

**DECISION BY THE CEO OF ARPANSA ON APPLICATION TO
CONSTRUCT THE REPLACEMENT RESEARCH REACTOR AT LUCAS
HEIGHTS**

REASONS FOR DECISION

4 April 2002

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PART ONE – THE APPLICATION, THE ARPANSA PROCESS AND PRIOR PROCESSES

1.1 The application

On 21 May 2001, I received an application from the Australian Nuclear Science and Technology Organisation (ANSTO) for a licence to construct the Replacement Research Reactor (RRR). The reactor facility is proposed to be built on land owned by ANSTO at the western end of the Lucas Heights Science and Technology Centre, adjacent to the existing 'HIFAR' research reactor.

The application states that INVAP SE, an Argentinian company, is contracted to ANSTO for the design and construction of the RRR.

The application is made up of:

- an application document that contains the required information; including
- a Preliminary Safety Analysis Report (PSAR) of 11 volumes. The PSAR describes the features of the design in detail and analyses the reactor from the point of view of safety, including its ability to withstand accidents. A Probabilistic Safety Assessment (PSA) was provided as an appendix to the PSAR.

Additional documents received from the applicant during the course of the assessment are listed at Annex 1.

1.2 The process of assessment of the application

1.2.1 ARPANSA staff regulatory assessment

I referred the application to the ARPANSA Regulatory Branch for its review in detail. The Branch is made up of officers with a wide range of expertise in radiation protection and nuclear safety, the officers leading the review being of international standing and highly experienced in assessing the safety of ANSTO's nuclear facilities. The process was an iterative, deliberative review of the information and analyses in the application. The staff sought further information, clarification or verification of the information in the application from ANSTO. An international expert was engaged to advise the staff and assist in the assessment of seismic design. The Canadian Nuclear Safety Commission provided an expert to work on thermal-hydraulic and transient analysis. Finally, the Argentine Nuclear Regulatory Authority (ARN) undertook a review of the PSAR against its regulatory standards and the leader of the ARN review team visited Australia to advise staff about the findings and to discuss the issues raised.

As staff undertook their assessment, I was informed and advised of their thinking and I took part in discussions with the senior staff involved.

In making their assessments, the ARPANSA staff drew upon two documents published by ARPANSA:

Regulatory Assessment Principles for Controlled Facilities (RB-STD-42-00 Rev 1), dated October 2001 – known as 'the RAPS'

Regulatory Assessment Criteria for the Design of New Controlled Facilities and Modifications to Existing Facilities (RB-STD-43-00 Rev 1), dated October 2001 – known as the Design Criteria.

These documents are intended as a guide to ARPANSA staff in assessing the safety and design of controlled facilities. The principles and criteria set out in the documents are based upon the international safety framework (discussed at Annex 2) and the approach adopted by leading nuclear regulators.

The details of assessments are recorded in ARPANSA working documents. The overall assessment is provided in the *Regulatory Branch Assessment Report (RB-ASR-09-02)*.

1.2.2 Public submissions

I advertised on 5 June 2001 that I had received the application and intended to make a decision on it. I described the process for making submissions and called for them to be received by 5 September 2001.

This step was supported by making the application document and full PSAR available at public libraries in each capital city, in the Sutherland and Liverpool areas and at ARPANSA offices. Full copies were also provided to a number of community and environmental groups. The application document and a summary of the PSAR were available on the ARPANSA website. Subsequently, 'questions and answers' between ARPANSA staff and ANSTO were included on the website.

On 11 October 2001, I advertised again inviting a second round of public submissions. This second round was sought on the basis of an issues paper that I prepared that set out major matters on the safety of the proposed RRR on which further public input was sought, being seismic issues, accident analysis, and spent fuel and radioactive waste management. The issues paper also referred to physical security in the wake of the 11 September terrorist attacks and I issued a further statement on this subject on 12 November.

The closing date for the second round of public submissions was 21 December 2001, but submissions were accepted until 11 January 2002.

Details of the submission process, submissions received and all issues raised in the submissions are documented in the *Public Consultation Report (RB-ASR-19-02)*.

1.2.3 Public forum

I invited further public comment and testing of the application at a public forum that took place on 14 and 17 December 2001. The format of the forum was that a number of people and interest groups who had made submissions in the first round of public submissions made oral presentations, along with presentations by ANSTO, the Australian Safeguards and Non-Proliferation Office (ASNO), and the Department of Industry, Tourism and Resources (the Commonwealth department then responsible for radioactive waste management). Each presenter was subject to questioning by a panel, which I chaired. The members of the panel were: Dr Robert Budnitz, a US

scientist and independent consultant on nuclear safety (including seismic) issues; Mr Garry Schwarz of the Canadian Nuclear Safety Commission; and Dr Bill Williams of the Medical Association for the Prevention of War, Australia.

Following the forum, each of the panellists provided me with a report and these reports were published on the ARPANSA website. The full transcript of the forum was also made available on the website.

1.2.4 Peer review

I arranged for a peer review of the PSAR to be carried out through the auspices of the International Atomic Energy Agency (IAEA).

The final report of the peer review team (*IAEA Experts Mission to Review the PSAR of the RRR for ARPANSA*) was published in July 2001 and was made available on the ARPANSA website.

The peer review presented ten main conclusions and recommendations, making specific recommendations in four broad areas relating to the probabilistic safety assessment, the seismic design basis, some issues relating to the thermal-hydraulic analysis of reactor transients, and analysis of additional failure scenarios.

Importantly, the peer review concluded that:

'the PSAR reflects the present design of the RRR accurately, effectively and in considerable detail. It has been prepared using IAEA safety standards and reflects good current international practice. It provides an adequate basis for licensing purposes.'

The recommendations made by the peer review have been followed up with ANSTO and have been taken into account in the regulatory assessment made by ARPANSA staff. I have also considered them in the relevant parts of this decision.

1.2.5 Nuclear Safety Committee (NSC)

The NSC is an advisory body created by the *Australian Radiation Protection and Nuclear Safety Act 1998*. On 23 April 2001, I wrote to the chair of the Nuclear Safety Committee seeking its advice on:

- *'the adequacy of the seismic design basis for systems important to safety in the proposed replacement research reactor, taking into account international best practice*
- *whether the accident analysis in the PSAR satisfies the radiation dose/frequency criteria specified in ARPANSA's regulatory assessment principle 28 and the assumptions used in the Reference Accident for the siting assessment have been accounted for in the PSAR*
- *the adequacy of the strategies for managing the spent fuel and other radioactive waste (including emissions, taking into account the ALARA criterion) that would arise from the operation of the proposed replacement reactor.'*

The Committee formed three working groups to tackle the three subjects. The work and draft reports of those working groups were discussed at meetings of the full Committee. As a member of the Committee, I attended those meetings and participated in some discussion of the work in progress; I did not participate in the working groups. Staff members of ARPANSA – from the secretariat and scientific branches – assisted the Committee and the working groups, but these staff members have not been involved in the regulatory assessment process. Thus, I believe the Committee's report stands as an independent piece of work.

I received the Committee's advice on 27 February 2002. The advice (which I made available on the ARPANSA website) includes a covering letter and three reports on the issues prepared by working groups of the NSC, but endorsed by the full Committee. I asked the ARPANSA regulatory assessment staff to take the report into account in their work and respond to the recommendations made in their regulatory assessment report to me. I have also taken the reports into account as set out in Part Twelve of this decision.

1.3 Environmental impact assessment.

The proposal to construct and operate the RRR at Lucas Heights was made the subject of an environmental impact assessment under the *Environment Protection (Impact of Proposals) Act 1974*. ANSTO, as the proponent for the project, prepared and issued a draft environmental impact statement (EIS), which was released for public review in the latter part of 1998. To assist in the public review process, some independent scientific peer reviews were commissioned and made available - one of these reviews was by an IAEA team. ANSTO then prepared a supplement to the draft EIS that responded to the issues raised in the public review.

In early 1999, Environment Australia, having reviewed the EIS, reached the conclusion that the requirements of the *Environment Protection Act* had been met and that '*there are no environmental reasons, including on safety, health, hazard or risk grounds, to prevent construction of the proposed reactor at Lucas Heights*'. This conclusion was subject to the implementation of some 29 recommendations. The Minister for Environment and Heritage accepted these conclusions, subject to the recommended conditions, and conveyed this to the Minister then responsible for ANSTO, the Minister for Industry, Science and Resources. That Minister announced in May 1999 that he had accepted the conditions recommended by the Minister for Environment and Heritage.

A number of the environmental conditions required that matters be included in the PSAR and assessed to the satisfaction of ARPANSA. These have been referred to and dealt with as part of my decision.

PART TWO – THE LEGISLATIVE FRAMEWORK

2.1 The basis of my decision-making

In making my decision to issue a licence to ANSTO to construct the RRR, I:

- identified all relevant provisions of the *Australian Radiation Protection and Nuclear Safety Act 1998* (the Act) and Regulations
- determined the statutory matters to be taken into account
- determined the meaning of the statutory matters to be taken into account, having regard to the object of the Act
- reviewed all the evidence relating to the material questions of fact that needed to be determined arising from the matters to be taken into account, and on the basis of the evidence determine those questions.

In this Part, I have set out all of the provisions of the Act and regulations relevant to the making of this decision. I also set out what I understand those provisions to require.

In Parts Three to Twelve, I review the evidence and make findings of fact.

In Part Thirteen, I set out my findings on material questions of fact, the evidence upon which those findings are based and give my reasons for decision.

I understand the term ‘taken into account’ to mean that the matters must be given weight as fundamental elements of my decision. I have carefully considered them as vital parts of reaching the decision as to whether to issue a licence. They are not, however, absolute ‘pass/fail’ criteria.

2.2 Provisions of the Act and Regulations

The object of the Act is (section 3)

‘to protect the health and safety of people, and to protect the environment, from the harmful effects of radiation’.

I understand that all other provisions of the Act need to be read in the light of this object.

The Act states (sections 7 and 8) with regard to defence and national security, that

‘Nothing in this Act requires or permits a person to take any action, or to refrain from taking any action, if taking the action or refraining from taking the action would be, or could reasonably be expected to be, prejudicial to Australia’s defence (section 7) or national security’ (section 8).

These two sections also set up mechanisms whereby the Chief of the Defence Force or the Director-General of Security may declare that provisions of the Act do not apply in relation to defence and security.

Section 9 states that:

'It is the intention of the Parliament that this Act is not to exclude the operation of the Nuclear Non-Proliferation (Safeguards) Act 1987, to the extent that the Nuclear Non-Proliferation (Safeguards) Act 1987 is capable of operating concurrently with this Act.'

The section includes as an example that a controlled person who may be required to be licensed under the ARPANS Act may also need a permit under the Safeguards Act in respect of the same thing. The licence-holder must satisfy the requirements of both Acts to the extent possible.

Section 14 of the Act says that there is to be a CEO of ARPANSA (the Australian Radiation Protection and Nuclear Safety Agency). Section 15 states that the CEO has a number of functions. The function directly relevant to this decision is in paragraph 15 (1)(i):

'such other functions as are conferred by this Act, the regulations or any other law'.

Section 16 allows the Minister to direct the CEO if the Minister is satisfied that it is in the public interest to do so and must table any direction in the Parliament. No directions have been issued.

Sections 25 to 27 deal with the establishment, functions and membership of the Nuclear Safety Committee. The relevant functions of the NSC in this context are those in paragraph 26 (1) (d) :

'to report to the CEO on matters relating to nuclear safety and the safety of controlled facilities.'

Subsection 26 (2) says that *'The Committee's functions are to be performed only on the request of the CEO or the Council'*¹. The membership of the NSC (section 27) is: the CEO; a person to represent the interests of the general public; a representative of the Radiation Health Committee (another Committee established by the Act); a person to represent the local government or local administration of an area affected by the safety of a controlled facility; and up to 8 other members (seven such members have been appointed). As noted in section 1.2 above, I sought and received the Committee's advice on aspects of the application.

Section 30 of the Act requires that:

'A controlled person must not do any of the following:
(a) prepare a site for a controlled facility;
(b) construct a controlled facility;
(c) have possession or control of a controlled facility;
(d) operate a controlled facility;

¹ The Radiation Health and Safety Advisory Council is established under section 19. The Council has not made a request of the Nuclear Safety Committee.

- (e) *de-commission, dispose of or abandon a controlled facility;*
unless:
 (f) *the person is authorised to do so by a facility licence; or*
 (g) *the person is exempted in relation to the conduct concerned by regulations made for the purposes of this section.'*

The definitions in the Act (section 13) make it clear that ANSTO is a 'controlled person' being a Commonwealth entity². The RRR falls under the definition of a 'nuclear installation'³ in the Act and a nuclear installation is a controlled facility. ANSTO cannot proceed to construct the RRR without being authorised by a facility licence (no exemption having been made).

ANSTO does have a facility licence authorising it to 'prepare a site' for the RRR. I issued this licence in September 1999.

Sub-section 32(1) of the Act states that:

'The CEO may issue a licence to a controlled person that authorises persons to do some or all of the things referred to in subsection 30 (1).'

The Act defines persons covered by a licence to mean controlled persons authorised under a licence to undertake an activity in relation to a controlled facility. The definition of Commonwealth entity also extends to Commonwealth contractors, which would include INVAP⁴. INVAP may thus be authorised to undertake activities in relation to the construction of the RRR.

Sub-section 32 (3) requires that

'In deciding whether to issue a licence under subsection (1), the CEO must take into account the matters (if any) specified in the regulations, and must also take into account international best practice in relation to radiation protection and nuclear safety.'

Section 34 provides for applications for licences:

- 'An application for a licence must:*
 (a) *be in a form approved by the CEO; and*
 (b) *be accompanied by such fee as is prescribed by the regulations.*

² The definition of a Commonwealth entity includes a body corporate established for a public purpose by or under an Act. ANSTO is established by the *Australian Nuclear Science and Technology Organisation Act 1987* for the purposes set out in section 5 of that Act.

³ A 'nuclear installation' is defined to include 'a nuclear reactor for research or production of nuclear materials for industrial or medical use'.

⁴ A Commonwealth contractor is defined as a person who is a party to a contract with a Commonwealth entity. INVAP entered into a contract with ANSTO for the design and construction of the RRR on July 2000.

The regulations set out the information that may be requested for a construction licence application (items 1-4 and 8-12 of Part 1 of Schedule 3) and the fee required for the construction of a research reactor (Schedule 3A, item 7).

Sections 35 and 36 of the Act allow for a licence to be subject to conditions and to be amended. The relevant subsections of section 35 are:

'(1) A licence is subject to the following conditions:

- (a) the conditions set out in this section;*
- (b) the conditions prescribed by the regulations;*
- (c) conditions imposed by the CEO at the time of issuing the licence;*
- (d) any conditions imposed by the CEO under subsection 36(2) after the licence is issued.*

(3) A facility licence is subject to the condition that any person authorised by the licence to prepare a site for a controlled facility or to construct, have possession or control of, operate, de-commission, dispose of or abandon a controlled facility must:

- (a) at any time when the person has possession or control of such a site or facility – allow the CEO, or a person authorised by the CEO, to enter and inspect the site or facility at reasonable times; and*
- (b) comply with any requirements specified in the regulations in relation to such an inspection.'*

Subsection 36(1) provides that the CEO may at any time in writing given to the licence holder, amend a licence. Subsection 36 (2) provides:

'without limiting subsection (1), the CEO may:

- (a) impose additional licence conditions; or*
- (b) remove or vary licence conditions that were imposed by the CEO; or*
- (c) extend or reduce the authority granted by the licence.'*

Part 4, Division 4 of the Regulations prescribes another 12 standard licence conditions. These conditions require a licence-holder to:

- take steps to prevent breaches of conditions and to investigate and rectify breaches that do occur and to notify the CEO of such breaches
- take steps to prevent accidents and control and minimise the effects of any accidents and to notify the CEO of accidents
- comply with the national standard for limiting occupational radiation exposure and with other (named) recommendations and codes of practice
- comply with the plans for safety mentioned in the licence application and review such plans every twelve months
- notify the CEO of proposals for changes, seeking the CEO's approval for changes having significant implications for safety
- advise the CEO about the movement of sources and apparatus and seek approval for any transfer of a controlled facility
- seek approval for the construction of an item important for safety identified in a safety analysis report
- seek approval to load nuclear fuel into a controlled facility.

Powers under the Act are to be exercised in accordance with international agreements (section 84). The agreements referred to are those defined as relevant international agreements for the purposes of section 70 of the Safeguards Act and two further similar agreements prescribed by the regulations.

An important relevant matter is dealt with in the Regulations at Regulation 40:

- (1) *This regulation applies if the CEO receives an application for a facility licence.*
- (2) *As soon as practicable after receiving the application, the CEO must publish a notice in a daily newspaper circulating nationally, and in the Gazette, stating that the CEO intends to make a decision on the application.*
- (3) *If the application relates to a nuclear installation, the CEO must also include in the notice:*
 - (a) *an invitation to people and bodies to make submission about the application; and*
 - (b) *a period for making submissions; and*
 - (c) *procedures for making submissions.*

I have described in section 1.2 above how I fulfilled these requirements.

2.3 Matters to be taken into account arising from section 32 of the Act

2.3.1 Matters

As noted above, Section 32 of the Act requires that in deciding whether to issue a facility licence, the CEO must:

“take into account the matters (if any) specified in the regulations, and must also take into account international best practice in relation to radiation protection and nuclear safety”.

Regulation 41 of the *Australian Radiation Protection and Nuclear Safety Regulations 1999* (the Regulations) does specify seven matters that must be taken into account by the CEO in deciding whether to issue a facility licence to a controlled person.

There are two straightforward matters – whether the application includes the information asked for by the CEO; and whether the application has been signed by an office holder of the applicant, or a person authorised by an office holder of the applicant.

The five other ‘matters to be taken into account by CEO’ are as follows:

- *‘whether the information establishes that the proposed conduct can be carried out **without undue risk** to the health and safety of people, and to the environment’*
- *‘whether the applicant has shown that there is a **net benefit** from carrying out the conduct relating to the controlled facility’*

- *‘whether the applicant has shown that the magnitude of individual doses, the number of people exposed, and the likelihood that exposure will happen, are **as low as reasonably achievable**, having regard to economic and social factors’*
- *‘whether the applicant has shown a **capacity for complying** with these regulations and the licence conditions that would be imposed’*
- *‘the content of any **submissions made by members of the public** about the application’*.

2.3.2 International best practice in radiation protection and nuclear safety

The Act does not define ‘international best practice in relation to radiation protection and nuclear safety’. I have tried to find the plain meaning of the term, having regard to the context of the Act as a whole and especially the object of the Act.

The term ‘best practice’ is, as far as I am aware, not one used in the nuclear industry internationally as a particular term of art. I note, however, that in the foreword to a recent publication by the International Nuclear Safety Advisory Group (INSAG)⁵ that the Director General of the International Atomic Energy Agency refers to the publication as presenting ‘the principles underlying the best current safety policies and practices of the nuclear power industry.’

I have, then, thought of international best practice in radiation protection and nuclear safety from first principles, bearing in mind that I am dealing with the proposed construction of a research reactor. The process of designing, constructing and then operating a research reactor has a number of aspects. First, there are the higher-level decisions about the approach to be taken in the design to radiation protection and nuclear safety and then how those approaches are to be analysed and reviewed. I describe in Annex 2, a very well established international safety framework for these activities set up through the IAEA and associated bodies and through international conventions. As noted in the above paragraph, in the Director General’s foreword, this safety framework does strive to be a description of how things **should** be done, rather than merely a summary of how they are done. I accept that they represent international best practice for the conceptual and analytical aspects of a design and construction project. Certainly, there are no competing approaches in respect of design and construction of research reactors even claiming to be international best practice in radiation protection and nuclear safety.

Second, a specific reactor design will include a number of safety features – systems to detect problems and to shutdown the reactor, to cool the core after shutdown in various circumstances and to contain and control any released radioactivity. There is increasing international agreement about the desirable approach to such safety features – both within the general safety framework in Annex 2 and in discussions of future reactor systems. It is also a matter that can be addressed by comparing proposed safety features with those built into recently designed and constructed reactors in other countries.

Third, in the construction phase itself, there are issues about management of construction, quality assurance approaches and the codes of practice and standards

⁵ Basic Safety Principles for Nuclear Power Plants, 75-INSAG –3 Rev. 1, INSAG –12, Vienna 1999

for the construction of items important to safety. At this more detailed level, the international safety framework can only point to international best practice in the broad sense. The codes of practice and standards should be consistent and chosen from those used internationally, though there may not be a single set of such codes and standards that alone constitute international best practice. International best practice in radiation protection and nuclear safety may capture more than one way of doing things at this detailed level.

Finally, there are the radiation protection and nuclear safety outcomes that are actually achieved. Noting that these can only be estimated from the design at this time, it would nonetheless be appropriate to benchmark these outcomes against those achieved in recent, modern research reactors in other countries, where these are available.

Therefore, my view is that taking into account international best practice relating to radiation protection and nuclear safety with regard to the application before me involves the following being considered:

- the **radiation protection and nuclear safety objectives** included as a part of the design, compared with those laid out in the international safety framework that I find to be international best practice in radiation protection and nuclear safety
- the specific **safety features** of the design compared with those recommended in the international safety framework and most successfully applied in recent research reactor designs
- the **management of the design and construction project**, the codes and standards applied to the design and construction of systems important to safety, compared with management approaches and the codes and standards used for similar systems in reactors designed in other countries with best practice safety systems
- the **design outcomes** for occupational radiation doses, discharges to the environment and consequent radiation doses to the public, and the likelihood of core damage, compared with those achieved in recent research reactors in advanced countries.

I have also considered the issue of defining international best practice in radiation protection and nuclear safety with regard to protection of the environment from the harmful effects of radiation. I have construed my role, derived from the object of the Act, as being in relation to the protection of environment from the harmful effects of radiation. Other harms to the environment that may arise from the construction and operation of the RRR were assessed in the EIS process.

International best practice in relation to radiation protection and nuclear safety and protection of the environment is changing. The International Commission on Radiological Protection (ICRP) in its publication ICRP 60⁶ took the view that measures to protect humans from radiation also protected the environment.

⁶ 1990 Recommendations of the International Commission on Radiological Protection. These Recommendations form the basis of radiation protection in most countries of the world.

'The Commission believes that the standard of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk. Occasionally, individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imbalance between species. At the present time, the Commission concerns itself with mankind's environment only with regard to the transfer of radionuclides through the environment, since this directly affects the radiological protection of man.'

