In all cases, it is highly unlikely that a cask would sustain enough damage to cause a release of radiation.[14] It was considered that a cask would sustain similar conditions in the context of a road accident, thereby also making it highly unlikely that enough damage would be sustained to cause a release of radiation.[15]

Consideration was given to the exposure of emergency workers who would respond to an accident involving a cask of used fuel and would be required to work within close proximity to the cask for an extended period of time. It is estimated that a person working at the accident scene for 10 hours within an average of 5 metres from the cask would receive a dose of around 1 mSv, or 2 per cent of the maximum annual dose limit which applies to radiation workers.[16]

For low level waste transport, data from previous studies indicates that there has not been a road accident which has resulted in significant radiological risks. Where an accident has resulted in a release, contamination has been cleaned up quickly and has not subsequently been found to contribute to natural background radiation at accident sites.[17] The non-radiological risks associated with conventional traffic accidents are much greater, with it being estimated that one or two deaths would occur in road accidents over 70 years of low level waste transport from other causes.[18]

CONSEQUENCES OF ATTACK EVENTS

The attack scenarios considered involved the attempted theft of a cask during sea or road transport or the attempted sabotage of a rail consignment through either damage to the rail line or attack using armour-piercing rocket propelled munitions.

The size and mass of the casks–more than 100 t–means that they cannot be moved without the use of a crane. This makes theft of a cask extremely difficult. In the case of sea transport where the purpose-built vessels have additional security features built into the hatch covers, removal and transfer of the cask at sea is considered technically not feasible.[19]

For rail consignments, the railway line would be designed to minimise the likelihood and consequences of any attempted sabotage. As noted in the context of rail accidents, the robust nature of the cask minimises the potential for damage to it to result in radioactive release. It is considered that an armour piercing rocket has the potential to penetrate the outer wall of a cask and cause a release of radioactivity. However, the successful acquisition and skilled use of such a weapon is extremely unlikely given the range of available risk management measures further discussed below.[20]

MANAGING RISKS

A range of measures are in place during the transport of radioactive materials to reduce the probability of accidents and, should they occur, to minimise the extent of any radiological impact. Risks are managed by three main approaches[21]:

- packaging: the transport casks incorporate a significant amount of engineering to ensure that the contents are protected against the highest credible level of accidental or deliberate events
- further design and engineering: facilities and transport vehicles are designed and maintained to the highest standard to minimise likelihood of accidental or deliberate events occurring
- regulation: high safety standards are adhered to throughout the whole transport chain.

In addition, the likelihood of both accidental and deliberate events can be further minimised by using exclusive transport lines, such as private roads and rail lines between the port and storage facility, as illustrated in Figure L.2.

The safety measures discussed above are also relevant to the protection of consignments against security threats. Further security measures are available to reduce the risk of a deliberate attack being successfully undertaken, including[22]:

- operational measures: operators plan transport routes taking into account information available from intelligence and security services. For transport within Australia, transport plans must be approved by regulators and can incorporate security escorts.
- Australian domestic arrangements: Australian authorities maintain highly developed response and recovery measures. Depending on the circumstances, the South Australian Police or the Australian Defence Force can provide security services and tactical response capabilities.
- international protocols: in the context of sea transport, there are numerous international standards, policies, accreditation requirements and support agencies available to minimise the risk of successful attack on a vessel.