This view is certainly coming under challenge – and the ICRP itself has set up a working group to assess its position. The challenge is especially so for environments where non-human species are likely to be those most exposed - as may be the case for a waste repository, for example. There are ongoing discussions as to the ethical basis that might apply in relation to protection of the environment from ionizing radiation⁷. The US Department of Energy has published an 'interim technical standard' setting out an approach to evaluating doses to aquatic and terrestrial biota. I consider that there is not yet an established radiation protection system for non-human species that can be regarded as international best practice and for application in the context of a research reactor, other than focussing on the protection of humans.

2.3.3 'Without Undue Risk'?

In interpreting the meaning of 'without undue risk to the health and safety of people, and to the environment' and taking into account international best practice in radiation protection and nuclear safety, I take the view that the radiation protection objective and the technical safety objective suggested by the INSAG are international best practice⁸.

The radiation protection objective is: ***to ensure in normal operation that radiation exposure within the plant and due to any release of radioactive material from the plant is as low as reasonably achievable, economic and social factors being taken into account, and below prescribed limits, and to ensure mitigation of the extent of radiation exposure due to accidents.***

There are substantial and long discussed intellectual underpinnings to this statement. The prescribed limits for radiation exposure from an activity are those originally recommended by the ICRP with limits for exposure of the public and of workers in the activity (1mSv per year and 20 mSv per year⁹ respectively). These limits have been taken up by the IAEA in its Basic Safety Standards and have been adopted in Australia, Europe and in most countries. They are derived on the basis of knowledge of the effects of ionizing radiation on human health – most notably the risk of a fatal, delayed cancer - and have been suggested as risk levels on the basis of comparison with other accepted risks in society. The ICRP states:

'It is the Commission's intention to choose the values of dose limits so that continued exposure just above the dose limits would result in additional risks

⁷ *Ethical considerations in protecting the environment from the effects of ionizing radiation, A report for discussion, IAEA TECDOC 1270, Vienna, February 2002*

⁸ *Basic Safety Principles for Nuclear Power Plants, A Report by the International Nuclear Safety Advisory Group (INSAG-12), IAEA, Vienna, 1999*

⁹ The limit for workers is in fact stated as being an average of 20mSv over 5 years, not to exceed 50mSv in any one year.

from the defined practices that could reasonably be described as 'unacceptable' in normal circumstances. Thus the definition and choice of dose limits involve social judgements.'

The idea of the prescribed limits is accompanied by the notion of 'ALARA' – that is, that operators should seek to make exposures as low as reasonably achievable. The system of radiation protection has, over time, come to a well accepted approach to this concept. 'Dose constraints' are set that are lower than the limits proposed by the operator and agreed by the regulator. ARPANSA uses the concept an agreed 'ALARA objective' of a very low level of exposure below which the operator need not show that it is impractical to reduce exposure further.

As the ICRP commented, the system does involve social judgements. I note, however, that it has been adopted in most countries of the world and I find it to be international best practice in radiation protection and a proper basis to define 'without undue risk' in relation to radiation protection.

Turning then to the technical safety objective (which I regard as relating to 'nuclear safety' as the term is used in the Act), this is stated as: ***To prevent with high confidence accidents in nuclear plants; to ensure that for all accidents taken into account in the design of the plant, even those of very low probability, radiological consequences, if any, would be minor; and to ensure that the likelihood of severe accidents with radiological consequences is extremely small.***

Analysing the elements of this statement, I would regard 'without undue risk' for the RRR at Lucas Heights with respect to the technical safety objective as being that:

- the design of the plant makes an accident highly unlikely
- the plant is designed to withstand a range of predicted accidents without off-site radiological consequences that breach prescribed dose limits; and
- the likelihood of 'beyond design basis accidents' (including those that may arise from sabotage and terrorism) is extremely small.

I have considered what constitutes an 'extremely small' likelihood. INSAG suggests that the frequency of occurrence of severe nuclear core damage in an existing nuclear power plant should be below about 10^{-4} events per plant per year (odds of occurring of 1 in 10,000 per year). For future plants, INSAG saw that application of safety principles and modern design approaches could lead to the achievement of a goal of not more than 10^{-5} events (1 in 100,000) leading to severe core damage each operating year. I regard this figure as setting international best practice for nuclear safety at new reactors.

2.3.4 Meaning of net benefit

As I made clear in my decision on the licence to site the RRR, I interpret the net benefit matter as relating to the radiological protection principle of justification. That is, that the benefit of an undertaking exceeds the radiological detriment - harm and risk - that it may cause to workers, the public, and the environment.

Much of the public debate about the RRR has been about alternative possibilities and many of the public submissions to me have focussed on these issues. It is my role, however, to assess the proposal before me – the net benefit of the RRR. That is how the legislation is framed.

2.3.5 ALARA

The words used in the regulations:

‘the magnitude of the individual doses, the number of people exposed, and the likelihood that exposure will happen, are as low as reasonably achievable, having regard to economic and social factors

define the process of ‘optimisation of protection’. This process is laid out in the ICRP 60 publication referred to above, in the International Basic Safety Standards sponsored by the IAEA and other international organisations, and in the Australian radiation protection standard.

I have adopted the approach used in these documents as being the meaning of ALARA in this decision.

2.3.6 Compliance capacity

The regulation requires that I take into account whether the applicant has shown a capacity for complying with the regulations and the licence conditions imposed.

In view of the fact that ANSTO has contracted INVAP to design and construct the RRR, I believe that it is necessary, in taking into account whether ANSTO has the capacity to comply with the regulations and licence conditions, to examine their relationship with INVAP as determined by the contract and also to assess INVAP’s capacity to comply with the regulations and licence conditions.

In my view, a capacity for complying with the regulations and licence conditions has two parts. The first is whether the organisation has the financial and human resources needed to comply. The second is the subtler question of the ‘safety culture’ of the organisation.

The term ‘safety culture’ has emerged as being a vital part of nuclear safety in the years since the Chernobyl accident. INSAG defines safety culture as:

‘that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.’

As this definition makes clear, safety culture goes to ‘characteristics and attitudes’, matters quite different in kind to (also vital) resources issues.

I also interpret here ‘whether the applicant has shown a capacity for compliance’ as not confining me simply to assessment of the application. I think that in both aspects of compliance capacity that I have referred to, but especially that of the safety culture, it is appropriate to assess the organisational ‘track record’ of performance.

2.4 Nuclear Non-Proliferation (Safeguards) Act 1987 (the Safeguards Act)

The implementation of the Convention on the Physical Protection of Nuclear Material under the Safeguards Act gives the Director General of the Australian Safeguards and Non-Proliferation Office (ASNO) a role in regulating the physical protection arrangements applying to nuclear material. I reached a Memorandum of Understanding with the Director General in June 1999 that describes our mutual understanding of our roles and commits ARPANSA and ASNO to co-operation and assistance and to appropriate information exchange. A note of understanding about evaluation of physical protection and security arrangements for the RRR project itself was also agreed in May 2001. This resulted in the development of jointly agreed expectations for the security provisions of the RRR.

2.5 Meaning of Construction

ANSTO has sought a licence to construct the RRR. On the basis of the plain meaning of the words, I have taken the meaning of 'construct a controlled facility' in the case of the RRR as being:

'manufacturing, assembling and installing structures, systems and components of the reactor; carrying out civil works commencing with bulk excavation for foundations; and performing tests, inspections and commissioning of any of these items, up to but not including the loading of nuclear fuel.'

Section 30 of the Act divides the conducts relating to a controlled facility into 'prepare a site'; 'construct'; 'have possession or control'; 'operate'; 'decommission, dispose of or abandon'. Several of the matters to be taken into account by the CEO in making a decision about a facility licence refer to the conduct proposed to be covered by the licence. Taken literally, this might mean that, for example, in relation to the matter of undue risk, I need only consider the risks posed by the construction of the reactor, not by its operation, as that would be covered by another licence application. I do not interpret the Act and Regulations in this manner. To do so would empty the assessment of undue risk of meaning, as there are very few, if any, radiological risks involved in the construction phase, per se. My view is that Parliament divided the life of a nuclear installation or other controlled facility into the phases described above to reflect the complexity of such major projects and to ensure that they are properly assessed at each stage as they are developed.

In assessing whether to issue a licence to allow the preparation of a site for the RRR at Lucas Heights, I did make an assessment as to its operation on that site, as best as could be judged at that conceptual stage of the design. Similarly, I have taken into account any operation of the RRR in my assessment as to whether ANSTO should be issued a licence to construct it, in the light of the greater amount of information now available from the design of the reactor. Satisfaction at this stage would not prevent me refusing a licence to operate if it were that significant siting or construction issues arose in the intervening period. That is, should the project proceed to seeking a licence to operate, then the safety will again be assessed, this time with the 'as built' reactor to review. This would seem to me to be Parliament's intention and consistent with the object of the Act. I consider that it also meets international best practice in nuclear

safety – for example, the IAEA safety guide on safety assessment of research reactors¹⁰ states that:

‘To obtain a construction licence or an agreement for the start of construction, the operating organization shall submit information which demonstrates that the design will result in a safe facility and that construction will achieve the design intent.’

¹⁰ Safety Assessment of Research Reactors and Preparation of the Safety Analysis Report, IAEA Safety Series No. 35-G1 (1994)

PART THREE - THE SYSTEMS, STRUCTURES AND COMPONENTS OF THE RRR

3.1 Overview of the design

Features of the design of the RRR as described in the PSAR are:

- an open pool reactor with a maximum thermal power of 20 MW
- cooled and moderated by light water
- a nuclear core of 16 fuel assemblies made up of 19.7% enriched uranium in the form of a uranium silicide¹¹ compound, the core being at the bottom of the pool under some 8 metres of water and contained within a 'chimney'
- the reactor and storage pools tank being contained within a substantial concrete reactor block
- a containment structure surrounding the reactor block and other elements of the facility
- a reflector tank of heavy water around the core, containing a large number of sites for irradiation of materials
- four beam tubes for delivery of thermal and cold neutrons for research
- a system for control of the power from the core consisting of five control blades
- a first shutdown system employing the five control blades
- a second shutdown system relying on the draining of heavy water from the reflector tank
- two reactor protection systems that monitor various parameters and initiate the safe shutdown of the reactor
- decay heat removal is achieved by natural circulation of water in the pool – it does not require any power or other active systems.

The application also describes the reactor fuel and the arrangements for spent fuel management.

I summarise the purposes for which the RRR is intended (drawn from the application, page 2) as being to:

- maintain Australia's *nuclear technical expertise* in order to provide sound advice to the Government about nuclear policy issues of strategic significance and meet international obligations
- maintain and enhance health care benefits and ensure security of supply through *local production of the necessary range of diagnostic and therapeutic radiopharmaceuticals*
- provide a *neutron beam research facility*
- provide *research and training facilities and programs*
- provide *industrial radioisotopes and facilities for industrial scientific purposes*.

¹¹ It is ANSTO's intention to change to a uranium molybdenum fuel, once this form of fuel, currently under development, is fully tested and qualified. This new fuel offers advantages in terms of density of uranium. See also the discussion with regard to spent fuel processing implications at Part 8.

3.2 Elements of the RRR that are important to safety

ANSTO has applied a three level safety classification methodology – safety category 1 applies where the element (system, structure, or component) forms a primary means of ensuring nuclear safety; category 2 applies where the element, which may perform a performance function, makes an important additional contribution to nuclear safety; and category 3 to all other elements. Where an element is classified as safety category 1 it must be designed and tested against the highest standards and its ability to meet its performance requirements and its safety functions must be demonstrated. These requirements are less stringent for safety category 2 elements. For safety category 3, normal industrial standards are to apply – at least the appropriate Australian Standard. The guidance in the international safety framework requires a safety classification to be described, but there is no particular safety classification that is international best practice as such. The ARPANSA staff have reviewed the safety classification, and find it workable and effective and judge that it has been implemented in a systematic fashion. I find, therefore, that it is consistent with international best practice in relation to nuclear safety.

For the purposes of my assessment, I have grouped the safety category 1 systems as the following:

- the reactor core, including the fuel assemblies.
- the reactor cooling systems
- the first and second shutdown systems and the associated protection systems (being the instrumentation and control mechanisms that trigger the shutdown systems)
- the containment and the containment isolation system.

3.3 Reactor core

The core is made up of 16 square fuel assemblies, each in turn consisting of 21 flat fuel plates. Each fuel plate has uranium silicide powder dispersed in an aluminium matrix and sealed between two aluminium alloy covers (the cladding). The cooling water flows between the fuel plates.

The PSAR provides evidence that the fuel material to be used has been well established in use in a number of research reactors throughout the world. INVAP is contracted to provide the first two cores of fuel and the PSAR states that the fuel can be sourced from several suppliers. The use of this type and structure of fuel plates and fuel assemblies is consistent with the practice in modern research reactors – the specific core design of each research reactor is, however, unique.

The core is designed to produce the neutron fluxes at the irradiation points and at the neutron source sites required by the performance specifications. The challenge for the designers was to start with low-enriched uranium fuel and then to arrange the fuel and the materials that moderate and reflect neutrons in a way that achieves quite a demanding requirement in terms of neutron flux. The way they have gone about doing that results in a core that has certain behaviours in terms of changes in the power it produces as other parameters change. Analysis of the RRR core as presented in the PSAR and accepted by ARPANSA staff shows that the RRR core has a negative temperature co-efficient of reactivity. This is an important inherent safety feature – it

means that if the power in the core increases for some reason, the reactivity of the core will reduce, which will work against any further increase in power. I find that having a core with such inherent safety behaviour meets international best practice for the design of modern reactors.

A first and basic safety requirement for the core is that normal operations would not result in any damage to the fuel such as would release radioactivity from it. This basic requirement leads to the setting of some design criteria and limits. These are described in Chapter Five of the PSAR. These include limits on the temperature to be reached by the fuel material itself and the cladding, as well as limits on the mechanical stresses that can be applied to the plates. The mechanical stresses on the fuel assemblies have also been calculated in the PSAR and are well within the performance criteria. I accept that the design criteria and limits set parameters that if achieved will prevent damage to the fuel. The PSAR presents calculations to show that the limits will not be exceeded in normal operation. These have been reviewed by the ARPANSA staff and I accept that normal operations would not result in fuel damage. Accident analysis is treated in Part Six of this decision.

The composition of the fuel changes over the cycle of operation of a reactor as the uranium is 'burnt up' and fission products and other elements are produced. This burn-up is not uniform throughout the core, so that refuelling involves some shuffling of fuel assemblies in the core, as well as replacement of 'fully' burnt-up fuel assemblies. The refuelling operation is a potential vulnerability for any reactor. It involves shuffling of fuel assemblies and this gives scope for mistakes and opportunities for mechanical damage to fuel assemblies.

I am satisfied from the PSAR and subsequent answers by ANSTO to questions from ARPANSA staff that the design minimises these opportunities. At this stage in the assessment process, I must be satisfied that accidents that may arise from these causes are analysed and protected against through other systems (see Part Six). Operational processes to prevent such mishaps will be a part of consideration of an application for a licence to operate the reactor.

3.4 Reactor cooling systems

According to the application, full power operation of the RRR would require 18.8 MW of heat to be removed from the core and ultimately transferred to the atmosphere. The primary cooling system during normal operation pumps water up through the core and out of the pool and then exchanges heat with a secondary cooling system. At the very basic level, there obviously must be enough water passing through the core at a temperature that can be handled by the systems and that results in the cladding and fuel material not being heated to anywhere near the temperatures that may cause fuel damage. The rate of flow is limited by the need to avoid any significant mechanical stresses on the fuel plates because of turbulence.

The primary cooling flow must be sufficient to remove the heat from the hottest fuel element in all expected operating conditions of the reactor and for anticipated possible transients (rapid increases in power) above the expected operating conditions. To be sure of this, there need to be calculations of the thermal balance in the core and calculation of the heat able to be removed. The characteristics of the fuel elements also need to be known so that the temperatures at which damage occurs can be

conservatively included in the assessment. These issues have been reviewed in great detail by the ARPANSA staff assisted by the expert from the Canadian Nuclear Safety Commission.

The RRR core is quite energy intensive – generating some 265 kW/l. The flow required is then 1900 m³/h through the core. These calculations are presented in Chapter 5 of the PSAR for the various operating states of the reactor. The ARPANSA staff have reviewed these calculations, including with the assistance of an expert from Canada and on this basis I accept them.

The calculations described in this and the previous section have been carried out using models and correlations that have been extensively validated and accepted internationally. I find that the approach is international best practice. The RRR, as with other research reactors, is unique and it is appropriate that there be further validation of the computational models on this specific design to check against the RRR specific coolant system, core and fuel geometry. ANSTO has agreed (and I have imposed a licence condition to this effect) that there be a program of work established and carried out for validation of the computational models. The IAEA peer review proposed that direct measurements of fuel cladding temperatures, during reactor commissioning, could provide valuable validation for normal operational conditions, including transition to natural circulation. The practicality and likely effectiveness of such measurements are to be examined as part of the validation program I require.

During reactor low power mode, normal shutdown state or shutdown during abnormal conditions, the primary cooling system operates without forced pumping of water by natural convection. Flap valves on the system outlets and inlets close as the forced circulation decreases and the water then circulates around a circuit within the reactor pool. The flow achieved is demonstrated in the PSAR as being sufficient to remove the 800 kW of heat generated immediately following reactor shutdown. Establishment of the natural convection flow is assisted by the fact that the forced flow is upwards – that is, in the same direction as the desired convective flow and this is initially assisted by the ‘coast down’ of the pumps using the inertia of flywheels. This has been closely reviewed by the ARPANSA staff who regard it as an excellent feature and a very strong safety characteristic of the design that means that the ultimate cooling is achieved by natural phenomena, not any intervention or system.

I accept this view – noting that it will be necessary to be entirely confident of the operation of the flap valves. Only one of the four needs to operate successfully to achieve the necessary flow and they will also be type tested before being approved for installation. On the basis of the PSAR, the advice of ARPANSA staff and my knowledge of other research reactors, I regard having this system as international best practice in nuclear safety.

Other separate cooling systems deal with the heat generated in the reflector tank, including from irradiation rigs located in that tank. These have been reviewed on a similar basis and I find them to be adequate.

ARPANSA staff undertook a review of the calculation of the 'power peaking factor' (PPF) that applied in a large range of conditions of the core¹². The PPF is the ratio between the highest power generated in the hottest coolant channel to the average power in the core in a particular core configuration. In the safety analysis both the hottest and the average coolant channel are modelled on the basis of a PPF of 3.0. to demonstrate adequate cooling of the hottest part of the core. The purpose of seeking the additional modelling of the PPF was to assure that this value of 3.0 left a sufficient margin to allow for the uncertainties arising from variations in the manufacturing of the fuel, in all operating core configurations. These results demonstrated that the assumption of a PPF of 3.0 provided a margin of over 20%, which ARPANSA staff estimate to be sufficient to allow for the uncertainties. The exception was when the reactor was in a condition known as 'cold zero power' (when the reactor is just starting up in a state where there are no neutron absorbing 'poisons' available) and when there were abnormal control plate positions. This left a margin of 8%. These are an unlikely set of circumstances and it may be that the margin can be shown to be adequate. Nevertheless, I will ensure through the approval of the construction of relevant equipment, should construction proceed, that there is a control method to prevent the manual movement of control plates to positions other than those of predetermined control strategies or that these circumstances be re-analysed using a higher PPF to demonstrate compliance with safety criteria.

3.5 Reactor protection and shutdown systems

There are two separate systems designed to shutdown the reactor – that is to stop the core from continuing the nuclear reactions, but noting that heat is still generated because of the decay of fission products in the fuel and other radioactivity.

The first shutdown system consists of five control assemblies that are constructed of a cadmium compound that is a very strong absorber of neutrons. The control assemblies can be driven into the core from above within a second and it is calculated that only four out of the five assemblies would be needed to fully shut down the reactor. The control assemblies are forced into the core by compressed air and by gravity.

The second shutdown system works in an entirely different manner. It operates through six valves in the reflector tank opening and resulting in the draining of the heavy water reflector which in turn shuts down the reactor in a matter of a few seconds. The system would fully succeed if only five out of the six valves open.

The two shutdown systems are triggered by two different 'reactor protection systems', the first being computer based and the second 'hard-wired'. These are the systems that monitor various conditions in the reactor system and when certain parameters are exceeded send a signal to trigger the working of the shutdown systems. (A shutdown is also termed a reactor 'trip'; the specific conditions that are detected by a protection system and cause it to require the shutdown of the reactor are 'trip parameters'.)

An issue that was examined during the assessment of the application was the coverage of the trip parameters of the second shutdown system. It was argued in

¹² This matter of calculation of the power peaking factor is one of the issues not agreed between INVAP and the Egyptian operators of the ETRR 2 reactor built by INVAP in Egypt,

public submissions that the more limited coverage inherent in the design meant that the second shutdown system was not a fully effective independent system, including because one of its trip parameters is the failure of the first shutdown system. ARPANSA staff required ANSTO to demonstrate that each shutdown system would be fully effective when acting separately. Conservative assumptions were built into these analyses which assumed complete failure of the first shutdown system. The analyses indicated that both the first and second shutdown systems, operating alone, can successfully shutdown the reactor in these 'reactivity insertion transients', including for simultaneous withdrawal of all control blades. An important result of these analyses was that the responsiveness of the second shutdown system was considerably improved by the addition of a 'period trip', that is, an arrangement that triggers the shutdown system on measurements that indicate quick growth in numbers of neutrons. I will only approve the construction of this item on this basis.

With the addition of this period trip and based upon these further analyses, I find that the RRR design has two, independent, diverse and fully effective shutdown systems and this is very much at the front of international best practice in nuclear safety for research reactors.

3.6 The containment system

The RRR design provides a containment system to prevent uncontrolled release to the environment of fission products that may escape from a damaged core in the event of an accident. The system consists of:

- a physical barrier of reinforced concrete that surrounds the main parts of the reactor and includes a number of interconnected rooms and having a leak rate of less than 3% of contained volume per day
- a system to isolate the containment volume from the outside environment in less than one minute if high levels of radioactivity are detected in the ventilation system stack
- an energy removal system – re-circulating chilled water - to control pressure within the containment boundary by transporting heat to the outside atmosphere.

The containment structure is designed to withstand pressures of 2.5 kPa above or below ambient pressures. The pressure differences could arise from the thermal output of equipment, heat and evaporation from the reactor pool or changes in atmospheric pressure. The containment isolation system operates valves that isolate ventilation pipes penetrating the containment boundary and seals all other through wall penetrations. The number of penetrations has been minimised – personnel access to the containment is through airlocks with two interlocked doors.

The operation of the containment system is supported by the recirculation of air through filters that removes contamination and allows further decay of fission products within the containment.

The performance of the containment system has been analysed and found to be a highly reliable and effective low-leakage barrier. The system allows for options in accident management to be exercised through the recirculation and filtration and by the possibility of venting.

International best practice for research reactors, for example as described in the draft IAEA *Safety Requirements for Research Reactors, April 2001* is that '*where required, a confinement system shall be designed for converting a potentially uncontrolled release of fission products following a core disruptive accident into a controlled release with acceptable limits. A confinement system consists of a barrier which surrounds the main parts of the research reactor - - - .*' I consider that the RRR containment system exceeds this specification in that the physical barrier is supplemented by the isolation and energy removal systems which means that it functions as a *containment*, not simply a *confinement* system. Therefore I find that the RRR is international best practice in nuclear safety for research reactors in this regard.

PART FOUR – DESIGN FOR RADIATION PROTECTION

4.1 Framework

The PSAR sets out the applicant's commitment to occupational and public dose limits and dose constraints and to the ALARA approach. The dose limits in safety criteria 1 and 2 of the PSAR are those in the *National Standard*¹³ as they would need to be by the licence condition imposed by Regulation 47 and the prescribed practice determined by Regulation 59.

A dose constraint is, effectively, the working dose limit for a particular source of radiation exposure. Safety criterion 1 refers to a dose constraint of 15 mSv for workers and 0.1 mSv for the public from normal operation of the RRR facility. These dose constraints have been in effect for a considerable period of time. I believe that the occupational dose constraint, in particular, is higher than is justified in a facility operated in accordance with modern principles. As a point of reference, the average and maximum dose to staff operating HIFAR are well below 10 mSv per year and I expect that operation of a modern pool reactor would result in lower doses. A lower dose constraint would be more consistent with international best practice in radiation protection that requires a dose constraint be set taking into consideration what can be achieved in similar, well managed facilities. In issuing previous ANSTO licences I have required that dose constraints be reviewed and I will ensure that this encompasses any operation of the RRR.

4.2 Design issues

Operational radiological safety is treated in depth in chapter 12 of the PSAR. Important design issues include arrangements for zoning and access control – that is, controlling the numbers of people and the time spent in areas of exposure; radiation shielding – the material shielding people from the various sources of radioactivity; ventilation; and radiation and radioactive contamination monitoring instrumentation.

The ARPANSA staff consider that the planning for zoning and access control is based upon accepted principles. Detailed arrangements will need to be determined and agreed in the context of any future licence application. In particular, these will need to address strict access control to 'forbidden' and 'restricted' areas. I accept this assessment.

Design of radiation shielding is done on the basis of calculations of the quantity, type and energy of the radiation – from the reactor core itself, from spent fuel, from irradiated targets and so on – the dose acceptable in the area, and the nature of the shielding material. The ARPANSA staff assessment is that these calculations appear to have been carried out using accepted computer programs and using conservative values considered best practice (though some review may be necessary as the dose constraint is lowered). I accept this assessment. I will require concrete density and

¹³ Recommendations for Limiting Exposure to Ionizing Radiation (1995); National Standard for Limiting Occupational Exposure to Ionizing Radiation (1995), now published by ARPANSA as Radiation Protection Series No 1

other factors to be checked during construction and for the effectiveness of the shielding to be tested during cold and hot commissioning. I expect that the results of these tests will be included with any application for a licence to operate the RRR.

The design incorporates use of ventilation, filtration and radioactive decay systems such as decay tanks in the cooling circuits, filters on airborne discharges and in hot cells and charcoal and HEPA filters in the recirculation mode for containment isolation. I accept the approach taken – I will want the frequency of replacement of HEPA and charcoal filters to be addressed in any application for an operating licence.

An issue raised by a public submission was exposure to levels of argon 41 above the reactor pool. Exposure to radiation from contamination in the pool is however effectively limited by there being a separate hot water layer at the top of the pool that is supplied separately from the other pool water and purified and the ventilation system drawing the air from above the pool. I am satisfied that this effectively manages exposure of workers to argon 41.

The IAEA peer review also commented on the need to manage the build-up of radioactive tritium in the heavy water of the reflector tank. There is a system proposed for continuous monitoring of tritium in air in the heavy water process room, linked to ventilation and scrubbing. This issue does need to be directly addressed, but it is not a large issue and will be assessed as part of the review of any operating licence application.

4.3 Waste management

Section 12.4 of the PSAR describes the proposed waste management system for the RRR. It describes the arrangements for monitoring, control, segregation and classification of wastes and commits to approaches for waste minimisation.

One of the existing site-wide licence conditions applying to ANSTO operations is the airborne discharge authorisation. This establishes an overall goal and notification limits for the discharges of radioactivity on from each of the ANSTO stacks. It is based upon an ALARA objective of achieving a total dose from airborne discharges to a member of the public of no more than 20 μSv per year (essentially 10 μSv from HIFAR and 10 μSv from radiopharmaceuticals operations). Limits for discharges from the RRR will be set in due course in a revised discharge authorisation for the entire site. I will ensure that the goal of total dose being no more than 20 μSv will not be increased.

The quantities of solid, liquid and airborne wastes expected to be generated during commissioning and in each year of operation are described in the PSAR. The **solid wastes** generated each year are comparable in quantity to HIFAR and are expected to include: about 5 m³ of various low-level wastes such as paper towels, rags, plastic gloves, clothing, pipettes, activated components and samples; a 72 litre bin of intermediate-level activated metal components; 4 m³ of low-level waste of various filters; and 8 litres of ion exchange resins (used for water quality control). The **liquid waste** includes 50,000 m³ of water from controlled areas and cooling tower blowdown that is potentially radioactive; about 10 m³ of low-level liquid waste; and some 400 litres of waste oil and some tritiated samples. The **airborne waste** will be: argon 41 (approx 4 TBq); xenon and krypton (0.6 GBq) and tritium (40 GBq). I am satisfied that

the anticipated overall releases and consequent public doses would be very much less than for HIFAR, principally because of the large reduction in argon 41 emissions.

The ARPANSA staff is satisfied with the on-site management of wastes proposed, noting the continuing progress with the ANSTO waste management action plan and the special licence conditions imposed on the existing waste operations licence. I accept this assessment.

4.4 Low level waste repository

I note that ANSTO's application is predicated on low level wastes finally being sent for disposal to the national low level waste (LLW) repository. ANSTO is currently designing a facility on the site to condition waste for transfer to this facility for disposal.

This facility is being planned by the Federal Government as a national facility for use by all jurisdictions and will represent the route for final disposal of the LLW produced by ANSTO. I have been advised by the relevant federal department that the preferred site and two alternatives for the national repository located in South Australia were referred for environmental assessment in January 2001 under the *Environment Protection and Biodiversity Conservation Act 1999*. A draft EIS is being prepared and the intention is that it will be ready for submission to Environment Australia shortly. The process would then be that public comment would be called on the draft EIS and a supplementary report prepared. The Minister for Environment would then be in a position to make a decision on the proposal during 2002. The department states that *'the earliest the repository could commence operations would be during 2003.'*

I understand that the Premier of South Australia has now written to the Prime Minister stating that the SA Government 'is opposed to any national radioactive or nuclear waste dumps being established in this State'. The Premier goes on to say that the Government will legislate against any national 'nuclear or radioactive waste dump' being set up in SA, including a low-level waste repository. At the time of writing, I am not aware of the Federal Government's response.

The Premier of SA states that he proposes that SA will deal itself with the LLW generated by research and other activities in SA. Should it come about that the national approach to a waste repository not proceed, it will be necessary for the Commonwealth to devise an approach to final disposal of LLW from Lucas heights, including LLW generated by operation of the RRR. In the meantime, this waste will have to be continued to be handled properly on the Lucas Heights site. I am satisfied, on the basis of my assessment of the present waste management plan, including the licence and conditions applying to the waste operations on the site, that it can be.

The Nuclear Safety Committee also recommended that ANSTO submit a health risk assessment for reuse of sewer water containing radioactive wastes from the Lucas Heights site and an ecological risk assessment for waste entering local waterways with sewer surcharge. These are not matters specific to the RRR, but ANSTO has prepared an analysis of the radiological consequences of release of aqueous discharge to the Cronulla sewage system (in response to a condition of the RRR siting licence and the Environment Minister's conditions). This will be reviewed by ARPANSA staff and if further analyses are considered necessary, they will be required to be undertaken.

4.5 Dose estimates for normal operation

The PSAR at section 12.5 presents detailed estimates of dose to reactor facility staff from the normal operation of the RRR. The total collective dose is estimated to be about 7 person-mSv per year, with the dose to the most exposed worker to be in the order of 2 mSv per year.

Dose estimates to the public are also derived from accepted computer modelling techniques. Calculated doses are less than 1 μ Sv per year. This is only a few percent of the reported values for HIFAR – attributable mainly to a reduction in air-borne discharges. These calculations are considered soundly based by the ARPANSA staff.

If these values are achieved, I find that the RRR will meet the ALARA criterion and international best practice.

PART FIVE – SEISMIC DESIGN

5.1 Evaluating the seismic hazard at Lucas Heights – A history

Australia is in an intraplate zone for earthquake activity and generally regarded as seismically 'quiet'. In assessing what earthquake should be designed for at Lucas Heights, one attempts to estimate what the pattern of vibration would be at that place for an earthquake that would be expected to occur no more than once in 10,000 years. However, there is no more than tens of years of worthwhile data.

Nonetheless, the matter has been given very considerable attention. To simplify the subject, a starting point is the search for the single number that might characterise the earthquake risk at Lucas Heights. This is the peak ground acceleration (PGA). It is the most often quoted number for seismic hazard – it indicates the basic (horizontal) force that the ground will apply to a structure embedded in it.

Like all vibrations, the ground vibration induced by an earthquake at a particular place can be mathematically analysed into a set of vibrations occurring with certain amplitudes at different frequencies or periods (the inverse of frequency). The PGA is the vibration amplitude at zero period and is the characterising parameter – but what is really needed to design a structure is a curve that establishes an amplitude for the different frequencies of vibration likely to affect structures, systems and components in the facility being tested. The amplitude at any frequency in any real earthquake will, of course, differ from your adopted curve, but not drastically so.

When studies were conducted in the 60s and 70s with respect to HIFAR at Lucas Heights, the estimated PGAs that were regarded as appropriate for the area were around 0.15g – that is, about 1/6 th of the acceleration experienced by a falling object. Further examinations and discussions of the uncertainties resulted in a PGA for evaluation of the HIFAR reactor of 0.23g .

After a comprehensive probabilistic safety analysis was performed for HIFAR in the 90s, it was recommended that there should be commissioned a probabilistic seismic hazard analysis for Lucas Heights and this was carried out by the Institute of Geological and Nuclear Sciences (IGNS) of New Zealand. In simple terms, this is a process for assessing the curve for the design earthquake at a site that uses probabilistic methods for estimating the size and depth of earthquakes in various areas that may affect the relevant site, breaking the surrounding area into zones of earthquake activity. It is the state of the art technique in this field and IGNS has the leading international reputation. Their result was a certain curve of amplitudes as described above – but anchored at a PGA of 0.41g, well in excess of previous estimates.

This result was controversial as it was well above the earlier estimates and seemed inconsistent with Australia's intraplate and seismically quiet character¹⁴. ANSTO

¹⁴ It worth noting the observation in the IAEA peer review that the RRR seismic design basis is conservative – that nuclear power plants in Canada, eastern USA, China, Russia, Korea, Brazil, Argentina, Brazil and Europe have design basis seismic values less than 0.3g. It appears that only nuclear facilities in interplate areas, such as California and Japan, have values greater than 0.3g.

sought critiques of the analysis. ARPANSA also convened a meeting of Australian experts to work with IGNS to review some of the parameters in their models that were debated. IGNS then undertook a further analysis drawing on the revised parameters. The outcome of this revised IGNS work – which I understand is accepted by Australian experts – is a curve anchored at 0.37g.

While this process was still in train, ANSTO settled on a seismic hazard curve to be used in the preliminary design for the RRR. The design curve followed a US Nuclear Regulatory Commission recommended curve and was anchored to 0.3g PGA. ARPANSA staff accepted that as reasonable at that stage of the process – the curve actually used amplitudes that exceeded those for IGNS (even anchored at 0.41g) at many frequencies of interest. This is the basis for the seismic assessments and evaluation presented in the PSAR.

5.2 The current situation

The ANSTO document now used for the seismic analysis for the RRR, overtaking the PSAR in this regard, is called *Consolidated Report: Methods, Criteria and Analysis for Seismic Qualification*, dated 30 November 2001.

In terms of the above discussion, the approach now to be adopted is that the IGNS curve anchored to 0.37g will be used for those frequencies where it produces the higher amplitudes and the NRC curve anchored at 0.3g elsewhere. This is accepted by the ARPANSA staff, by the seismic consultant advising ARPANSA, and by the Nuclear Safety Committee as an appropriate approach¹⁵. I agree. The expert seismic consultant employed by ARPANSA reported that, given the stage of the design, the impact of this change on the design is negligible for the systems and components and minimal for the structures, such as the reactor building.

The purpose of the seismic hazard analysis is to define two generic earthquakes at the site for design purposes. The first is called the Safe Shutdown Earthquake (SSE). This gives the maximum level of ground motion to be used for design purposes and the design must achieve safe shutdown and continued cooling of the decay heat when subject to this earthquake, though significant repairs might be necessary before operation could be resumed. The probability of occurrence of the SSE is defined in the international guidance as 10^{-4} per year. The SSE is now defined as set out in the earlier paragraphs.

The second earthquake is the Operating Basis Earthquake (OBE). This is a substantially less severe earthquake, one that has a fair probability of being experienced at a site during the lifetime of a facility (the OBE chosen has a return period of 1000 years). It is expected that a reactor would be able to operate during this earthquake and to continue operation after normal safety checks. The curve chosen for Lucas Heights in this case has been derived from the US NRC and is anchored to a PGA of 0.09g. This has been assessed and supported by the ARPANSA staff and the expert seismic consultant. I accept that it is appropriate.

¹⁵ I have discussed the NSC's remaining query about the approach in Part 8 of the decision.

5.3 Seismic Qualification of Structures, Systems and Components

For seismic design purposes, RRR buildings and structures are classified as:

- Seismic class 1 – those that need to remain functional during the SSE (the very severe earthquake). These include the structures associated with the reactor building, the reactor facility sub-station, and the systems that are needed for the safe shutdown of the reactor
- Seismic class 2 – those that need to remain in operation during and after the OBE. These structures are checked for the SSE to determine that deflection and/or failure does not in turn damage safety category 1 structures.

ANSTO has prepared a full list of seismic classification of components and structures. All safety category 1 structures, systems, and components are seismic class 1 and there are a number of safety category 2 items that are seismic class 1. The view of the ARPANSA staff is that generally the seismic classification is satisfactory. There are several instances where ARPANSA staff has suggested that seismic class 2 items should be classified as seismic class 1. These issues will be taken up with ANSTO as part of the approval process for the various items.

The process of seismic design is achieved principally by analysis using established methods and modelling. A fully established and internationally accepted single code of practice is not available for the seismic qualification of all the components of research reactors. However, ANSTO has chosen codes it considers relevant, often from those established for power reactors.

The seismic design of the systems, structures and components of the RRR has been reviewed by the ARPANSA staff assisted by a US seismic expert. Their report gives me confidence that the seismic design has been very conservative for seismic class 1 items – that is, that the systems, structures and components that form the primary means of ensuring the safety of the facility would be able to withstand earthquakes of greater intensity than the design basis.

The structural integrity of the reactor pool is fundamental to the safety of the design. The *Consolidated Report* devotes a substantial discussion to this subject, to establish that, effectively, a loss of coolant accident from seismic causes is not credible. This conclusion is supported by the ARPANSA staff and by the Nuclear Safety Committee (see Part 12 below). I accept the arguments presented.

The IAEA peer review recommended physical testing for all seismic class 1 items that have moving parts. In particular, the review focussed on the testing of the control rod drive mechanism as this is required to achieve reactor shutdown by the first shutdown system. The peer review made the point that this first shutdown system is required to operate during a seismic event above the OBE as the second shutdown system may be too slow. The ARPANSA external seismic expert discussed this issue – the control rods and the control rod drive experience very low displacements in a SSE seismic event and receive low stresses. The issue remains as to how much clearance there will be in the core for control rod insertion. His recommendation was that if questions persist on this, then a physical test using a 'shake table' may be required. I will take this recommendation into account when ANSTO seeks my approval to construct the control-rod drive system.

The fact that the seismic design has been conducted against a hazard analysis derived from an advanced and contemporary approach (together with one used to assess sites for nuclear power plants) means that the seismic design for the RRR exceeds international best practice in nuclear safety for research reactors. The subsequent analyses have been carried out using internationally accepted codes and leave significant safety margins in the design, very much consistent with international best practice in this field.

PART SIX – ACCIDENT ANALYSIS

6.1 The forms of safety analysis

Accident analysis is addressed in the PSAR in Chapter 16 and in the Probabilistic Safety Analysis at Appendix A of the PSAR. Review of the accident analysis was a primary focus of the assessment by ARPANSA staff. It was also reviewed by the Nuclear Safety Committee.

The approach to accident analysis required by international best practice is to consider a range of postulated 'initiating events' for accidents. The design is then tested to see if the features built into it are likely to prevent the accident sequence from proceeding, or result in the reactor being shut down in a safe state without any release of radioactivity, or conclude in possible radiological consequences.

There are two approaches to accident analysis. The **deterministic** approach takes an assumed initiating event and examines the response of the various systems, including the engineered safety features.

The second approach is **probabilistic safety analysis** (PSA). Here, an assessment is made of the probabilities that systems will fail when called upon, including assessments of the probabilities of common cause failures that may affect more than one independent system. Given these probabilities, the total probability of all event sequences that lead to damage to the core of the reactor is assessed.

To have confidence that the design is properly tested, it is necessary that a sufficiently wide and diverse set of postulated initiating events is selected for the analysis and event sequences are assessed with the reactor assumed to be in several of the possible operating states. The relevant IAEA safety guide¹⁶ describes a range of postulated initiating events in 8 groups: loss of electrical power supplies; insertion of excess reactivity; loss of flow; loss of coolant; erroneous handling or malfunction of equipment or components; special internal events; external events; and human error.

6.2 The outcome of ANSTO's accident analysis

For the deterministic analysis, the PSAR defined groups of events that included all the groups in the IAEA document, adding loss of heavy water; initiating events arising from the reactor utilisation; and initiating events due to the spurious trigger of the safety systems.

For each group, a number of specific events were examined. These specific events were either eliminated from further consideration or classified as Design Basis Initiating Events (DBIE). The grounds for eliminating the event from consideration were that it is not applicable to the design, that it is eliminated by design provisions or that it is sufficiently unlikely to occur. Events falling into the last category of not being sufficiently likely to occur were said to be considered in the probabilistic analysis (though five were also included in the deterministic analysis as described below). The

¹⁶ 'Safety Assessment of Research Reactors and Preparation of the Safety Analysis Report' IAEA Safety Series 35-G1, 1994

various DBIEs were then sorted into whether they would better be considered as part of another group or whether the consequences of the DBIE were 'bounded' (that is the consequences were exceeded by the consequences of a related DBIE). If bounded by another, the DBIE was not reviewed further – clearly if the reactor is protected against the worst event of a class, it should be protected against the lesser event.

The DBIEs remaining were examined to see what effects they could induce in terms of changes to the operation of the core of the reactor (reactor 'transients'). The transients were analysed by calculating the effects on the reactor parameters, using appropriate computer programs. However, this analysis was not carried out where it was judged that the consequences would be minor.

Following from these analyses, there remained 13 events that were studied to assess the consequences for the reactor parameters and the likelihood of damage to the core or the irradiation rigs. The computer simulations showed that none of the induced transients lead to any such damage.

The five very unlikely events mentioned above were considered in the PSAR as 'Beyond Design Basis Accidents' (BDBAs). These first two events were loss of flow accidents, one involving failure of the first shutdown system, and the other with the loss of flow not detected. The analysis showed that the latter would result in core damage and a release of radioactivity with a resultant dose of 68 μSv at the buffer zone boundary. The third event is the blockage of two cooling channels in a fuel assembly. This also results in core damage and a release, with an even lower calculated dose. The fourth is the erroneous early removal of irradiated targets into a hot cell resulting in the melting of the targets. A very small off-site dose was calculated.

Finally, the loss of power with a total plant blackout for 10 days was reviewed. The analysis demonstrated that the shutdown core is successfully cooled simply by natural circulation within the pool and evaporation of the pool water for that period, with the loss of only some 50 m^3 of water. I find this a striking illustration of the strength of the RRR design to withstand accidents, because of passive systems working simply on the basis of the laws of physics.

I now turn to the probabilistic safety analysis (PSA). As with deterministic analysis, the starting point is the identification and selection of initiating events. The ANSTO PSA uses a systematic approach that begins with the identification of the relevant radiation sources in the design, the barriers that separate the sources from workers and the public, the primary failure mechanisms of those barriers, and finally the initiating events that may cause the identified failures. The initiating events are then grouped into sets of representative events.

Once the initiating events were determined, each were analysed and the possible accident sequences that flow from each were reviewed to draw out the safety systems and functions that may be called upon in those sequences. 'Fault trees' that estimate the likelihood of the various causes of failure of components were established together with 'event trees' that map out the possible sequences of events based upon the success or failure of the components that are called upon to operate.

The total probability of all accident sequences is the 'Core Damage Frequency' (CDF). The results from the PSA are that the mean CDF arising from various internal events analysed is 7×10^{-8} /year; for seismic events the CDF is 3.3×10^{-8} /year.

A PSA is also a useful tool to assess the design of a reactor plant. Because it is wide ranging and based on probabilistic approaches and it incorporates the interactions between the different systems and components, it can indicate whether the design is balanced. That is, whether the design is overly relying on later levels of defence in depth or whether the likely accident scenarios are dominated by one class of event. All who discussed the PSA in public submissions and the peer review team accepted that the PSA is useful from that point of view and should be updated as the design develops.