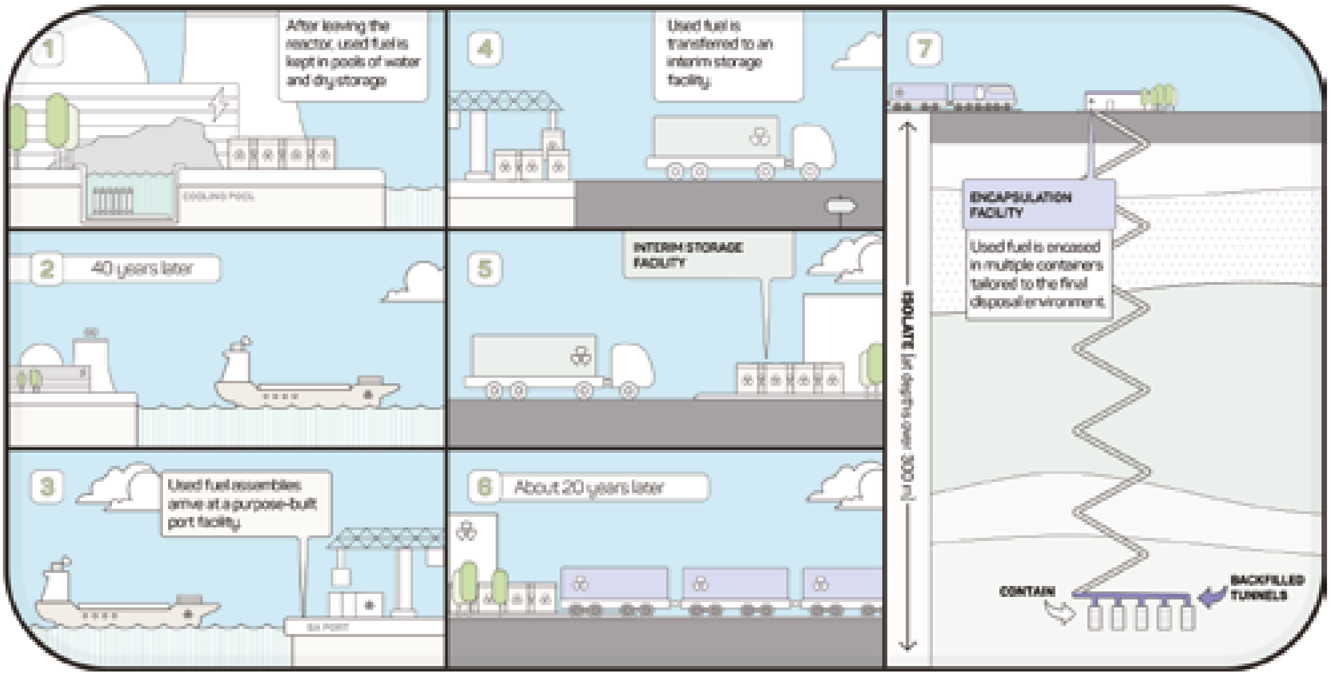

Figure L.2: Steps for importation, storage and final disposal of used nuclear fuel in South Australia

CONCLUSION

The potential risks surrounding the transport of radioactive materials to and in Australia have been assessed factoring in the likelihood of an event occurring and its potential consequences. Possible events have included both accident and attack scenarios during road, rail and sea transport. In all cases, engineering, operational, regulatory and response measures would be in place to minimise the risks.

Given these measures, the risk of an accident occurring that could breach a cask of used fuel and cause radiation to be released is very low. If a cask was lost at sea and was irrecoverable, there is potential for some members of the public consuming locally sourced seafood to receive a very small dose of radiation. However, the maximum annual dose expected would be a thousandth to a billionth of natural background levels.

The attack scenarios that have been analysed are conceivable, although the events that have the greatest potential to cause a release of radiation (namely a rocket attack) are the most logistically challenging. In any case, none of the attack events is likely to be undertaken successfully due to the security measures that would be in place during transport. These include engineering, operational, regulatory and response measures.

NOTES

1 Jacobs & MCM, *Safety and risks in the transportation of radioactive materials to and in Australia*, report prepared for the Nuclear Fuel Cycle Royal Commission, Adelaide, 31 March 2016, section 6.2.
2 ibid., executive summary, p. 1.
3 ibid., p. 11.
4 ibid., p. 13.
5 ibid., p. 38.
6 ibid., pp. 19–21.
7 ibid., pp. 24–25.
8 ibid., p. 30.
9 ibid., p. 30.
10 ibid., pp. 31–32.
11 ibid., p. 33.
12 ibid., p. 33.
13 ibid., pp. 32–33.
14 ibid., pp. 34-36.
15 ibid., pp. 36-37.
16 ibid., p. 25.
17 ibid., p. 38.
18 ibid., p. 39.
19 ibid., pp. 40–43.
20 ibid., pp. 41, 43–45.
21 ibid., executive summary, p. 1.
22 ibid., pp. 40–45.

Transcripts and submissions can be found at the Nuclear Fuel Cycle Royal Commission's website: www.nuclearrc.sa.gov.au/transcripts and www.nuclearrc.sa.gov.au/submissions