6.3 Assessment of ANSTO accident analysis

The ARPANSA staff accepted the deterministic analyses that were included in the PSAR. The computer codes are considered to be highly regarded and accepted internationally. I accept the assessment that the deterministic analyses in the PSAR are valid. However, as part of the approval processes required under the licence, I will ensure that ANSTO undertakes a program of systematic verification and validation of all these codes for the specific design of the RRR.

As noted in some public submissions and as considered by the ARPANSA staff, other events of interest needed to be considered to ensure that the design was rigorously tested and the analysis matched international best practice in nuclear safety. The ARPANSA staff sought from ANSTO the analysis of further events of interest, notably scenarios involving withdrawal of a single control blade and the simultaneous withdrawal of all control blades at low power, and with the shutdown systems to be evaluated independently. That is, the second shutdown system had to deal with the events based upon trip parameters other than failure of the first shutdown system. The analyses showed that, even with this more stringent range of accidents and with the assumption that the first shutdown system did not operate, the fuel would not be damaged. ARPANSA staff, in reviewing the ANSTO analyses, noted that for the full withdrawal scenario the analysis partly relied upon an inherent characteristic of the core that some boiling in the cooling water tends to slow the reaction. This is accepted by the ARPANSA staff, but the calculations will be validated as part of the validation program mentioned in the above paragraph.

In addition, the analysis of the complete blockage and melting of a single fuel assembly was sought. This was proposed to be done as a design basis accident to assess whether the control room would remain habitable following such an accident – the suggestion that such an accident be analysed was also made by Mr Schwarz at the public forum. ANSTO argued that the accident was not credible and have not provided the requested analysis. I require that the analysis be carried out – and any design measures necessary to ensure that the control room remains habitable in such circumstances be implemented. Noting that the reference accident involving the melting of four fuel assemblies would result in a maximum dose of less than 1mSv, I am satisfied that there would not be significant off-site consequences from this accident.

The initial range of deterministic analyses carried out by ANSTO fell short of international best practice in nuclear safety as demonstrated by the international guidance and the practices of other nuclear regulators, in that a number of initiating events had not been considered. With the further work carried out, I am satisfied that the testing of the design meets international best practice, with the exception of the work on the single fuel assembly blockage and the habitability of the control room that I require to be carried out.

Turning to the PSA, ARPANSA staff assessed that a number of postulated initiating events and sequences have been screened out of consideration in the PSA. Although the consequences of some are bounded by other sequences, I expect that they will nevertheless be included in the future development of the PSA to ensure transparency and completeness. Others may have the effect of increasing the CDFs estimated. This view is shared by a number of quite authoritative people who made public submissions.

I accept that the overall result derived from the PSA of a CDF of 4×10^{-7} per year is likely to be too optimistic. I have earlier indicated that I would expect that the CDF for a new reactor should be no more than 10^{-5} per year. Noting that the PSA estimated CDF is 25 times lower than this objective, the ARPANSA staff were of the view that the RRR would meet this criterion. A very complete PSA for the current reactor HIFAR produced a CDF of 2.6×10^{-4} and there are very simple arguments that would lead one to believe that the RRR is more robust, at the very least, by a factor of 10 – most notably the RRR's seismic design and the implausibility of a LOCA. The RRR should have a CDF of less than 10^{-5} to meet international best practice and I believe that this will be achieved.

Undertaking a PSA at all for a research reactor exceeds international best practice, at least as laid out by the international safety framework – for example the draft IAEA Safety Requirements document for research reactors describe only a deterministic safety analysis as being required. I find that, notwithstanding the criticism, having done this PSA puts the RRR at the forefront of international best practice for research reactors. The PSA will continue to be a valuable document to assist with the analysis of the design and the 'as built' reactor and should continue to be updated and developed.

6.4 Loss of coolant accident

The matter of whether a fast loss of coolant accident is credible for the RRR was a part of the assessments made for the siting conducted by ARPANSA and for the EIS. The inlet and outlets for the primary cooling system, for example, penetrate the reactor pool. It might be envisaged then that a rupture in the piping outside the pool could drain the pool and uncover the core – this is the loss of coolant accident or LOCA. This has been addressed in the RRR design – the cooling outlets are well above the core and are fitted with siphon breakers that mean that the pool cannot be emptied below the level of the outputs by a pipe rupture. I accept that this is a further strong element of safety in the RRR design, very much consistent with international best practice in nuclear safety.

The possible rupture of the pool structure caused by an earthquake was examined as part of the review of the seismic design and I have discussed it at Part Five.

6.5 Sabotage and Terrorism

6.5.1 Review of security in changed circumstances

Following the events of 11 September 2001, ARPANSA took up the issues of security with ANSTO, ASNO and the Australian Security Intelligence Organisation (ASIO). In my statement of 12 November 2001, I said that:

'ARPANSA has formally requested ANSTO to review and provide to it an assessment of the potential sabotage or terrorist targets within the proposed RRR facility, and the consequences of successful attacks on these targets. The assessment is to include examination of the irradiation and experimental facilities and the consequences of the impact of a large commercial aircraft on the facility. This site assessment for the replacement reactor will be fully reviewed by ARPANSA and then made available to ASNO.'

The 'design basis threat' and the reviewed site assessment of potential targets will form the basis for evaluating the adequacy of the physical protection and security arrangements.

In addition, ARPANSA has called for an assessment by ANSTO of the potential physical damage and radiological consequences of acts of sabotage or terrorism, including the impact of a large commercial aircraft hitting the facility. That assessment will also be fully reviewed by ARPANSA and evaluated as a part of the safety evaluation report provided to me.'

Information security is a vital part of defence in depth for physical security – it would be completely self defeating for the description of the measures and the analyses of the various scenarios to be public documents in the way that other accident scenarios and information are. The description of my decision in this public document is truncated by the need to keep secure such information about the means of attack on the reactor and the security measures taken. I have prepared a classified annex to this decision that draws on a range of documents properly given national security classifications.

6.5.2 Analysis of sabotage

The design of the reactor has been reviewed in detail to assess where it may be vulnerable to sabotage from within the building. Scenarios that would allow successful attacks have been examined, and redundant and diverse physical security measures designed to frustrate such attacks. Scenarios involving the use of targeted explosives within the reactor building have been modelled taking into account the advice of expert explosives consultants. The design is strong. To succeed in draining the reactor pool would require intimate knowledge of the facility, considerable planning, considerable time and uninhibited access to several areas of the facility. ASIO has recommended appropriate steps to protect against such attacks.

The blast damage to buildings and the reactor block, resulting from explosives placed external to the structure, including truck bombs, has been modelled. It was concluded that there would be only minor damage to the reactor building and the reactor block

and therefore nothing to affect the safety of people or damage the environment. Other parts of the facility would not, of course, be so fortunate.

I have imposed a licence condition requiring that the security measures recommended in classified reports prepared by security agencies be implemented and certified by ASIO.

Like all modern industrial plant, computer systems play an important role in the operation of the RRR and in protecting it against accidents. Just as the physical plant needs assessment of vulnerabilities and protection against sabotage, so does the computer software and hardware need assessment and protection against hacking and other forms of sabotage. This issue has been subject to broad review at this stage – the design is not yet sufficiently advanced to allow full assessment and protection - but the general direction of the necessary measures is clear. I have imposed a licence condition requiring that the computer system be certified by the Defence Signals Directorate.

The world is in new circumstances with regard to sabotage and terrorism, including in relation to nuclear facilities. The steps taken in the review of this design in this regard far exceed international best practice as it existed prior to 11 September 2001. I can say that, for now, the RRR has established international best practice for protection of such a facility. But there will be developments internationally in the design and analysis of physical protection measures, in the consideration of design basis threats, and in the analysis of the impacts of attacks. I will keep these matters under review, working with the relevant Australian and international agencies. I have imposed a licence condition requiring ANSTO to ensure that its site security assessment and threat assessment are formally reviewed by ASIO and updated periodically and if security circumstances change.

6.5.3 Analysis of consequences

Could a commercial airliner be flown into the RRR? Possible directions and angles of attack by commercial aircraft have been examined by ANSTO, calling upon expertise in the aviation industry. ARPANSA staff reviewed this information and discussed it with the experts involved. The staff concluded that the uncertainties involved in attempting to hit the facility limit the speed, directions and angles of attack. I have also reviewed this evidence and find it convincing.

If, nonetheless, a large commercial aircraft did hit the RRR, would it penetrate the building and the reactor block? ANSTO first presented qualitative arguments extrapolated from experimental findings to show that penetration of one or two engines from the aircraft is highly unlikely (the 'soft' structures of the aircraft will be destroyed on impact). I found these arguments reasonable. They were followed up by recent quantitative modelling undertaken by ANSTO staff. The stated results of this figuring provides a high degree of comfort that the facility would be safe under this (what I now regard as being unlikely to be successful) form of attack. Nevertheless, I will arrange for the latest ANSTO analysis to be reviewed. I will monitor international developments in the area of calculating impacts of large aircraft on reinforced concrete structures in the next months and will require any actions arising from these developments to be undertaken.

Finally, at the last level of defence in depth, what would be the consequences of exposure of the core following destruction of the pool and the containment caused by this postulated crash? Could such consequences be mitigated by the emergency management plan?

ANSTO has carried out modelling of the consequences of a full-core meltdown and release of the radioactive inventory. An important part of this calculation is that the dispersion of the radioactive cloud is driven by the fire resulting from the crash. Aviation experts advise that in such circumstances a fire is virtually inevitable. The heat of the fire spreads the radioactive contamination, reducing the largest doses likely to be received off-site.

The analysis showed that the radioactive contamination would be spread some distance from the reactor, but dispersed in a way that meant that the largest radiation dose to an adult member of the public would be less than that requiring action under the guidance published internationally. For some scenarios, it might be the case that the potential thyroid doses to children would warrant consideration of use of iodine. The ground contamination would not require measures to be taken.

The ARPANSA staff review of these calculations confirms the ANSTO analysis, and extends it for different assumptions as to the energy of the fire. If the core were melted in other sabotage scenarios the consequences would be similar to those of the HIFAR reference accident. In the context of these consequences, arising from a highly unlikely event that is, in turn, highly unlikely to succeed, and noting that emergency arrangements could play a role in mitigating the consequences, I find that the siting of the RRR at Lucas Heights remains acceptable.

6.6 Emergency arrangements

The most up to date international guidance on the approach to dealing with nuclear or radiological emergencies is contained in a Safety Requirements document only recently approved by the Board of Governors of the IAEA.¹⁷ This publication draws together the approach to nuclear and radiological emergencies contained in several other publications.

The practical goal of emergency preparedness is stated to be:

'to ensure that arrangements are in place for a timely, managed, co-ordinated and effective response at the scene and at the local, regional, national and international level, to any nuclear or radiological emergency.'

The vital part of this goal – especially in regard to accidents with off-site consequences – is the need for the response to be co-ordinated. That means that arrangements need to be worked through with the various action agencies that have a role in such an emergency – police, ambulance, fire brigade, and any other emergency agencies likely to be involved.

¹⁷ Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety requirements, GS-R-2, Vienna 2002

The IAEA Safety Requirement proposes that facilities be divided into five categories for the purposes of considering the requirements. Category II of this classification includes:

‘some types of research reactors, for which on-site events are postulated that could give rise to doses to people off the site which warrant urgent protective action in accordance with international standards, or for which such events have occurred in similar facilities.’

The document goes on to say that for a facility in threat category I, II, or III, *‘appropriate emergency arrangements shall be established from the time that nuclear fuel is brought to the site and complete emergency preparedness as described here shall be ensured before the commencement of operation’.*

Is the RRR a Category II facility? According to the IAEA Safety Requirement, that depends upon whether it could give rise to doses to people off-site which warrant urgent protective action in accordance with international standards. The radiation doses to people that have been judged to warrant ‘urgent protective action’ (such as sheltering, evacuation, iodine prophylaxis) have been determined on the basis that the protective action itself involves disruptions and risks to people and therefore should be undertaken if a ‘significant’ dose is thereby averted. These significant doses for various protective actions are called ‘intervention levels’.

The intervention level recommended for the action of sheltering is 10 mSv of dose over two days being averted through taking this action. For temporary evacuation, the intervention level is 50 mSv of avertable dose in no more than a week. The notion is that the levels of dose that may occur from a certain accident in a particular area are predicted from analysis of the accident and then the indicated actions are taken.

None of the scenarios discussed in regard to the RRR, including the siting reference accident, leads to doses above 10 mSv.

One particular issue is the possible doses to the thyroid from an accident – the present IAEA advice is that the avertable intervention level for iodine prophylaxis aimed at avoiding the take-up of radioactive iodine is 100 mSv.¹⁸ Many authorities in the world are moving towards or have taken action to establish a different avertable thyroid dose for children, on the basis of the evidence arising from study of the aftermath of the Chernobyl accident. The proposal currently being considered by the Radiation Health Committee in Australia is that the intervention level for iodine prophylaxis for children be set at 30 mSv thyroid dose.

Several of the scenarios described above in relation to possible consequences for terrorist attacks lead to a prediction of children receiving a thyroid dose of this order. The emergency arrangements should thus include the possibility of the need to distribute iodine, especially to children.

¹⁸ This is the dose to the thyroid considered alone – a 100 mSv thyroid dose is equivalent to 5 mSv ‘whole body’ dose.

I find that emergency arrangements consistent with the guidance offered in the IAEA Safety requirements document referred to above will need to be established for the RRR. I have imposed a licence condition requiring that ANSTO have an independent review of emergency arrangements before seeking any operating licence for the RRR.

PART SEVEN – SPENT FUEL AND WASTE MANAGEMENT

7.1 Nature of the issue

In this Part, I deal with the management of spent fuel and the resulting waste form after it is reprocessed or conditioned. Other radioactive waste management issues are in Part Four.

This issue is different from the other assessments that I have undertaken. ANSTO can be held to be accountable and to be assessed in its proposals for management of spent fuel and radioactive waste until it is sent for disposal or long-term storage at national facilities. The development of these facilities is the responsibility of another agency and subject to Government policy.

Assessing spent fuel and waste management strategies requires assumptions that they will be available and operate at a date well into the future and continue for the life of the RRR and beyond. For example, the first load of spent fuel from the RRR is not planned to be shipped for reprocessing until around 2013, with the resultant waste not being returned to Australia until some time in the 2020s. The last load might be shipped in the 2060s.

Further, while most authorities accept that deep geological disposal is an appropriate and safe disposal method for spent fuel, no country has yet achieved a working repository. So it is simply not possible to point to an extant process that manages spent fuel from the time of its removal from a reactor to a final repository, or even an accepted long-term surface storage arrangement.

Finally, it appears that at least some of the technologically feasible options for tackling this issue are not consistent with Government policy. The ANSTO request for tender for the RRR ruled out strategies that required direct disposal of fuel in Australia, the reprocessing of fuel in this country (note that this is prohibited under the Act), or indefinite storage of fuel in Australia.

Spent fuel arising from the operations of the RRR will first be transferred under water and stored in the storage pool adjacent to the reactor pool. There is space available for 9 years of spent fuel in this pool. This is a very great safety improvement over the present reactor where spent fuel has to be transferred to other buildings on the site.

The key features of ANSTO's spent fuel management strategy are well captured by the diagram at the end of Appendix 3 of the application. This shows three possible routes, all leading to '*LLILW return to Australia in waste form and packaging accepted by Australian regulators for long term storage at national store and eventual disposal.*' The three possible routes (in order of preference):

1. Reprocessing by COGEMA in France¹⁹
2. INVAP to arrange processing in Argentina

¹⁹ ANSTO has a contract with COGEMA for the reprocessing of HIFAR spent fuel at COGEMA's plant at La Hague. This contract is extendable to RRR fuel, provided it is suitable.

3. INVAP to provide an alternative solution consistent with the terms of the RFT above (presumably involving processing in another country).

7.2 Spent fuel and options for management

Spent fuel – fuel that has been used in a reactor for the period of time for which it was designed - includes:

- a substantial proportion of the original uranium material. Commonly fuels are “burnt up” only to the degree that around 50% of the original uranium is fissioned
- plutonium, which is potentially able to be used as fuel in reactors (and in nuclear weapons)
- fission products - a very large number of different elements resulting from the fission of U235 and plutonium.

Spent fuel is highly radioactive as a result of the presence of the fission products. It must be treated very carefully to ensure the safety of the operators who deal with it and to ensure that there is no release to the environment. The first stage in dealing with spent fuel involves some period of storage in water to ensure that the fuel does not overheat and melt. Subsequently the fuel may continue to be stored under water – the water’s function is now principally as a radiation shield – or it may be transferred to some form of dry storage.

Because the spent fuel contains material that in turn could be used as further fuel for reactors – the uranium which can be directly used as fuel and the plutonium which can be used mixed with uranium fuel for MOX (mixed oxide) fuel - a number of countries seek to recover these materials by reprocessing. This is a chemical process whereby the spent fuel is dissolved and undergoes a number of chemical reactions to separate the uranium and the plutonium from the other materials. The remainder of the fuel substance and the waste arising from the reprocessing activity and the other parts of the fuel elements are formed into materials that should be able to be stored and possibly finally disposed of.

Not all countries that operate nuclear power plants have decided that they should reprocess their spent fuel. The reasons for not proceeding with reprocessing are broadly two fold: one is that the economics of the reprocessing may not be regarded as favourable, given the ready availability of uranium on the world market; the second is that reprocessing does result in the separation, particularly, of plutonium and gives rise to concerns about nuclear proliferation. So, for example, the United States has a policy of not seeking to reprocess fuel from its nuclear power plants; Germany has decided that it will not continue reprocessing after 2005; and other countries such as Canada and Sweden have decided they will not use reprocessing. Yet other countries have not made a decision either way at this stage.

However, in the case of the RRR, the issue of reprocessing is not one that is contemplated primarily on the basis of seeking to recover materials for further nuclear fuel (though the availability of recovered uranium may well be taken into account in the commercial negotiation). Rather, what ANSTO is seeking, I believe, is a way of conditioning the spent fuel such that it is in a form whereby it can be stored and

ultimately disposed of. The reprocessing process adopted by COGEMA La Hague produces a satisfactory vitrified waste form. The general waste form produced by La Hague is known to me and I regard it as likely to be able to be safely stored for a significant period of time in Australia. There has not been a full assessment of this carried out by ARPANSA nor has ARPANSA made any assessment of the suitability of the COGEMA vitrified waste product for final disposal in a geological repository.

For the RRR, an alternative approach to the *reprocessing* of spent RRR fuel is a form of *conditioning*. That is, the fuel could be dissolved and subjected to forms of chemical treatment which result in an acceptable waste form without there being any attempt to recover radioactive material. It should be noted that given the small quantities of fuel that would arise from the RRR, such a process could be carried out in quite small scale facilities. I do not consider that it would be necessary to reproduce a La Hague plant in Argentina (or in another country) to chemically condition spent fuel for storage and/or disposal. It may also be possible for conditioning to be a physical process and for the spent fuel to be included in physical containment for direct disposal. This is the route being followed by Sweden and Finland for their power reactor fuel. At present, it is not regarded as being possible for aluminium clad fuels such as the RRR fuel.

7.3 What is the size of the problem

In response to questions from the Nuclear Safety Committee, ANSTO estimated that for 40 years of operation, the total volume of the vitrified fuel waste and compacted associated waste returned from COGEMA would be some 16-20 m³, encapsulated in 100-125 canisters. ANSTO proposes that the canisters would be returned in transport/storage casks and that 5-7 such casks will store the 40 years of spent fuel wastes. Each cask would occupy a floor area of less than 5 m² and is around 7 m high. The volumes of material if the second option of processing in Argentina were to be taken up are estimated as 0.6-0.7 m³ of vitrified fuel material and up to 3 m³ of other waste if cement encasing were used.

The total radioactivity in a year's worth of RRR spent fuel (after 6 year's cooling and average burnup) is around 3300 TBq. Substantial decay of this radioactivity would occur by the time it is planned to be returned to Australia.

I do not foresee any major technical obstacle to the storage of this volume of material and quantity of radioactivity in a secure manner for a long period.

7.4 Strategies for spent fuel management - issues

7.4.1 Introduction

It has been vigorously argued in very many of the public submissions that I should not license the construction of the RRR on the grounds that the arrangements proposed by ANSTO for management of spent fuel will not be effective. With regard to the first route, using the reprocessing plant at La Hague to deal with the RRR spent fuel, there are three objections raised:

- first, that the uranium silicide fuel proposed for the RRR is not suitable for reprocessing in the La Hague plant

- second, that there is a legal challenge on foot in France to the reprocessing of Australian spent fuel in La Hague. The case in summary is that there are currently no regulatory authorisations in France which permit the processing of this type of fuel in the modern La Hague facilities and that therefore the Australian fuel constitutes radioactive waste and this is not permitted to be imported into France
- third, that the existence of the reprocessing plant at La Hague and the equivalent UK plant at Sellafield is becoming a political and environmental issue of significance in Western Europe and France and the UK are coming under pressure to close down the plants because of these discharges.

There are also critical questions raised about the second option of processing in Argentina, with the variant of INVAP managing processing in another country.

The strategies presented by ANSTO require international transport of spent fuel and the radioactive waste products. This has been criticised as being unsafe.

7.4.2 Reprocessing silicide fuel

I am aware that the particular process adopted at La Hague is not suitable for dealing with uranium silicide fuels in bulk. However, according to a letter from COGEMA to ANSTO in September 2000:

'In the event a limited quantity of U₃ Si₂-Al type fuel is produced in the initial period of operation, COGEMA confirms that, in this very special case, such fuel would in principle be reprocessable in dilution with the U Mo-Al type provided that enough quantity of the U Mo-Al fuel is available in total and for each reprocessing batch. Based on your indicative specifications and estimated quantities COGEMA could take delivery of a two years production (316 kg) of U₃ Si₂-Al fuel. This would require about 2000 kg of U Mo-Al spent fuel, i.e. a fraction of the RRR overall production and lifetime.'

Is the change to U Mo-Al fuel likely in the timescale suggested as being required by the COGEMA letter? I have read the most recent paper, 'Status as of March 2002 of the UMo development Program', about the French program for the qualification of U Mo-Al fuel. That paper reports on the results of irradiations of such fuel plates to date and sets out a program of further experimental work aimed at resulting in qualification of the fuel in mid 2005 as a reprocessable fuel. There are some other countries taking part in the program to qualify these fuels, but I have no reason to believe that they will produce an earlier result.

I judge that it is reasonable to expect that the changeover to U Mo-Al fuels will occur in a time period that will allow reprocessing to occur via COGEMA, or at worst for there to be a small quantity of U Si fuel remaining requiring a different approach.

7.4.3 Authorisation for reprocessing Australian fuel

Now to the second issue: the French regulators have not yet authorised the reprocessing of other than standard power reactor fuels in the modern plants at La

Hague (known as UP2 - 800 and UP3). The reprocessing of research reactor and other fuels was given a form of authorisation in a much earlier process only for an earlier plant – the UP2-400, but not the detailed specific authorisation allowing actual reprocessing. I understand that this is because the French nuclear regulator (DSIN) would much prefer that the UP2 – 800 or UP3 plants were used for the reprocessing of other fuels – including higher burn-up power reactor fuels, MOX fuel and research reactor fuel.

The present situation is that DSIN has prepared a draft decree under French law, which would enable the reprocessing to take place in the modern plants, but that the relevant ministers – the minister for industry and the minister for environment - have not yet agreed this. I am advised that the political circumstances in France are such that it cannot be expected that a decision will be made until the resolution of the current round of elections during 2002 in France. My understanding is that DSIN does not, however, see any technical objections to the authorisation of the reprocessing of the research reactor fuel in the UP2 – 800 or UP3 plants.

I judge that there are paths available for the authorisation for reprocessing of the Australian fuel, including the RRR fuel, but a political decision may be required. In the application, ANSTO refers to an agreement at inter-Governmental level to support the contractual arrangements.

7.4.4 Political and environmental opposition to reprocessing

The third issue of the political and environmental opposition to Sellafield and La Hague largely turns around the OSPAR commission. OSPAR is an agreement by the countries bordering the north-east Atlantic ocean about the reduction of discharges of all forms of pollutants to those waters. With regard to radioactive substances the OSPAR commission at ministerial level has declared that by 2020 discharges of artificial radionuclides to the marine environment shall be “close to zero”. This position represents a consensus of the OSPAR countries and is accepted by the UK and France. For example the UK environment agency is currently setting discharge levels for the Sellafield plant and is looking to make a step towards the “close to zero” commitment by reducing the allowed discharge levels. Similarly the DSIN has been preparing for some time a discharge authorisation for La Hague with a similar intention.

The definition of what ultimately constitutes “close to zero” by 2020 leaves a certain amount of room for debate. There have been other decisions taken by the OSPAR commission – not at ministerial level and not supported by the UK and France - which more directly suggested that non-reprocessing options be taken up. The formal position is that the UK and France are committed to “close to zero” discharges from these plants by 2020. I would judge that, with certain amount of investment, a very low level of discharge will be reached by then. It will be argued by France and the UK that these levels satisfy the ‘close to zero’ criterion and that therefore this is not an issue for the future of these two plants. Having said that, there is no doubt that the other decisions made by the OSPAR Commission, albeit not supported by the UK and France, shows that there are substantial political pressures in Europe to end reprocessing and it might well be that these succeed sometime during the life of the RRR.

7.4.5 Processing in Argentina or a third country

Turning to the second route for dealing with spent fuel, the processing of the fuel in Argentina, the critiques are:

- the necessary facilities and authorisations do not exist at this time
- that importing spent fuel for processing into Argentina constitutes the importation of radioactive waste and that is said to be contrary to the constitution of Argentina
- the Argentine economic circumstances will not permit the undertaking to take place.

As far as I am aware, Argentina does not process research reactor fuel in the manner proposed at this time. It does, however, certainly have facilities that would enable it to do so (I visited such a facility in December 2000), bearing in mind that processing of relatively small fuel quantities can be undertaken in hot cells, without the scale required for a reprocessing program for a full-scale power program. I understand that the technological process is available in Argentina and the activity would be regulated by the Argentine Nuclear Regulatory Authority (ARN), which is a competent and capable body.

I am not in any position to judge the argument about Argentina's constitution. I note that the ARN has offered a contrary opinion and that there is an agreement between the Governments of Australia and Argentina that is progressing through both parliamentary systems.

Finally, I have not thought it worthwhile to try and estimate what the impact of the Argentinian economic crisis might be on a matter that will only come to fruition some ten years or so hence.

I do find that this fall-back option is less developed than that offered by the COGEMA option. I expect ANSTO and INVAP, as part of any application to operate the reactor, to develop the proposals further.

The final option of arranging for processing in another country has not been addressed in any serious way at this time and I have not relied upon it in my assessment.

7.4.6 International transport

The strategies for dealing with spent fuel involves international transport and the question of the safety of such transport was raised at the public forum. Greenpeace provided me with a report it had had prepared by a consultant²⁰. The focus of this report is on the operations of the Pacific Nuclear Transport Limited (PNTL) fleet, the international code for vessels carrying irradiated nuclear fuel and other nuclear materials, and the emergency arrangements in place, including in Australia. I have also reviewed an IAEA document on this subject²¹ that was the result of a research project carried out from 1995 to 1999.

²⁰ 'A review of aspects of the marine transport of radioactive materials' A report to Greenpeace International Tim Deere-Jones

²¹ 'Severity, probability and risk of accidents during maritime transport of radioactive material', IAEA TECDOC 1231, Vienna, July 2001

I note also that international transport of radioactive material is subject to the IAEA *Regulations for the Safe Transport of Radioactive Material*. These include stringent requirements for the packaging of spent nuclear fuel for transport. Spent fuel and vitrified wastes may only be transported in very strong, thick walled, heavily shielded flasks.

The Greenpeace report argues that the ships of the PNTL fleet are not amongst the top-ranked vessels in the world merchant fleet in that they are not fully double-hulled. It argues that the ships routinely traverse regions classified as marine high risk areas, that the owners' emergency arrangements are deficient, and that Australia does not have a disaster management plan to deal with at sea spills of radioactive materials. It suggests that the relevant international code for transport of irradiated nuclear fuels (INF) was based upon designs of vessels in the 1970s and has not been updated.

The report states that a total of 19 incidents occurring to INF vessels has been recorded by the authoritative UK body in the period 1991 to 2000. The report says *'All of these were relatively minor in terms of their eventual outcome, but plainly demonstrate that the INF vessels and their crew are susceptible to a range of incident types.'*

The IAEA report relies upon a research program carried out in several countries. Its assessment relies upon not only the probability of a ship accident, but the estimation of radiological consequence, taking into account the known performance of spent fuel packages. The report reviewed maritime casualty data to allow estimates of the frequency of severe ship collisions and ship fires per nautical mile sailed. Modelling of ship collisions allowed estimation of the likelihood of deep hold penetration and concluded that should crush forces be applied to a flask due to such penetration, the forces would be relieved by collapse of ship structures rather than flask structures. Modelling of ship-board fires also showed that a fire was unlikely to burn at a sufficient temperature or long enough to cause or enhance the release of radioactive material. Finally, consequence analysis shows that neither the loss of a flask into the ocean nor the release of material into the atmosphere as a result of collision and fire would subject individuals to significant radiation doses.

I consider that, while the international system is not beyond criticism, international transport of RRR spent fuel and resulting wastes could be conducted safely. The Greenpeace report makes a valid point about Australian emergency planning, and I am aware that this is being addressed.

International maritime transport of spent fuel and other nuclear materials is a matter of international concern and has been debated strongly at recent meetings of the General Conference of the IAEA. The subject will certainly be kept under review.

7.5 Intermediate-level waste store

The Australian government proposes to build a store for intermediate level radioactive waste. This store will be designed to be suitable for storage of longer lived radioactive waste, including the waste products arising from reprocessing or conditioning of spent fuel. Certainly it will be needed to store the reprocessed and conditioned spent fuel arising from HIFAR – some of which is in the UK to be conditioned into a cement form;

some of which is at La Hague; and the remainder is yet to be used or is stored at the ANSTO site.

An advisory group has been set up and is preparing advice on the siting criteria for a store. The advisory group, which includes an ARPANSA officer, has produced a discussion paper on the store that has been released for public comment. The aspects of the siting canvassed in that discussion paper include:

- geological hazards, such as earthquakes, volcanic activity and landslides
- local environmental hazards, such as flooding and fires
- natural environmental features, such as surface drainage
- access to transport, support facilities and infrastructure
- social impacts
- sites or areas of special environmental, cultural or historical significance
- security
- security of Commonwealth land tenure and compatibility with adjacent land use.

The proposal is for a store designed for safe storage 'for a period of up to at least fifty years until a suitable geological repository is established.' In my view, it would be foolish to design the store for a life of only fifty years. The issue of a final repository may take a considerable amount of time and I consider there is no difficulty with safe storage well beyond 100 years.

I have been advised that the next step is the release of a report responding to public comment on the discussion paper. This is expected to be released shortly and the aim is that a short list of potential sites be finalised by the end of 2002.

I earlier offered the opinion that at the time of the construction licence, I would expect to see progress in moving to establish a store and the above is progress. It should be noted, however, that South Australia has already legislated to prevent a store being located in that State.

With regard to ultimate disposal of the waste arising from spent fuel and other long-lived radioactive waste, the discussion paper indicates that Australia will look to develop a geological repository. I understand that the advisory committee on the store will turn its attention to the criteria for such a repository at the end of its current process. This is in response to the Environment Minister's condition 27 that '*timely consideration*' be given to '*strategies for the long term management and eventual permanent disposal of Australia's long-term intermediate-level nuclear wastes*'.

PART EIGHT – PROTECTION OF THE ENVIRONMENT

8.1 The Environment Minister's Conditions

I have assessed ANSTO's compliance with the conditions, accepted by the then 'action Minister' responsible for ANSTO, that I regarded as relevant to this application. I did this as part of the assessment I must make in regard to protection of the environment under the Act. Some of the conditions also required the involvement of ARPANSA.

8.1.1 Groundwater monitoring

Conditions 2 (establishing a construction environmental management plan) and 11 require a program of groundwater monitoring at the site and an independent report on the results of the program and requirements for further monitoring was to be submitted to ARPANSA and the Department of Environment and Heritage. ANSTO was also to establish bores at appropriate locations on the site and in the buffer zone with the locations and monitoring regimes to be agreed with ARPANSA.

ARPANSA staff reviewed the independent groundwater monitoring and management program as required and have also reviewed the groundwater monitoring results obtained over the past twelve months. Those results show no artificial radionuclides in the groundwater, apart from tritium at a level 30 times less than the WHO drinking standards. The independent report has recommended further boreholes and I wrote to the ANSTO project manager in December 2001 requesting additional information on the identification of significant sources, delineation of the groundwater flow regime and the level of radiological analysis. The ARPANSA staff suggest that there is a need for further evidence on flow paths between the upper and lower aquifers relevant to the site to provide assurance that the location of the bores is effective in monitoring groundwater for contamination.

I find that there is a process in train to settle the program for continuing groundwater monitoring and that this is not an obstacle to proceeding to construction.

8.1.2 Site emissions and monitoring

I discussed discharges of radioactivity from the site at Part Four above. I found that the estimated airborne discharges from the RRR and the resultant public radiation dose was consistent with international best practice in radiation protection.

Condition 10 sought further assessment and analysis of the exposure pathways and future events in relation to exposures that may arise from discharges to the sewer from the site. This assessment has recently been completed (March 2002) and provided to ARPANSA. The condition required this assessment only before reactor operations commence.

Condition 12 called for ANSTO to consult with ARPANSA to establish a radiological site characterisation or 'footprint' for the reactor site and buffer zone. ANSTO has provided information on the progress for complying with this condition. It has in progress the establishment of a monitoring system employing new detector technology that will enable a very detailed investigation and characterisation of the site to be

carried out. I am satisfied that the progress is adequate at this stage of the project and expect that the characterisation will be completed before any commissioning of the reactor facility.

8.1.3 Hazards and risks

Condition 13 required an independent peer review of the PSAR and this has happened as described section 1.2 above.

Conditions 14 and 15 set two important conditions, effectively as design conditions. The first was that the assumptions used to design the 'reference accident', which was used in the environmental assessment and in my assessment of the application for a licence to prepare the site for RRR, constitute design parameters for the RRR and must be incorporated in the final design to the satisfaction of ARPANSA. The second was that the PSAR needed to demonstrate that the design effectively rules out a fast loss of coolant as a credible accident arising from an earthquake of lower frequency than the design basis earthquake.

With regard to the assumptions used in the 'reference accident', ANSTO has described those assumptions and how they are treated in the RRR design at Appendix 2 to the application. In brief the important assumptions for the siting reference accident were that the accident was one resulting from an increase in core reactivity for some reason with a failure of reactor shutdown systems. There would be damage to 25% of the core and a release of radioactivity into the pool water and then into the containment that was isolated after 2 minutes with a leak rate of 3% per day. The ANSTO analysis shows that the performance of the RRR design is very much better than that assumed for the reference accident. On the basis of the ANSTO analysis and the assessment of the ARPANSA staff, I find that the assumptions on which the reference accident were based are well met by the design. As set out in Part Six on accident analysis, I would judge that there may be credible accidents with greater consequences than ANSTO argue for in Appendix 2, but they are certainly bounded by the consequences of the siting reference accident.

I have discussed a fast LOCA at Part Six, where I found that it was effectively 'designed out' from the RRR.

Condition 16 called for the assessment in the PSAR of the consequences of the loss of off-site electricity for water supply and firefighting purposes. If the risks are significant, on-site power provisions for water pumps needed to be made to the satisfaction of ARPANSA. The PSAR assesses the loss of off-site electricity in relation to the cooling of the reactor, pointing to the standby power supply and the fact that no forced circulation is required to cool the core when the reactor is shutdown. With regard to firefighting, fire protection is assessed in chapter 10 of the PSAR and the issue of water supply in fire emergencies has also been dealt with. Condition 18 also dealt with fire protection requiring that the final design of the reactor include a fixed and possibly automatic fire suppression system in the containment system to the satisfaction of ARPANSA and examine the need for a drencher system for the cooling towers. These issues were examined in the PSAR and the ARPANSA staff assessment is that the design features of the fire suppression system in the reactor building are satisfactory. ARPANSA staff advised that a drencher system was not needed for the cooling towers

– cooling of the core with natural circulation places no reliance on heat removal to the cooling towers. I find that these issues have been dealt with satisfactorily.

Condition 17 required that the safety implications of an inter-linked store for spent fuel elements needed to be assessed in the PSAR to the satisfaction of ARPANSA. This issue is treated in chapter 10 of the PSAR. The ARPANSA staff assessment is that the spent fuel storage is designed with appropriate consideration of criticality control, capacity and movement of transfer flasks above the core or pool. Having regard to these findings and given that the spent fuel handling is a distinct improvement over current arrangements, I find that the matter has been treated satisfactorily.

Conditions 19 and 20 addressed the period of joint operation of HIFAR and the RRR. Condition 19 required assessment in the PSAR to the satisfaction of ARPANSA of common mode failure involving HIFAR and the RRR and the resourcing requirements to ensure adequate infrastructure and staffing safety. Condition 20 requires that ANSTO seek a separate approval and authorisation of dual operation, should that occur for longer than six months. The ARPANSA staff point out that there are no common essential services between HIFAR and the RRR that would impact on safety, except (possibly) water supply. The RRR has adequate back-up water supplies to ensure safety. The issue of resourcing for staffing the RRR, including during any period of joint operation, is addressed by a licence condition.

Condition 21 requires ongoing monitoring and audit of the frequency and severity of external events. A commitment to this effect is included in the PSAR and it will be an ongoing requirement for the safety analysis.

8.1.4 Emergency planning

Condition 22 deals with emergency planning. It requires that existing plans be updated and subject to independent review at the detailed design stage. I have discussed emergency planning at section 6.6, where I find that the planning should be subject to review and I have imposed a licence condition to the meet the intent of this condition.

8.1.5 Nuclear wastes

Condition 26 requires that construction not be authorised until arrangements for the management of spent fuel have been demonstrated to the satisfaction of ARPANSA and the Minister for the Environment and Heritage. The evidence I have considered on spent fuel arrangements and the findings I have made are at Part Seven.

Condition 27 requires timely consideration of options for long term management and eventual permanent disposal of Australia's long-term intermediate-level nuclear wastes. I have observed in Part Seven that that process will commence with consideration of the issues by the committee established to advise on the proposed national intermediate-level waste store.

8.1.6 ANSTO environmental management system

Condition 28 requires that ANSTO continue as a high priority to review and upgrade its environmental management system to achieve ISO 14000 standards to be certified and in place by the time the RRR is commissioned. I agree that this system is an important piece of infrastructure to assist in the protection of the environment with

regard to the RRR, as well as the overall management of the site. I am aware that progress is being made.

8.2 The site licence

In April 1999, ANSTO applied to me for a facility licence to prepare the site for the RRR. After a period of assessment of this application, I issued such a licence in September 1999.

There were 11 special licence conditions imposed on the licence to site the RRR at Lucas Heights and ANSTO was required to report quarterly on the implementation of those conditions. They have done so – the latest report being for the period up to 31 December 2001. Some of the licence conditions reproduce conditions required by the Minister for Environment and Heritage.

Table 1 describes the site licence conditions and ANSTO's response to date together with ARPANSA staff comments.

Table 1 ANSTO Compliance with Site Licence Conditions as at March 2002

Licence Condition	Summary of ANSTO Action	Regulatory assessment finding
4 General Conditions	ANSTO notes and will comply	Satisfactory compliance.
5.1 Prepare a site	The 9 th report outlines the site preparations undertaken under the site Licence.	The Licence Holder has not performed any activities excluded from the site licence. Satisfactory compliance.
5.2 Type of facility	ANSTO notes and will comply	Satisfactory compliance.
5.3 QA System	ANSTO notes and will comply	Satisfactory compliance.
5.4 QA Auditing	ANSTO quality management system, including the RRR Project, is certified to AS/NZS ISO 9001:2000. INVAP and JEHDQMS to ISO 9001:1994.	Satisfactory compliance. ARPANSA recommends that upgrading occur of contractors' QMS certifications to the current AS/NZS ISO 9001:2000.
5.5 Buffer zone boundary and land use	A revised Buffer Zone Plan of Management was developed and accepted by Environment Australia.	Satisfactory compliance.
5.6 Radiological Characterisation	Three monitoring systems have been installed for airborne gamma characterisation.	ARPANSA expects the radiological characterisation to include monitoring programs and results for air, surface water, groundwater and soil.
5.7 (a) Topography and food production review	Analysis of data is expected to be completed in the first quarter of 2002.	Progress noted. ARPANSA expects the results of this review will be available for the next compliance report and incorporated into revisions of the PSAR.

Table 1 ANSTO Compliance with Site Licence Conditions as at March 2002

Licence Condition	Summary of ANSTO Action	Regulatory assessment finding
5.7 (b) Population Distribution	Population distribution analysis will be revisited when 2001 Census information becomes available in July 2002.	Progress noted. ARPANSA expects these updated data will be available late in 2002 and incorporated into revisions of the safety case.
5.7 (c) Groundwater	Final sampling and analysis to be completed in first quarter of 2002	ARPANSA has received the latest information dated 25 February 2002; refer to the discussion of compliance with the Environment Minister's conditions 2 and 11.
5.7 (d) Flooding and Stormwater	Construction Environmental Management Plan and Stormwater Control Plan submitted to ARPANSA	ARPANSA received these plans on 29/11/01 and 28/09/01 and notes that Environment Australia has approved or accepted them.
5.7 (e) Seismic Hazards	Consolidated report on methods, criteria and analysis for seismic qualification submitted 30/11/01. Initial investigation of local seismicity completed.	These additional reports and investigations have confirmed the upper bound for the seismic design basis. ARPANSA expects this information to be incorporated into revisions of the PSAR.
5.7 (f) Seismic – Experimental Guide Hall	Refer to PSAR chapter 4.	ARPANSA is satisfied with the information in PSAR Chapter 4.6.2 and response to reactive review question 4.2
5.7 (g) Water Tower	Matter resolved as not relevant to RRR.	This condition has been satisfied.
5.7 (h) Liquid Discharges	ANSTO is constructing a new waste treatment plant.	Noted. ARPANSA expects that identification and assessment of critical group doses from liquid discharges to be included in any revisions to the safety case and in the Trade Waste Agreement.
5.8 Communication Tower	Condition satisfied	This condition is satisfied.
5.9 External Events	ANSTO is committed to ongoing monitoring of external events	ARPANSA is currently satisfied with the compliance statements and commitment given in PSAR 3.3.2
5.10 Design Bases	Refer to PSAR	ARPANSA is satisfied that PSAR chapters 3, 4, 14, and 16, and responses to questions (eg 4.23 on wind loads) appropriately take account of the listed items (a) to (h) affecting the design bases of the facility.
5.11 Quarterly reporting	Nine quarterly reports produced to date	ARPANSA is currently satisfied with the Licence Holder's compliance reporting.

Based on the compliance reports and the application document, I am satisfied that the RRR proposal for which I issued a licence to site is entirely consistent with the proposal now before me as an application for a licence to construct.

The current application does seek to slightly expand the site for the RRR. ANSTO seeks to extend the facility site to provide some additional area for use during construction, carparking during operation and as intruder protection. This is a minor amendment that appears to increase the security of the site and I see no difficulty with this proposed additional area being included in the site. I have amended the site licence accordingly.

8.3 The directions of a new framework for protecting the environment

As I discussed in section 2.3, international best practice is beginning to evolve away from the view that protecting humans protects the environment. There is a framework being discussed about direct and separate assessment of the impacts of radiation on non-human biota.

The general working assumptions being developed are based upon conclusions that amounts of radiation of the order of 1 mGy d⁻¹ is unlikely to harm terrestrial ecosystems, 10 mGy d⁻¹ is unlikely to harm aquatic ecosystems. A Gray (Gy) is a measure of the energy imparted by radiation. There would be 'reference organisms' determined and assumptions made about their uptake of radiation from a facility or practice. If the doses are well below those mentioned above, no further assessment is required; if not, more detailed approaches would need to be used.

I have no reason to believe based upon the low level of discharges from the RRR that the threshold values will be approached. The developing approach will be kept under review and if further consensus is arrived at, it might be appropriate to verify this conclusion by more careful assessment and calculation.

PART NINE – MANAGEMENT OF THE DESIGN AND CONSTRUCTION

9.1 Approach to this issue

I have assessed the arrangements that ANSTO has put forward for its overall management of the project. The major issue is that whilst ANSTO is the applicant, the design and construction of the facility is contracted to INVAP SE. INVAP, in turn, has contracted with other companies – JHEDI for the civil works, but also other companies in different parts of the world for the design and construction of various items, most with some safety significance.

I sought assurance that ANSTO's contract with INVAP would permit ANSTO to fulfill its responsibilities under any construction licence, and that ANSTO would have the capacity to require INVAP and other sub-contractors to take any action necessary to permit ANSTO to meet its obligations under any licence.

In addition I reviewed the issue that, in my view, lies behind the issue of compliance capacity – the safety culture of ANSTO and INVAP.

9.2 ANSTO management of the project

The application sets out the organisation of the project within the ANSTO structure in a project management plan. There is a project core team responsible to the ANSTO Executive Director made up of the project manager, engineering manager, safety and licensing manager, tests and trial manager, construction manager and a quality assurance co-ordinator.

The ARPANSA staff followed up with ANSTO on a number of issues arising from this structure. It was concluded, after some clarification, that the project management plan adequately defines the responsibilities and lines of authority so as to exercise effective control over the detailed design, construction and commissioning of the reactor facility. I accept this assessment based on my understanding of the contract provisions as discussed below.

The position of project manager is key. ARPANSA staff and I have a high opinion of the project director associated with the application, but note that he is leaving the project to take up another post. It will be vital that a capable and experienced project manager is appointed in his stead and I understand that arrangements are proceeding.

9.3 The contract provisions

I sought and obtained a copy of the INVAP SE contract from ANSTO (without the pricing provisions). This was provided on the basis that it was kept secure and accessed only by myself and several other staff.

The central relationship is between ANSTO and INVAP and that relationship must change over the period leading to the operation of the reactor. INVAP is the designer and constructor, but ANSTO must fully accept the design and accept it as its own, otherwise one could not be confident of its ability to operate it. Both sides of this

equation must have the capacity to fill their roles during the construction phase in a way that supports safe operation of the facility.

The contract between ANSTO and INVAP SE (the contractor) was entered into on 13 July 2000. The contract is a design and construction contract. INVAP are project managers for the construction phase and has contracted with a joint venture between John Holland Group Pty Ltd and Evans Deakin Industries (JEDHI) to carry out the construction works. The contractual relationship is explained in Chapter 18 of the PSAR. Under the contract, management of the construction site safety, security and the environment during construction and cold commissioning is the responsibility of the contractor. ANSTO will review and verify the process, products and monitor performance under the contract.

As the contract is based on the delivery of certain specified works to predetermined levels of performance, ANSTO will review and verify the process, products and monitor performance under the contract. INVAP is providing contract security to the value of 10% of the contract sum until contract performance acceptance tests have been satisfactorily completed.

Under clause 51.1 of the contract covering the procedure on default of the contractor, the contract specifies the procedure to be followed. If INVAP defaults in the performance or observance of any condition of the contract, ANSTO may call upon INVAP to show cause why ANSTO should not take over the work to be completed or cancel the contract. If INVAP fails to show cause to the satisfaction of ANSTO as to why such measures should not be taken, ANSTO may proceed to take action against INVAP. Similarly if INVAP notifies the Project Manager in writing that it is unable to unwilling to complete the works or remedy the default, ANSTO may either take over the work to be completed or cancel the contract.

Should ANSTO elect to complete the whole or part of the work remaining to be completed, it may employ any person or persons other than INVAP to carry out that work. In that context the provisions of the contract provide for ANSTO to contract directly with INVAP's subcontractors, including consultants.

The contract also makes provision for bankruptcy proceedings. If INVAP takes or has taken or has instituted against it any action proceedings that may result in it being wound up or a receiver appointed to carry on its business for the benefit of its creditors, ANSTO may take an action against INVAP. The contract also allows for ANSTO to take over the work to be completed by INVAP and cancel the contract.

I am satisfied that there are appropriate mechanisms in the contract to enable ANSTO to manage the performance of INVAP and ensure its obligations under the licence are met.

9.4 Compliance capacity of INVAP and other contractors

From the time the contract was awarded to INVAP, there has been questioning of the company's capacity to design and construct the RRR. One might, charitably, put some of the reaction down to the general dearth of contact between Australia and Latin America. Some reaction seems to have gone beyond that.

It needs to be said that to date, on the information available to me, INVAP has delivered the goods. There is criticism of the design, of course, but my assessment and that of other reviewers is that it and the surrounding documentation is of evidently high quality. Contacts between ARPANSA staff and the INVAP design team have uniformly been good (I visited the team in Bariloche in December 2000). The INVAP staff have been across the issues in discussions, very willing to debate and discuss matters with the ARPANSA staff and very open in doing so.

To ensure that I have control over the contractors on the site, including for security purposes, I intend to propose to the Minister that a Regulation be made under the ARPANS Act to prescribe the site.

There have been questions about INVAP in relation to its contract to design and construct a research reactor in Egypt. The matter has been the subject of press articles in Australia. Certainly, there are issues between the Egyptian Atomic Energy Authority (EAEA) and INVAP about this reactor, called ETRR 2. The IAEA has been involved in a mission to review the circumstances and propose some ways forward. In September 2001, the director of ARPANSA's regulatory branch and I visited Egypt for discussion with the Egyptian authorities and to inspect ETRR 2. We have also raised the matter with INVAP.

There are reasonable similarities and some differences between ETRR 2 and the RRR. Both ETRR 2 and the RRR are pool reactors of around 20 MW power, designed for irradiation of materials and the production of radioisotopes and neutron beams. Both share design features such as a chimney surrounding the core, a warm water layer, control rod drives from below the core, heat removal systems and plant layout and configuration. It is also important to note that there are significant differences flowing from the different roles and priorities of the two operating organisations.

The ETRR 2 is constructed and appears to be a quite impressive installation. There do appear to be contractual issues between Egypt and INVAP regarding the issue of completion and handover. There are also some issues that relate, at least potentially to safety, that are still the subject of debate between INVAP and the EAEA. We took note of those issues and the ARPANSA staff has taken them into account in the assessment of the RRR design.

My assessment is that there is a complex of reasons that mean that the ETRR 2 project is not yet fully successful from the point of view of Egypt and INVAP. The situation does illustrate that the issue of the hand over between the designer and the operator is quite complex and potentially legally fraught. The Australian contract is clear on this issue. There are also legitimate reasons for debate between the EAEA and INVAP about performance and safety related issues. But I did not draw from this any suggestion that INVAP is not capable; rather that expectations between the two sides were not consistently understood throughout the project.

I have also turned my attention to the possible impact on INVAP of the crisis in the economy of Argentina. The past several months have been exceptionally difficult for that country, with political crisis accompanying severe economic difficulties, with consequences through the banking system for ordinary people, middle class as well as the poor, and for the ability of companies to do business. It is forecast that Argentina's

GDP may contract by 8% or more during 2002. The peso has fallen from US\$1 to US\$0.295 since 1 January 2002 (falling similarly against the A\$).

In assessing any impact of this crisis on INVAP's capacity to meet the safety requirements of the contract, it is worth remembering that there have been other economic difficulties in Argentina in the past two decades. The economy has been in recession for the past several years and during the late 70's and 80's there were two bouts of hyperinflation and two banking collapses. INVAP points to having survived these difficulties, though not always completely unscathed.

INVAP is formally owned by the province of Rio Negro, though there is provision for majority equity to be taken up by the National Commission of Atomic Energy (CNEA). Effective control at board level is exercised by the CNEA in that it appoints the majority of the board (though these are not usually CNEA employees). This arrangement is not a familiar one in Australia – but I interpret it as being that INVAP was spun off as a commercial venture from the CNEA many years ago, the particular company structure involved being one employed in Argentina.

ARPANSA staff and I reviewed the documentation about INVAP's commercial position that had been assessed by ANSTO during the pre-qualification and tender evaluation phases. There are also other measures in place in the management of the contract – INVAP insurance policies are kept under review; the annual company financial reports are reviewed; payments under the contract are carefully assessed; ANSTO has exercised options in the contract with regard to payments to suppliers; and ANSTO has a 10% contract performance guarantee redeemable on an Australian bank.

For its part, INVAP points to its successful operation for 26 years, including through the difficult economic times mentioned above. It stated that it does not rely upon any form of subsidy and that its operations on the RRR project are fully funded by the contract payments. It manages a significant number of sub-contractors on the project and none of them have brought forward any claim that INVAP has not met the terms of their agreements.

The most recent controversy has arisen from a provision being made in the new budget of the Argentine federal government to the effect (translated by INVAP):

'this article makes provision - - - for a sum to be reinstated by and in favour of INVAP SE, for a grand total of 12 million of pesos, destined to guarantee advance payments and up front financing of exports committed as part of its Contract with the Australian Nuclear Science and Technology Organization (ANSTO). To such effects, the Chief of Cabinet is sufficiently empowered in order to make the necessary modifications into the federal budget to accomplish with the dispositions above and, to precise the conditions and dates for repayment'.

My reading of this is that the provision is a facility that can be drawn upon by INVAP for the purposes described and that it is repayable. The terms and conditions are, presumably, to be settled when and if it is needed.

I am not surprised that a company dependent upon project payments may need a draw-down facility. And in the context of the impact of the Argentine crisis on the commercial banking system, the fact that the federal government has supported INVAP this way would seem to be a positive.

On my request, ANSTO supplied INVAP's most recent audited accounts with projections for the current and future years, together with an analysis of these accounts by ANSTO.

I consider that INVAP as a project design and construction company does not have a large cushion of cashflow from some ongoing and steady activity, nor very substantial shareholder equity (which is diminished in \$A terms by the devaluation of the peso). It has limited capacity to absorb financial risks and it appears that the ANSTO contract represents a significant portion of INVAP's total business. I find it difficult to be conclusive about the company's current state, nor to have any clear idea of how the unfolding events in Argentina may affect it. It is not clear how the considerable devaluation of the peso has affected INVAP's position overall.

Based upon all the evidence above, I am of the view that ANSTO has taken all prudent steps that will protect the contract arrangements from the effects of the crisis in Argentina. It is not possible to predict the future with entire confidence, however, and I have imposed a licence condition requiring ANSTO to inform me if the contract is terminated or there is any instance of default under it and to provide contingency arrangements to me for approval before implementation.

One of the most important risk from the point of view of safety would be the loss of key personnel from the INVAP team. ARPANSA's interest in this respect coincide with ANSTO's interest and I note that there is a provision in the contract requiring ANSTO's approval of changes of key personnel. I have made a licence condition that ARPANSA is informed of such key changes – should these raise issues of safety, I would intervene.

9.5 Safety culture

As mentioned in section 2.4, safety culture is defined by INSAG as:

'that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance'²².

This definition of safety culture has two general components. The first is the necessary framework within an organisation – this is the responsibility of the management. The second is the attitude of staff at all levels in responding to the framework. While this latter aspect does devolve to individuals, the senior management of the organisation must set the overall tone.

The regulatory body also has a role to play in fostering a positive safety culture in an operating organisation.

²² 'Safety Culture', A report by the International Nuclear Safety Advisory Group, (INSAG – 4), Vienna 1991

Safety culture as a separate concept did not particularly figure in the public submissions, the peer review, or the report of the NSC. There was the related criticism from the NSC that human factors were relatively neglected and some discussion in the public forum suggested that ANSTO management had an overly defensive attitude that may result in a reluctance to face and deal with safety issues that might cause public criticism.

During the period of consideration of this application, there has continued to be safety incidents reported at ANSTO - after each of these the criticism is made that ANSTO is not capable of operating the RRR safely.

In my decision on ANSTO's application for a licence to site the RRR, I stated that:

'I am satisfied that ANSTO does have a long track record of operating the HIFAR reactor safely and is a sophisticated organisation, familiar with contemporary nuclear safety culture.' and

'Paradoxically, an organisation with a strong safety culture will discover more 'incidents', than one with a poor regard for safety practices. The important thing is that events are examined and the lessons learnt. Building a safety culture is a matter of continuous improvement and I believe that ANSTO has demonstrated by its past conduct and the matters contained and addressed in the application that it is committed to this task.'

This is still my overall view. My experience with ANSTO, supported by the experience of ARPANSA staff, is that the mechanics of safety culture are well embedded in the organisation at the level of policy and overall commitment. This has translated very effectively to the working level in the operation of HIFAR; somewhat less so in some other parts of the organisation. There is some defensiveness exhibited that affects openness and transparency at times and this tendency needs to be kept in check.

There will be challenges to safety culture during the construction and commissioning of the RRR – the organisation will be under pressure. This will be a matter that I will keep a close eye on during the period.

PART TEN – THE APPLICATIONS OF THE REACTOR

10.1 Medical applications

Radiopharmaceuticals are used for both diagnosis and therapy in relation to a number of conditions. The PSAR refers to a statement that the '*diagnostic use of radiopharmaceuticals is now reaching its maturity, whereas therapeutic use is comparatively in its infancy.*'

The 'workhorse' of nuclear medicine diagnosis is the isotope technetium-99m. It is said to be used in 80% of nuclear medicine procedures world-wide. This is to be produced by the RRR by the generation of molybdenum 99, a fission product isotope resulting from the irradiation of targets containing U235. The RRR's irradiation facilities and radioisotope handling facilities are described in Chapter 11 of the PSAR.

The standard product for dispensing technetium-99m is a molybdenum-99/technetium-99m generator. Such generators have effective lifetimes for the production of technetium-99m of 14 days. Clearly for such generators and for a number of other important radioisotopes, including iodine 131, ANSTO is subject to overseas competition. Currently, ANSTO claims to have about 85-90% of the market.

Other radioisotopes that are useful for diagnostic and therapeutic purposes are listed in section 1.6 of the PSAR.

I read the discussion of medical applications in the Research Reactor Review, in the EIS documents, and in the recent Parliamentary inquiries. While there is a vigorous discussion of alternative sources for medical radioisotopes, there is (almost) universal acceptance that nuclear medicine does provide substantial benefits to the community.

It is difficult to forecast the future – the application of nuclear medicine has been increasing rapidly in recent years. In its diagnostic role in many conditions, it is used in conjunction with other modalities – ultrasound, CT, X rays, MRI. It is possible that improvements in some or all of these technologies will diminish the role of diagnostic nuclear medicine in the future. Or the reverse could happen. Hence, the assessment of the benefit of this application of the RRR cannot be a once-for-all event.

10.2 Scientific research and education

The RRR is designed to produce large neutron fluxes available through cold (low energy) and thermal (medium energy) sources to research instruments that are sited adjacent to the reactor in the reactor beam hall or at greater distances in the neutron guide hall. Section 1.6.2 of the PSAR briefly describes the research applications of neutrons in physics, chemistry, materials science and biology. It states that 8 instruments have been selected to be available for the initial operation of the facility proposed for 2005.

The RRR's neutron beam facilities are described at section 11.5 of the PSAR.

ANSTO makes a persuasive case of the value of research using neutrons in the EIS documents. It appears that the research fields that will benefit from having the facility are those very much in the cutting-edge of technological development. I note that the proposal is supported by the Australian Academy of Sciences, amongst others.

Again, in the discussions recorded in the EIS process and the Parliamentary inquiries, there are alternative sources of neutrons suggested and alternative approaches ('suitcase' science). Some also suggest that other fields of science would be more appropriate and yield more benefit for an investment of this size. I acknowledge these arguments, but I do not believe that they establish that there are not significant benefits from neutron research for Australia at this time.

Again, this cannot be a 'once-for-all' assessment.

10.3 Industrial applications

The industrial applications described in chapter 1 of the PSAR include: silicon doping for use in silicon chip manufacture, neutron activation analysis, the preparation of radioisotopes used in environmental tracer studies and industrial radiography, and neutron radiography.

The irradiation sites used for these applications are described at section 11.4 of the PSAR.

These applications are straightforward and provide clear benefits – they are essentially market driven.

10.4 National interest

The application states that the facility is intended to:

'maintain Australia's nuclear technical expertise in order to provide sound advice to Government in support of nuclear policy issues of strategic national interest and international obligations in this area.'

I am aware that this objective is a prime justification for the RRR, albeit that the necessity of building the RRR to achieve the objective is debated. This is a form of 'background' application in that it does not lead to a defined program of work for the RRR itself, though no doubt such work may arise from time to time.

PART ELEVEN – PUBLIC SUBMISSIONS

11.1 Introduction

The process of seeking public submissions and the number and nature of the submissions received is described in section 1.2. I have read the substantive public submissions and the form letters and considered the issues raised in them. In this part, I draw out what I consider to be the most significant and relevant of the issues raised in the public submissions and respond to them.

I received 10,619 first round submissions. Of these, 10,259 were identical letters. All the submissions were logged and were analysed by ARPANSA staff to identify specific issues. I have personally read the substantive submissions and the form letter received.

I received 60 second round submissions. There were 23 form letters (another 202 being received on 18 January). Again, I have read personally all the substantive second round submissions and the text of the form letters.

I was, of course, present at the public forum and I subsequently reviewed the transcript carefully. I believe that the significant, relevant issues raised at the forum are captured in the reports from the three panellists and I have set these out and responded to them.

11.2 Major issues in public submissions

All submissions were analysed to identify the issues that they raised. A total of 176 issues were identified in the first round public submissions. The majority of the issues in the first round public submissions related to the following:

- **Net Benefit**: Some respondents felt that there is no need for the RRR as scientific research can be done overseas and radioisotopes can be imported or produced by other means
- **Spent Fuel and Radioactive Waste**: The capacity of French and Argentinian entities to reprocess spent fuel was questioned. The need for certainty in radioactive waste storage plans was stressed
- **Site Characteristics**: Issues included the effectiveness of the 1.6km buffer zone around the LHSTC and public exposure to discharge gases
- **The Reactor**: Respondents were concerned about power distribution in the core, reactor controls and shutdown systems and thermal and hydraulic design in relation to possible control plate withdrawal accidents.
- **Engineered Safety Features**: Concerns included the effectiveness of the second shutdown system and the adequacy of the reactor containment systems.
- **Auxiliary Systems**: Issues included design of the fuel storage and handling and fire protection systems. The heating, ventilation and air-conditioning systems were addressed in relation to Argon-41 emissions.

- Operational Radiological Safety: Concerns included dose estimates for normal operations and reports of higher cancer rates among people living near nuclear reactors.
- Conduct of Operations: Respondents were concerned about staff qualifications and training.
- Environmental Assessment: Respondents claimed that ANSTO had not complied with all the conditions imposed when the Environmental Impact Statement (EIS) on the RRR was approved.
- Safety Analysis: Issues included seismic activity levels, human error, loss of flow events and sabotage.
- Probabilistic Safety Assessment: The adequacy of the PSA was questioned in relation to risks, including those from internal fires, aircraft crash, vehicle bombs, earthquakes and human error.

The 60 submissions received in the second round by 11 January 2002 include 106 issues pertaining to the 10 questions in the Issues Paper. Below is a summary of the questions raised:

Accident Analysis

- The adequacy of the PSAR, in particular whether a loss of coolant accident had been designed out.
- Whether the Probabilistic Safety Assessment (PSA) sufficiently demonstrated a balanced design. The risk analyses does not take account of the wide variation in possible disasters.
- Critical points during construction when design details and assumptions in the accident analysis must be verified.
- Information and assurances needed to satisfy public concerns on terrorism and sabotage threats while keeping security arrangements confidential.
- The need for more analysis of the joint operation of HIFAR and the replacement reactor should the full commissioning of the latter be delayed.

Seismic Analysis

- Whether ANSTO's analysis has taken account of various Lucas Heights seismic siting studies and seismic hazard estimates and whether the studies and estimates are conservative and consistent with world's best practice.

Spent Fuel and Waste Management

- Whether ANSTO has demonstrated that molybdenum fuel will soon be available or that silicide spent fuel will be able to be managed.
- Whether there should be an option for the handling of spent fuel entirely within Australia.
- The degree of progress with the national waste repository and national waste store before construction and operating licences may be granted.

- Adequacy of strategies to monitor and control radioactive discharges to ensure that radiation doses to the public would be as low as reasonably achievable, social and economic factors taken into account.

I have taken all these issues into account and discussed them at the appropriate sections of this document.

11.3 Public forum - Reports from forum panellists

11.3.1 Dr Bob Budnitz

Dr Budnitz addressed a number of issues stating that they were not in order of significance, but roughly in order in which they were raised in the forum. These were:

- The review of security issues. Dr Budnitz advocated public release of additional information, suitable for the public domain, dealing with the general categories of threats considered, the types of measures used; the types of analysis carried out and so on. I have included what material I can as a part of this decision and I may be able to release consequence analyses shortly.
- Emergency preparedness. This was a matter debated at the forum, sometimes on the premise that it was planned that there not be off-site emergency arrangements. This has not been ARPANSA's intention and my approach to emergency arrangements is set out at section 6.6.
- Accident analysis. Dr Budnitz advocated the release of consequence analyses, including to demonstrate that the view that there will be significant consequences out to 80 km from the reactor are not justified.
- Earthquake safety – pool integrity. Dr Budnitz emphasised the special safety role of the pool and focussed on the need for ARPANSA to be satisfied with the pool integrity with a significant margin above the SSE. This subject is discussed at Part Five of this decision.
- The PSA. Dr Budnitz pointed to criticisms that he and others have made of the PSA and asks that ARPANSA review the PSA with those issues in mind. It needs to be borne in mind that development of the PSA needs to continue as a living tool for design, construction and operation. Dr Budnitz also raised, in this context, the seismic capacity of the control-rod drives and the issue of earthquake-caused fires. The former issue is dealt with in Part Five and the latter can be taken up in the future development of the PSA.
- Spent fuel conditioning abroad. Dr Budnitz made clear that ARPANSA needs to assess the safety of such operations in France and Argentina. I agree with this. I have had discussions with DSIN and assess that the La Hague facility is very well operated and regulated from a safety perspective and DSIN do not have technical problems with authorising the reprocessing of research reactor spent fuel. I have confidence in the Argentine regulator, but the specific arrangements have not yet been assessed.
- The Egyptian reactor's safety record. We have learnt from this and both INVAP and the Egyptian authorities have been open and frank with us. See the discussion at section 9.4.

- Operating HIFAR and the RRR together. This will be an important issue that will need to be considered carefully at the time of any application for an operating licence for the RRR.
- Impact of potential accidents on property. The issue is the contamination of land and property in an accident where the immediate public health consequences are not large. The modelling of accidents includes the modelling of surface contamination and this matter is discussed there.
- Transport accidents. This is discussed at section 7.4 above.
- Acceptable vs achievable levels of safety. Dr Budnitz made the point that regulation is and should be based on the former, not the latter and that this should be explained to the public. I agree and that is what I have tried to do in section 2.3 'What is 'Without Undue Risk?'
- Safety performance of the radioactive waste surface store. Dr Budnitz makes the point that the store should be demonstrated to have a safe effective working life of well beyond 50 years. I agree and will raise this matter with the Minister for Science.

11.3.2 Mr Garry Schwarz

Mr Schwarz presented 6 major issues arising from the forum in his report.

- Spent fuel and radioactive waste management. He suggested that ANSTO should update the information in the public arena that gives it confidence in its strategies. I have laid out my view of those strategies in this decision and it may well be useful for ANSTO to put out some form of statement on the issues at the appropriate time. Mr Schwarz also makes the very useful point that *'as technology continues to evolve and governments reconsider current policies, a change in the approach for the management of RRR spent fuel over the lifetime of the RRR is a possibility. It is my opinion that any change will tend towards decreasing the risk associated with spent fuel management to the public and the environment.'* I think this is a very well-taken point.
- Security Threats. Mr Schwarz commends the carrying out of an analysis of the consequences of a deliberate large aircraft crash, noting that the atmospheric dispersion caused by the large fire resulting may limit the consequences. He suggests that a bounding accident that might arise from other sabotage events should also be undertaken. This analysis is discussed at section 6.5. Mr Schwarz also makes the vital point that it is important not to allow 'acceptable' consequences of these bounding analyses to limit the degree to which the design is required to limit the likelihood of their occurrence.
- Emergency Response Plan. Mr Schwarz makes it clear that there does need to be a public emergency response plan, irrespective of the PSAR analysis that would indicate that off-site consequences are not such as to require such a response. I agree with his view – an emergency response plan is the final level of defence in depth, it is international best practice, and provides added confidence to the public that they are being protected. Mr Schwarz proposes that the reference accident for emergency planning be based upon a bounding security accident or upon the HIFAR accident. His view is that the accident basis for the plan should be settled before the construction licence is issued, but that the plan itself could be developed

during the construction period. I agree with the general approach that Mr Schwarz has suggested, but my view is that there needs to be further consideration of the basis for emergency planning and have required that the arrangements be subject to independent review. Again, Mr Schwarz makes the important point that designers cannot be let off the hook of achieving safety at earlier levels of defence in depth through the existence of emergency response plans.

- Accident Analysis. Mr Schwarz states that : *'from the discussions at the Forum and my own look at the PSAR, I am of the opinion that the RRR safety analysis needs to include events that are more demanding of the safety features to better demonstrate their adequacy and the defence in depth of the RRR. This would give the regulator and the public more confidence that the plant is safe, and has a good measure of defence in depth against radiological consequences to the public'*. This was also my view and the view of the ARPANSA staff that resulted in ANSTO carrying out the analysis of further 'events of interest' described above at section 6.3. Mr Schwarz specifically raised the analysis of fuel blockage suggesting that the analysis of the consequences of a total flow blockage of a fuel assembly would give assurance that even if such an event were to occur, the reactor is adequately protected and the consequences to the public are acceptable. The analysis may also provide further insight into such an event, which could lead to additional design or administrative measures to further minimise the likelihood of its occurrence. This is also discussed at section 6.3.
- PSA. Whilst commending the carrying out of the PSA and the further developments proposed, Mr Schwarz is of the view that an in-depth peer review by an individual recognised as a specialist in the field of PSA for reactors should be carried out, before the construction licence is issued. I would prefer that the PSA be updated and developed in the first instance – a peer review of it would be appropriate at this later stage and before the final SAR.
- Design. With regard to the stage that the design should have reached by the time of the construction licence, Mr Schwarz states that: *'the design should be advanced to the extent that the regulator can have reasonable assurance that no significant design changes will be required following the issuance of the construction licence. In particular, the resolution of any remaining issues pertaining to the safety of the plant is not expected to result in the need for important design changes'*. I agree with this general statement and it forms the basis of the judgements made in this decision. As Mr Schwarz acknowledges, the judgement of the individual regulator needs to be made against this criterion. He goes on to emphasise that all safety significant issues relating to shutdown systems must be satisfactorily resolved before issuance of a construction licence. I agree with that view and that was the reason further analyses of the performance of the shutdown systems was sought by ARPANSA staff. These are reported at section 6.3.

Mr Schwarz goes on to raise two issues that were not raised at the forum:

- Staffing and Training Program. He suggests that a program for staffing and training for the operating stage should be established at the construction licence time. I agree, as do the ARPANSA staff, that this is a very important issue that cannot be

left until late in the piece. I have imposed a licence condition requiring the development of such a program against a timetable to be agreed.

- Configuration Management. This is the system that ensures that the design and other documentation is brought up to date as changes are made and that changes receive the level of approval that their safety significance requires. Mr Schwarz suggests that a system needs to be in place prior to the issuing of a construction licence. I have imposed a licence condition requiring a system for change control be established.

11.3.3 Dr Bill Williams

Dr Williams states a view that the proposal does not meet a number of criteria drawn from the Act, the Regulations, an ARPANSA staff document prepared for my review of the site licence application and the Minister for the Environment's conditions. He discusses the issues in five parts making five recommendations.

*Recommendation 1 – Further consideration of the application requires full documentation including radiological consequence analysis for major explosive impact on a suburban 20-megawatt pool-type reactor and spent fuel storage facility. This documentation should be made available to the public and subjected to detailed **independent** expert analysis as part of the construction licence application assessment. This assessment should include re-visiting the issues of design and defence-in-depth and must re-address 'siting assessment.*

I have common ground with Dr Williams in agreeing that the consequence assessment for a successful aircraft and other sabotage attack should be undertaken and these analyses have been reported in this decision. I was sufficiently confident in the approach taken to these analyses not to seek independent peer review at this stage – the most precise calculations are not needed at this stage and the work that has been done, as discussed in section 6.5, gives a good indication of the magnitude of the consequences.

I agree also with Dr Williams' discussion that further work and analysis will be carried out overseas and that 'international best practice' in this area will develop.

Recommendation 2 – In the light of the independent public review recommended in (1) above, the details of planning for an emergency response to a serious radiological emergency must be re-assessed – independently. This would include consideration of extensive distribution of potassium iodide, advice re preparation for and potential duration of sheltering, upgrading of medical (radiological) response capabilities and detailed evacuation instructions. The issue of grazing animals and property contamination must also be considered.

This issue was canvassed at the forum and doubt was cast on the degree of present planning and the need for future emergency plans. I have no difficulty with Dr Williams' general description of the elements of emergency planning that should be in place – and indeed these exist to a greater or lesser extent in current plans. I note that medical responses are only likely to be needed for deterministic exposures, highly unlikely for off-site exposure in any circumstances (though possible for workers in

worst circumstances). I have discussed in section 6.6 the approach to emergency planning that I will ensure is applied.

Recommendation 3 – ANSTO must document finalised authorisations for spent fuel rod processing in specified facilities that are currently engaged in an equivalent process. In line with the recommendation of the Senate Committee (May 2001), ANSTO should prepare and fully cost a contingency management plan for spent fuel conditioning and disposal within Australia.

These matters were certainly very fully canvassed in the forum and Dr Williams' recommendation encapsulates a strong body of opinion at the forum and in public submissions (and the report of the Nuclear Safety Committee). I have given a great deal of thought to this issue and I have set out my views and findings in Part Seven.

Recommendation 4 – ARPANSA should stipulate that DITR demonstrate public acceptance, local authority acceptance and State Government acceptance of the proposed National Store and consequent issues. Site finalisation and public environmental assessment should be mandatory before granting a construction licence and thus legitimising the production of further long-lived radiological toxins.

I agree with what I see as being Dr Williams' position that the site for a national store should be determined through a step-wise fully consultative process that seeks the acceptance (at the least) of the local community involved and also basic public support, including at State level. Environmental assessment must, of course, be mandatory. This is an inherently political process that will take time, even allowing for the fact that Australia's store is small by comparison with those required for power and weapons countries. This notion of a step-wise and consultative process is becoming international best practice and I have recommended it in my letter to the Minister for Science.

Where I have differed with Dr Williams is in the timing. This is an issue that must be being tackled at present with a way forward foreseen. But it will take time. But it has time as far as the RRR is concerned, with spent fuel residues not required for long-term storage until the mid 2020s. I believe that the siting criteria for a store are not so rigorous – especially in view of its size – that there cannot be many sites considered and contingencies examined and discussed with communities. This is a solvable problem, with time.

Recommendation 5 – ARPANSA should call for a re-assessment of the costs and benefits of a RRR, taking heed of the findings of the Senate Inquiry, which recommended an independent public inquiry. Experts from senior scientific bodies such as CSIRO and ASTEC, as well as senior representatives from medical science would be able to provide an updated analysis, and thus advise ARPANSA (and the Commonwealth Government) re this issue of 'net benefit'.

I acknowledge Dr Williams' view that the balance with regard to 'net benefit' may have shifted somewhat in the light of the risk of terrorist activity and while this may be so, I do not find it to have done so to a significant degree on the basis that proper steps to secure the facility are taken. I also accept Dr Williams' point that the balance may change over time – I agree that the assessment of 'net benefit' cannot be 'once for all.'

PART TWELVE – REPORT OF THE NUCLEAR SAFETY COMMITTEE

12.1 Report on seismic analysis and seismic design

The working group formed by the Committee to deal with this issue examined the seismic hazard evaluation for the RRR site. As noted above in Part Five, there has been a good deal of effort put into this

The working group went into this important issue in some detail and appears to be satisfied with the outcome – except for one detail, namely, the ‘damping factor’ used for the hazard curve. Damping is a measure of the energy dissipation in a vibrating body – if there were no damping, it would continue to vibrate. Damping values are given as a percentage of ‘critical damping’, that is the value that would make the vibration die out almost immediately. The IGNS seismic hazard curve was presented including a damping factor of 5% - when ANSTO combined it with the earlier hazard curve it used (see section 5.2), it did so using a damping factor of 7%. The working group recommends that *‘a solid and simple explanation is recommended from ANSTO as to how they claim the bounding process works. To achieve transparency and verify conservatism, external review is recommended’*.

I understand that the working group did find it difficult to obtain a solid and simple explanation – but my understanding, based upon the seismic Consolidated Report and the report of the seismic expert who worked with ARPANSA staff, is that a 7% damping factor is the value used in the analysis of the vibration of reinforced concrete structures for the SSE earthquake as set out in the relevant codes and standards. Hence, it is applicable to analysis of the RRR building and other structures. Other damping factors are applied when other forms of structure and equipment are being considered and hence seismic curves are presented with an ‘average’ damping factor of 5% ‘built in’, as was the case for the IGNS curve.

The working group supported the carrying out of a seismotechnical study consistent with the recommendations of the relevant IAEA safety guide. This is being done – the first results show that there is no evidence of recent seismic activity in the vicinity. The next stage will be to examine the excavation to see if there are indicators of recent activity in the excavated layers.

The other recommendations made by the working group refer to the need for performance specifications in relation to seismicity for components critical to safety to be carefully monitored and assessed through the construction phase and for the testing of certain components to be carried out. I generally agree with and accept these recommendations and their intent will be incorporated into ARPANSA’s arrangements for approval of safety significant items.

12.2 Report on the review of accident analysis

12.2.1 Status of the PSAR

The first issue discussed by this working group is a fundamental one:

'The WG could not agree on the status of the PSAR in regard to the amount of information presented in the submission, and accordingly alternative views are presented. One view was that the material presented in the preliminary analysis was appropriate for the purpose, and is in compliance with IAEA Safety Series No 35-G1. The information presented is adequate to allow a decision to be made on whether construction should commence.'

A second view is that the submission refers to the 'frozen design' and contains advanced design and schematic drawings, yet the design specifications, particularly for the Engineered Safety Features, are not fully developed or presented in a structured manner. Due to this perceived shortcoming and the discursive nature of the design bases presentation, some members of the WG were not confident that sufficient information has been provided to allow a common interpretation of the bases for the development of the design specifications.'

It is certainly the case that the PSAR, which properly forms the heart of the application (and I assume the reference to 'the submission' in the working group's report refers to the application), complies with the guidelines in IAEA 35-G1 as noted in the first paragraph above. Also, as referred to in section 1.2, the IAEA peer review declared that the PSAR forms a suitable basis for making the licensing decision. I thus agree with the working group authors of the first paragraph.

I have struggled to appreciate the concern that lies behind the second paragraph. The information has been presented in the accepted format of a PSAR as ARPANSA expected. There may be alternative forms of presentation involving some other structured approach, but this does not negate the validity of the PSAR approach. It is acknowledged by all that there is further detailed design work to be done and the PSAR is indeed 'preliminary'. My view is that the PSAR contains sufficient information for me to make a decision on the construction licence, but that it will be necessary for the implementation of the design intentions to be examined as safety category items are ready for actual construction.

12.2.2 Human factors

The working group makes substantive criticism of the PSAR in regard to the treatment of human factors. Appendix A2 to the report describes some approaches to human factors in (presumably operating) nuclear power plants in the US overseen by the US Nuclear Regulatory Commission. The working group suggests that the spectrum of accidents assessed in the PSAR should be reviewed in the light of the human factors issues described in the appendix.

I think the criticism has validity, but is a little overstated. For example, simply to say that the section on human error in the accident analysis is less than three pages does not do the PSAR justice. The issues of human factors are discussed in relation to the set-up of the control room and the provision of information to the operators; and the PSAR is also alive to the issue of the man-machine interface. The initiating events used in the accident analyses are often likely to arise from human factors. The PSAR does commit all the organisations involved in the design, construction and operation of the RRR to the active support of the development of a safety culture. This is supported

at the organisational and individual level through establishment of a safety management system, specific training and appropriate procedures.

Having said that, I believe that the working group has made a helpful contribution in proposing that there be a review of the risks by a recognised human factors specialist with experience in the nuclear industry. My view is that this is something that should happen fairly early in the next stage of the process as the designers begin to finalise the detailed design and as planning commences for the operational arrangements for the reactor. I have imposed this on ANSTO as a licence condition.

12.2.3 Spectrum of accidents

The working group makes a number of recommendations about the spectrum of accidents considered (A5.2-A5.4).

In section 6.3, I have referred to the analysis of additional 'events of interest' requested by ARPANSA. I have also referred to the view of the PSA arising from the regulatory assessment by ARPANSA staff. These analyses also required separate and independent analysis of the effectiveness of the shutdown systems. These sections deal with a number of the issues raised by the working group.

Other specific issues with regard to the spectrum of accidents considered are:

- perceived ambiguity in regard to codes and standards. The working group notes that the PSAR seems to qualify the use of codes and standards. This arises because such codes and standards may cover a wider scope than is relevant to the RRR. The ARPANSA staff find that the standards used are related to the safety categorisation of elements of the design and in general a consistent set of codes and standards has been used
- the pool structure and the Reactor and Service Pool Cooling System (RSPCS) to be designated as safety category 1. The coolant boundary parts are designated as safety category 1 – other parts of the pool structure provide additional contributions to safety and are reasonably categorised as safety category 2 (which is still of high quality and built to high standards). ARPANSA staff debated with ANSTO whether the long term pool cooling system, which forms part of the RSPCS, should be category 1, but were convinced that category 2 was sufficient
- confirmation that fuel remains in a safe state if the containment is isolated for a sustained period associated with convection cooling of the core. This has been done for a period of 10 days, which I would regard as being adequate.

Finally, the working group makes some recommendations about the continuing validity of the reference accident used in the site licence decision. The matter of sabotage-induced damage is dealt with in section 6.5 above. The issue of the melting of an exposed fuel assembly was considered in the discussions leading to the choice of the reference accident. The consequences were calculated to be similar but it was judged by ANSTO to be less credible than the reference accident chosen.

12.3 Report on the review of spent fuel and radioactive waste management

12.3.1 Implications of uranium silicide fuel and changeover to uranium molybdenum fuel

I have discussed this issue at Part Seven above. The working group suggests that it appears that the earliest that U-Mo fuel will be qualified internationally for use will be 2005, and that there will be a further period of consideration by ARPANSA before approval could be given for the loading of the new fuel. The working group points out that this may have implications for the amount of spent U-Si fuel that will be generated by the RRR, and therefore for the capacity of COGEMA to reprocess the fuel and return the waste to Australia in vitrified form.

The working group recommends that ARPANSA monitors the situation and establishes appropriate advisory mechanisms at the time ANSTO applies for a licence to operate the RRR. The working group requests that progress reports on this matter are tabled twice yearly at NSC meetings.

The discussion at Part Seven is not inconsistent with the position taken by the working group. The points made are appropriate and I have no difficulty in accepting the recommendation.

12.3.2 Overall strategy for managing spent nuclear fuel from the RRR

The working group discusses this issue at some length, covering technical and legal/political issues. Basically, the thrust of the argument made is that there are potentially significant problems with each of the routes proposed for the management of spent fuel. These include:

- the technical difficulties that may arise if COGEMA is required to reprocess significant quantities of U-Si fuel
- the legal challenge to the current arrangements for dealing with HIFAR fuel in France that would flow on to the RRR fuel, if the challenge is successful
- the longer-term environmental challenge to reprocessing in Europe
- the legal and constitutional issues that may arise with regard to conditioning of RRR spent fuel in Argentina
- the lack of a clear and known arrangement for conditioning in Argentina and the waste-form to be produced.

In the light of these potential problems, the working group argues for another fall-back option to be developed that would involve some form of domestic conditioning of the spent fuel in preparation for long-term storage. The working group points out that options for direct disposal after packaging may emerge over time.

I found the working group's discussion to be informative and challenging. It is not inconsistent with my discussion of the issues at Part Seven. The working group, however, reaches the conclusion that it *'is not able to conclude that the Applicant has, to date, demonstrated the overall strategy for managing spent nuclear fuel - - - - is adequate'*. I do not agree with this conclusion – my own view is that the strategy for reprocessing in France and return of the vitrified waste is safe and acceptable. The

alternative of conditioning in Argentina is reasonable, though I concede that it is underdeveloped at this point and subject to more stringent reservations.

There certainly are potential problems with both approaches; of that, there is no doubt. And it would be foolish to believe that any single strategy can be guaranteed to last for the period of years under contemplation with regard to the RRR.

The working group recommends that I consider requiring ANSTO to report on a six-monthly basis on the various legal and technical issues associated with the options involving COGEMA in France and the use of facilities. I think this idea has merit and will arrange for appropriate reporting on these issues.

The working group also recommends that there should be a contingency plan submitted to ARPANSA by ANSTO for additional spent fuel storage arrangements and/or spent fuel conditioning in Australia. I deal with these issues in Part Seven.

It is also recommended that it be tested as to whether there is the need for additional storage for spent fuel over current operational requirement. I understand that this reflects the working group's view that circumstances might arise in which more than ten years' arisings of spent fuel might need to be retained on site. This is a matter that could be reviewed later, should the need appear likely to arise.

12.3.3 Systems for managing radioactive waste

A good part of the working group's discussion in this section refers to waste arising from radiopharmaceutical production. This includes waste arising from expansion of such production that has been forecast to be associated with the operation of the RRR (though some of the figuring for expansion in the working group report seems at the high end of reasonableness).

The radiopharmaceutical production facilities at Lucas Heights are the subject of a separate licence from ARPANSA, as are the waste operation facilities. Some of the working group's discussion may need to be taken up by me in further consideration of those licences at an opportune time, rather than this licence application.

Given that I have issued a licence for ANSTO waste operations, I do not agree with the working group conclusion that there is insufficient evidence that ANSTO's systems for managing radioactive wastes are acceptable and in line with international best practice. The reasons for my issuing of that licence are set out in the documents that accompany it. I thus do not agree that there is a need for a contingency plan about waste management prior to the decision on this licence application.

Having said that, the working group does very reasonably raise the issue of what might happen if one or both of the proposals for a national low-level waste repository and national intermediate-level waste store were not to proceed to completion. These issues do need to be kept under review as circumstances develop. Continued progress on the intermediate-level waste store will be important in the consideration of any application for a licence to operate the RRR.

PART THIRTEEN – ASSESSMENT AND DECISION

I have decided to issue a licence to ANSTO to construct the RRR. In assessing the application I had in my mind the prime importance of the objective of the Act – to protect the health and safety of people and to protect the environment from the harmful effects of radiation.

The most important way in which I have been convinced that this design is consistent with this objective is that the design of the reactor ultimately assures its safety through the operation of systems through the laws of nature, not through human intervention or the operation of complex systems. The reactor proposed can be shutdown by systems that depend just on gravity; the heat remaining is then removed by natural convection in a large pool of water that is itself enclosed in thick concrete. This assurance of simple safety is supplemented by there being a containment building around the reactor structure that can effectively isolate it from the environment should an accident occur.

The Act requires me to take into account ‘international best practice in relation to radiation protection and nuclear safety’. During the assessment, the applicant has demonstrated that the radiation protection and nuclear safety objectives included as a part of the design meet those laid out in the guidance provided by the international authorities. The specific safety features of the design comply with those recommended in international guidance and applied in recent research reactor designs. The management of the design and construction project, including the codes and standards applied to the design and construction of systems important to safety, is consistent with management approaches and the codes and standards used for similar systems in reactors designed in other countries with strong safety systems. Finally, the designed outcomes for occupational radiation doses, discharges to the environment and consequent radiation doses to the public, and the likelihood of core damage are at least as good as those achieved in the design of modern research reactors.

The system of radiation protection is ALARA and the outcomes of the design should mean that the doses received by the public are extremely low, well below the internationally accepted prescribed limits. The applicant has demonstrated that accidents within the design basis and other events of interest do not lead to radiation exposures that exceed the limits for the public. The likelihood of more serious accidents is very small - significantly smaller than for the existing HIFAR reactor and likely to be lower than 10^{-5} per year, though additional work on the probabilistic safety analysis is needed to establish an agreed estimate.

It is clear that the benefits that would flow from the planned operation of this reactor are very substantial – at least as assessed today in the light of the planned utilisation and applications. Given that the doses received by workers and the public would be ALARA, and the reactor is designed to be constructed and operated so as to limit the risks of accidents, then the benefits very much outweigh the detriment. This is so, at least for now while there are extensive applications for nuclear medicine and a lively and developing scientific field for the application of neutrons.

The applicant has established that the RRR would produce small amounts of solid and liquid waste that could be well managed within the ANSTO waste management system, pending the establishment of the national waste repository and store. The airborne discharges would be very small - 1/40th of those from HIFAR.

ANSTO is an experienced and capable operator of nuclear reactors and has a well established safety control regime. The overall safety culture is acceptable, but needs continued high priority. The application made to me was in the correct form, thorough, highly professional and appropriately detailed. ANSTO and INVAP responded most positively to questions and requests for further information and analyses during the assessment, including ANSTO putting a large effort into the necessary review of physical security following September 11.

The contract between ANSTO and INVAP establishes ANSTO's control over the project and reveals appropriate contingency arrangements. The project management arrangements for the RRR are strong and should be effective at transferring the current design intentions into a well constructed facility from the point of view of safety. In addition, the licence conditions that I have imposed will ensure demonstration of this transfer of the design into safety outcomes. From my experience of regulating ANSTO and assessing this application I am confident that ANSTO has a clear understanding of its obligations and responsibilities under the Act and licences issued under the Act. For these reasons I find that ANSTO has shown that it is capable of complying with the licence and the licence conditions.

The application drew a large amount of interest from the public throughout Australia and thousands of people took the opportunity to advise me of their views on the application. Many useful comments were obtained and these contributed to the assessment.

The single biggest area of concern raised in the public submissions was the management of spent fuel and the waste arising from the operation of the RRR. These will be ongoing issues that will need resolution if the RRR becomes operational and for the entire lifetime of the reactor. I have accepted that ANSTO has, as its first contingency, a workable strategy that should produce a waste form suitable for long term storage in Australia. The second contingency of processing in Argentina will need to be further developed and others may need to come forward over time.

Finally, I am satisfied that in deciding to issue the licence I have not taken any action prejudicial to Australia's defence or national security and that my power to issue this licence has been exercised in accordance with Australia's obligations under the relevant international agreements.

ANNEX 1: Documents received from the Applicant

Topic categories of documents received from the Applicant

1. The Application and PSAR
2. Supporting plans and arrangements
3. PSAR supporting analyses
4. Project management, including quality
5. Reactive Review Questions and Responses
6. Other eg. related to site licence, environment conditions, international peer review.

1. The Application and PSAR
Facility Licence Application - ANSTO - F0118 - Design Construct & Commissioning For The Replacement Research Reactor Project (RRRP) - Folio 1
RRRP - 7220 - 2BEIN - 002 (10 Controlled Copies) RRRP - 7220 - 3BEIN - 002 (10 Controlled Copies) and 1 Transmittal Document
RRRP - PSAR Compliance with Regulatory Assessment Principles
RRRP - 7220 - 2BEIN - 002 - REVO - Replacement Research Reactor Project - PSAR ERRATA
FAX - ANSTO - RRRP - Construction Licence: Commercial Justification (copy to Don Macnab) 01/02/2002

2. The Application – Supporting Plans and Arrangements
RRRP - 7033 - EDEJH - 001 -C - Construction Inspection and Test Plan
RRRP - 7052 - ECEIN - 003 - A - Civil, Structural and Facilities Design Plan
RRRP - 7052 - ECEIN - 004 - A - System Engineering Management Plan
RRRP - 7052 - ECEIN - 005 - A - Software Development Plan
RRRP - 7075 - EDEIN - 001 - A - Continuous Improvement Plan
RRRP - 7001 - EDEIN - 001 - B - Project Management Plan
RRRP - 7005 - EDEIN - 001 - B - Risk Management Plan
RRRP - 7082 - EDEJH - 001 - B - Construction Environmental Management Plan
RRRP - 7006 - EBEIN - 001 - D - Safety and Licensing Plan
RRRP - 7033 - DEDJH - 001 - C - Construction Inspection and Test Plan
RRRP - 7032 - EDEJH - 001 - A - Construction Management Plan
RRRP - 7030 - EDEJH - 001 - A - Site Occupational Health and Safety Plan
RRRP - 7016 - EDEIN - 001 - A - Human Machine Interface Plan
RRRP - 7014 - 2DEIN - 001 - B - Integrated Logistic Support Management Plan
Revised Construction Environmental Management Plan - September 2001 RRRP 7082 EDEJH 001 C
RRRP - Construction Environmental Management Plan - 02 July 2001

3. The PSAR – Supporting Analyses
Replacement Research Reactor PSAR Electric Power - RRRP - 7220 - 2BEIN - 002 - Rev 0 - Chapter 9 - Amendment 1 - Revision 1
Request for Information: PSAR Supporting Documentation - Response to Request for the ANSTO RRRP Risk Register [fax]
"Replacement Research Reactor Project (RRRP) Request for Additional Safety Analysis - Low Power Operation - ANSTO Final Drafts of RRRP-0170-2BEIN-002-B, RRRP-0170-2BEIN-010-B [Reports in Attachment S2001/00131]"
Replacement Research Reactor Project (RRRP) Request for Additional Information (PSAR Supporting Documents) - RRRP-0170-2BEIN-015-A; RRRP-0410-2BEIN-036-B; RRRP-0410-2BEIN-037-A; RRRP-6230-2BEIN-008-A; RRRP-4100-EDEIN-005-A [Reports in S2001/00131]
RRRP-0410-2BEIN-037-A Neutron Beams and CNS Containment Preliminary Structural Analysis
RRRP Docs: 0170-2BEIN-015-A Reactor Pool Openings; 0410-2BEIN-036-B Surveillance Program; 0410-2BEIN-037-A Neutron Beams; 6230-2BEIN-008-A CNS Containment; 4100-EDEIN-005-A INVAP; 0170-2BEIN-002-B Screening of Initiating Events; 0170-2BEIN-010 Numerical
RRRP 0310 2BEIN 002 B - FMEA for Second Shutdown System - 7 May 2001
RRRP 0225 2BEIN 018 B - FMEA for the Control Rod Drive Mechanism (CRDM) 6 September 2001
RRRP 0225 2BEIN 028 A - FMEA for First Shutdown System - 5 November 2001
RRRP 0170 2BEIN 002 C - Screening of Initiating Events for Reactivity Insertion Accidents - 17 November 2001
RRRP 0170 2BEIN 010 D - Numerical Analysis of Reactivity Insertion Accidents - 19 November 2001
RRRP - Provision of Drawings for Information - RRRP 32 10 3AECR 251 A and RRRP 32 10 3AECR 253 A (maps kept in level 3 safe)
RRRP 0315 3BEIN 026 D - SSS Mock - up - Design and Test Report
RRRP 0315 3BEIN 027 D - SSS Mock - up Data Gathering Procedure
RRRP - Core Inventory
Replacement Research Reactor PSAR Amendment 1 - RRRP - 7220 - 2BEIN - 002 - Rev 0 - Amendment 1 [four copies] plus CD - covering letter only on file S2001/00716
ANSTO - RRRP - Request for Additional Information (Layout Drawings) - (Ref gjs/LayoutDrawings/ARPANSA/0386) - hand delivered 11/1/2001 (copy of minutes)
ANSTO - RRRP Project - Consolidated Seismic Evaluation Report - Revision B for Public Release (Ref gjs/Seismic/ARPANSA/0388) 22/01/2002
"RRRP – Table 3.4 - 1 Classification of Structures, Components and Systems" 18/02/2002

3. The PSAR – Supporting Analyses
"RRRP - PPF Analysis Events of Interest Analysis and Code Validation and Verification - FINAL Documents - RRRP/0140 / 3BEIN/ 048/ B, RRRP/ 0170/ 3BEIN/ 021/ A, RRRP/ 0170/3BEIN/ 022 /A, RRRP /0170 /3BEIN /018 /B refer Grey Binder S2002/00017" 22/02/2002
RRRP - ANSTO Response - Power Peaking Factor Analysis 22/02/2002
RRRP - ANSTO Response - Summary of Events of Interest 22/02/2002
RRRP - ANSTO Response - Validation & Verification Plan for Computer Codes Used in RRR Safety Analysis 22/02/2002
RRRP - ANSTO Response - Power Peaking Factor Analysis For U3Si2 Core and AG/IN/CD Control Plate - RRRP/0140/3BEIN/048/B 22/02/2002
RRRP - ANSTO Response - Independant Verification of the Numerical Analysis of Reactivity Insertion Accidents with Relap5 - RRRP/0170/3BEIN/018/B 22/02/2002
RRRP - ANSTO Response - Events of Interest Additional Analysis of Reactivity Insertion Accidents in Low Power Operation Mode - RRRP/0170/3BEIN/021/A 22/02/2002
RRRP – Response to matters arising from meetings with ARPANSA Seismic Expert 25/02/2002
Replacement Research Reactor PSAR Amendment 1 - RRRP - 7220 - 2BEIN - 002 - Rev 1 – Amendment 1 - covering letter on file S2001/00716 (Rcd 4 copies) 26/02/2002
Replacement Research Reactor PSAR Electric Power - RRRP - 7220 - 2BEIN - 002 - Rev 0 - Chapter 9 - Amendment 1 – Revision 1 - covering letter on file S2001/00716 (Rcd 4 copies) 26/02/2002
"RRRP – Safety Categorisation of Structures, Systems and Compents - Folio 94 - (Covering letter only documents in Grey Binder S2002/00024)" 08/03/2002
CD - ANSTO PSAR Amendment 1 Rev 1 Chapter 9 - March 2002 – RRRP 08/03/2002
RRRP - Fault Schedule RRRP - 0170 - 3BEIN - 020 - B Revision B - Folio 95 - (Covering letter only documents in Grey Binder S2002/00024) 11/03/2002
"RRRP - Safety Categorisation of Structures, Systems and Components - RRRP - 7205 - EDEIN - 001 - F" 11/03/2002
RRRP - 0170 - 3BEIN - 020 - B - Fault Schedule 11/03/2002
"ANSTO - RRRP - Site Photographs (Ref 35c, 36c, 46c, 49, 52, 56, 58, 84)" 14/03/2002
RRRP - 0170 - 2BEIN - 015 - A - Reactor Pool Openings Structural Integrity
RRRP - 0410 - 2BEIN - 010 - A - Reflector Vessel - Structural Analysis
RRRP - 0410 - 2BEIN - 037 - A - Neutron Beams and CNS Containment Preliminary Structural Analysis
RRRP - 7205 - EDEIN - 004 - A - Methods and Criteria for Structures and Components Seismic Qualification
Summary of the RRRP Main Shielding
RRRP - 0020 - 2BECW - 001 - B - Design Criteria and Methodology Report Sections A and B General Structural & Seismic Design

3. The PSAR – Supporting Analyses
RRRP - 0057 - 2BEIN - 003 - B - Source Term for Normal Operation
RRRP - 0140 - 2BEIN - 014 - Neutronic Parameters of the U3Si2 Equilibrium Core
RRRP - 0140 - 2BEIN - 001 - A - Neutronic Design Criteria
RRRP - 0057 - 2BEIN - 022 - B - Cosyma Calculations
RRRP - 0057 - 2BEIN - 006 - B - Source Term for Cosyma Calculations
RRRP - 0057 - 2BEIN - 002 - A - Input Data for PC Cream Code
RRRP - 0057 - 2BEIN - 005 - B - Input Data for Cosyma Code
RRRP - 0020 - 2BECW - 002 - A - Design Criteria and Methodology Report Section C - Design for Aircraft Impact (<i>classified confidential</i>)

4. Project management documents (including quality)
Disk for RRRP Contract Master Schedule Rev.003 gjs/CMS Rev. 003/ARP/0243
FAX - Certification of the ANSTO RRRP Quality Management System
"RRRP Project Document Transmittal: RRP 4.3 Design Review, Verification and Acceptance During RRP Detailed Engineering Phase; RRP 9.7 Internal Communication and Reports"
Replacement Research Reactor Project Document Transmittal ANSTO's Verification of the RRRP Contract Construction Inspection and Test Plan RRP 9.1-3

5. Reactive Review Questions and Responses and related documents
"RRRP - PSAR Reactive Review Comments - ANSTO Responses covering letter - only 1 copy of each received not 2 as mentioned in the letter, also CD containing the documents in Word97 format was not received (refer Grey Binder S2001/00091)"
"ANSTO Comments on ARPANSA Reactive Review to the Application for a Facility Licence, Construction Authorisation for the RRRP (F0118)"
RRRP - 7220 - 2BEIN - 002 - Reactive Review to Chapter 1 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review to Chapter 8 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 9 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 15 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 20 of the PSAR
Covering Letter RRRP - PSAR Reactive Review Comments - ANSTO Responses
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 3 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 4.5 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 13 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 14 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 19 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 5 of the PSAR

RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 6 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 12 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 17 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 18 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 4 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 7 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 10 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 10.4 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 12.3 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 16 of the PSAR
RRRP - 7220 - 2BEIN - 002 Reactive Review Response to Chapter 10 pt 1 of the PSAR
RRRP - 7220 - 2BEIN - 002 Reactive Review Response to Chapter 2 of the PSAR
RRRP - 7220 - 2BEIN - 002 Reactive Review Response to Chapter 11 of the PSAR
RRRP - 7220 - 2BEIN - 002 Reactive Review Response to Chapter 7 Part 2 of the PSAR
RRRP - 7220 - 2BEIN - 002 - Reactive Review Response to Chapter 7 Part 2 of the PSAR
RRRP - Further questions regarding radioactive wastes - ANSTO Responses
Covering Letter - RRRP - ANSTO Response to Questions Raised by the ARPANSA Nuclear Safety Committee (NSC) Working Group on Seismicity - 1 CD
Covering letter - RRRP - Consolidated Seismic Evaluation Report RRRP - 7500 - 3BEAN - 001 A (4 copies received) forward for the Nuclear Safety Committee Working Group on Seismicity
ANSTO Response to report of the ARPANSA Nuclear Safety Committee - Preliminary ANSTO Comments 25 March 2002
RRRP - Site Coordinates drawings (JHEDI/SK/102E)26/03/2002

6. Other documents

RRRP - ANSTO Responses to Recommendations and Comments of the IAEA Experts Peer Review Mission Final Report
Third Status Report on the Implementation of the Conditions Arising from the Environmental Impact Assessment of the Replacement Research Reactor at Lucas Heights - RRRP - Folio 58
ANSTO - Report on the Environmental Management Action Plan submitted to ARPANSA January 2002 (Ref 02/10) 04/01/2002

Annex 2 - The international safety framework

The international background

The international safety framework for nuclear facilities has developed over the past 45 or so years from the time non-military applications of nuclear energy began to arise. Much of the framework has been developed with nuclear power reactors in mind and it might be argued that it is not applicable to a 'research reactor'.²³ It is true that even a quite powerful research reactor like the RRR is two orders of magnitude below the power of a large power reactor and it operates at much milder temperatures and pressures. Nevertheless, it has the potential, if not safely constructed and operated, to cause radiation doses off-site. In addition, the RRR as proposed is a quite complex reactor system, involving large number of irradiations for commercial purposes and operating neutron beam facilities for experimental purposes. For these reasons, it seems appropriate that at least the basic safety framework adopted should be as far as possible consistent with international best practice for power reactors.

As nuclear power developed during the 50's, 60's and 70's, western countries progressively developed their safety rules – sometimes as a result of systematic study of a generic issue, sometimes in response to a specific siting or construction proposal for a certain type of reactor. The major countries took somewhat different paths in terms of the favoured reactor type – generally light water reactors in the US, gas-cooled reactors in the UK, and the Canadian deuterium-uranium reactors (CANDU). One important early decision made in the United States, applicable to its light-water reactors, was that the reactors should be housed in a containment that would act as a final barrier to release of radiation, should other systems fail. Generally, the 50s and 60s saw a focus on the technical issues – how to prevent loss of coolant accidents (LOCAs) from happening and preventing core damage if they did happen. The accidents at Three Mile Island (which vindicated the containment requirement) and then at Chernobyl (albeit to a reactor with great weaknesses in western eyes) focussed attention back on human factors and to the notion of 'safety culture'.

Over these years, the structure of safety regulation system in most countries changed. Initially, safety was handled within an 'Atomic Energy Commission' that had the role of developing and supporting nuclear power, either directly or through R&D support for a commercial industry. Over time, it was seen as necessary to separate the function of safety oversight from that of the advocate and supporter of nuclear power,

The International Atomic Energy Agency (IAEA) was founded in 1957 in the context of 'Atoms for Peace' initiatives. Its role was to support the benefits of the applications of nuclear energy throughout the world. Subsequently, it assumed the role of overseeing nuclear non-proliferation safeguards flowing from the Non Proliferation Treaty (NPT). That was consistent with the Agency role as a supporter for nuclear energy applications – the basic bargain of the NPT was that states would commit themselves

²³ The term 'research reactor' has come to mean any (non-military) reactor the primary purpose of which is other than the production of electricity. In the early days of nuclear energy, research reactors were used to support the development of energy applications through the testing of materials and the evaluation of new reactor types, fuel designs and so on. Countries with substantial nuclear power programs often continue to operate such research reactors to support their power industry. The production of radioisotopes for medical purposes and using neutron beams for research purposes have become significant activities for research reactors in recent years.

not to develop nuclear weapons, but would be supported to use peaceful applications of nuclear technology.

The IAEA undertook work on safety principles and guidance for nuclear safety from around 1974. The Agency now has a quite elaborate system for drawing up documents relating to radiation protection and nuclear safety. The work is undertaken by four committees: nuclear safety, radiation protection, waste safety, and transport. An advisory commission that reports to the Director-General of the Agency oversees it. The membership of the committees and the commission – and indeed the numerous working parties that address specific topics – comprises strong technical expertise from throughout the world. It is not possible to characterise the advice and requirements produced through this system as ‘lowest common denominator.’ The Basic Safety Standards for radiation protection form the basis for the regulation of the safe use of radiation throughout the world; the transport code similarly is used universally to regulate the transport of radioactive substance; and there is a large set of safety guidance and safety standards applicable to nuclear safety.

The Convention on Nuclear Safety, the Joint Convention and INSAG

Nuclear safety as an international issue became highly significant after the Chernobyl accident in 1986. Given the cross-border effects of that disaster, it was no longer possible to view nuclear safety as a solely national concern. The IAEA had previously been involved in nuclear safety issues, but its efforts were now redoubled – and safety became the third pillar of the Agency – the other two being safeguards and nuclear technology. Countries also negotiated the Convention on Nuclear Safety (which came into force in 1996) and subsequently the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (which came into force in 2001). The IAEA is the secretariat for these two conventions.

The Convention on Nuclear Safety is important in establishing a framework for nuclear safety – it is deliberately set up as an ‘incentive’ convention whereby it describes what might be characterised as the ‘gold standard’ for nuclear safety. States signing the Convention are agreeing that they will seek to meet that standard and are opening themselves to review by other countries of their safety framework and activities. Every three years, there is a review meeting where states review and discuss reports on nuclear safety from other states party to the Convention.

The nuclear safety framework proposed under the Convention is made up of the following elements:

- a *legislative and regulatory framework* including licensing, inspection, assessment and enforcement
- a *regulatory body*, separated from nuclear operational bodies and provided with adequate authority, competence and resources but the *prime responsibility for safety rests with the licence holder*
- *adequate financial and human resources* are to be available to support the safety of each nuclear installation throughout its life
- the capabilities and limitations of *human performance* are to be taken into account
- *quality assurance* programs are to be established and implemented for all safety-important activities

- *safety assessments* are to be carried out before the construction and commissioning of a nuclear installation and throughout its life.
- *radiation exposures to be kept as low as reasonably achievable* to workers and the public and no individual to receive a radiation dose greater than national dose limits
- *on-site and off-site emergency plans* are routinely tested and cover the activities to be carried out in the event of an emergency
- there be appropriate mechanisms and steps taken to ensure that:
 - all relevant *site-related factors* likely to affect the safety of a nuclear installation are evaluated over its projected lifetime;
 - the design and construction of a nuclear installation provides *defence in depth* against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur
 - the *technologies* in the design and construction of a nuclear installation are *proven by experience or qualified by testing or analysis*
 - the design of a nuclear installation allows for reliable, stable and easily manageable operation, with *specific consideration of human factors and the man-machine interface*
 - *operational limits and conditions* derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation
 - operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures
- the *generation of radioactive waste* resulting from the operation of a nuclear installation is *kept to the minimum practicable* both in activity and in volume.

Australia has reported in detail against these criteria in 1999 and 2002. The reports are publicly available and establish that Australia's structures and approaches are consistent with this statement of international best practice.

The Joint Convention (which Australia has signed, but not yet ratified) is modelled on the Convention on Nuclear Safety in that it is an incentive convention that sets out the 'gold standard' for the safety of the management of spent fuel and radioactive waste²⁴ and establishes a reporting and review mechanism. The general safety provisions are similar to those in the Convention on Nuclear Safety and there are provisions addressing the siting, design, construction and operation of facilities dealing with spent fuel and radioactive waste.

Another authoritative statement of international best practice with regard to nuclear safety is that made by the International Nuclear Safety Advisory Group (INSAG), a group established to advise the Director-General of the IAEA. INSAG, which was first established in 1985 and first reported on the Chernobyl accident, has published a number of authoritative publications on aspects of nuclear safety. In its 'Basic Safety Principles for Nuclear Power Plants' (INSAG-12) they state three objectives:

²⁴ The distinction is made between spent fuel and radioactive waste - some countries do not regard spent fuel as waste as they intend to reprocess it to extract materials that can be used in other nuclear fuels. Radioactive waste includes spent fuel where a country foresees no further use for the fuel and, of course, other radioactive waste. The Joint Convention explicitly recognises that the same safety objectives apply to spent fuel and radioactive waste.

General Nuclear Safety objective

To protect individuals, society and the environment by establishing and maintaining in nuclear power plants an effective defence against radiological hazard.

Radiation Protection Objective

To ensure in normal operation that radiation exposure within the plant and due to any release of radioactive material from the plant is as low as reasonably achievable, economic and social factors being taken into account, and below prescribed limits, and to ensure mitigation of the extent of radiation exposure due to accidents.

Technical Safety Objective

To prevent with high confidence accidents in nuclear plants; to ensure that for all accidents taken into account in the design of the plant, even those of very low probability, radiological consequences, if any, would be minor; and to ensure that the likelihood of severe accidents with radiological consequences is extremely small.

INSAG then goes on to list three 'fundamental principles' that apply to meeting these objectives:

Management Responsibilities: *safety culture, responsibility of the operating organisation, and regulatory control and independent verification*

Strategy of Defence in Depth: *defence in depth, accident prevention, and accident mitigation*

General Technical Principles: *proven engineering practices, quality assurance, self-assessment, peer reviews, human factors, safety assessment and verification, radiation protection, operating experience and safety research, and operational excellence.*