ANNEX A - TERMS OF REFERENCE FOR ISOLUS INVESTIGATION

INTRODUCTION AND BACKGROUND

1. Following a significant set-back in the development programme for the national Deep Waste Repository * facility (giving rise to concerns which are reflected in Reference A and in the Ministerial Submission at Reference B), Ministerial approval was given in February 1998 (at Reference C) for the SSA to commence an in-house investigation of the options for interim storage of the Reactor Compartments (RCs) and associated hull and structure of the UK's nuclear submarines following their withdrawal from service. USofS directed (in reference C) that, in addition to considering the options for Interim Land-Storage, the investigation should include alternative venues for storage afloat.

SCOPE

2. The scope of this investigation is to be limited primarily to reviewing the options for interim storage (following de-fuelling and de-equipping of the submarine, and draining of high energy systems). Subsequent process options (leading to ultimate disposal of the Primary Plant components and disposal or recycling of the remainder of the submarine) are to be considered only to the extent that they influence the rationale behind the storage options.

3. Alternatives to interim storage on land or afloat may be identified but, if found to be inadmissible or impractical, are not to be considered in depth. However, the opportunity shall be taken to make a preliminary assessment of any innovative proposals from Industry.

4. The range of options to be considered requires the Investigation to be divided initially into two phases as follows:

> Phase 1 (Viability) will review all practicable options for interim storage of the Reactor Compartment (RC) and associated hull and structure for the UK's nuclear submarines awaiting disposal, and eliminate those which merit no further consideration. Possible sites for implementation of the viable options for such storage shall be identified, and provisional recommendations made regarding the policy to be pursued for the interim storage of UK nuclear submarines following their withdrawal from service.
>
> Phase 2 (Feasibility), if authorised on the basis of the Phase 1 report, will examine more deeply the feasibility of implementing the viable interim storage options at each of the sites identified in Phase 1. By narrowing the options, the recommendation regarding the policy to be pursued for such interim storage will be confirmed and focused, potential Public/Private Partnership Initiatives will be explored, and outline technical proposals will be developed as a basis for further work.

* Refer to statement on long-term management of radioactive waste on front cover of this report

5. Assessment of the interim storage options will include consideration of the following issues:

Regulatory and legislative issues
The LTR programme and its effect on accumulating numbers of redundant submarines
Possible venues/sites for interim land or afloat storage
Rough orders of cost (ROC), and LTC implications
Environmental issues
Socio-economic and political implications
Possible delays to commissioning of a Land Store facility (for interim storage of the Reactor Compartments), or of a national Intermediate Level Waste (ILW) repository (for final disposal)
RC transportation/handling methods

6. The validity of any previous work on which the Investigation draws shall be reviewed and verified.

DELIVERABLES

7. The Conclusions and Recommendations of Phase 1 of the investigation shall be reported to CESSA by early-1999, together with a draft Submission to US of S seeking authorisation for Phase 2.

TASKING AND AUTHORITY OF INVESTIGATION-TEAM MEMBERS

8. [Information deleted o allow public release of this report.]

9. Team members are authorised to liaise with other Authorities as necessary, guided by SSA Secretariat regarding protocol.

REFERENCES FOR ANNEX A

A. RWMAC (Radioactive Waste Management Advisory Committee) Report dated December 1997
B. SSA Sec/42/20 dated 12 December 1997
C. D/US of S/JS 25/1/2 dated 27 February 1998

ANNEX B - STORAGE OF LAID-UP SUBMARINES A HISTORICAL NARRATIVE

INTRODUCTION

1. HMS DREADNOUGHT, the UK's first nuclear powered submarine was retired from naval service in 1982. Since this time she has been at a secure berth in Rosyth Dockyard awaiting disposal.

2. The MoD's original strategy for the disposal of Dreadnought was to conduct a defuel and de-equipping at Chatham Dockyard, and carry out preparations as necessary for ultimate sea disposal at a deep ocean site. Sea dumping had been used continuously for the disposal of Intermediate Level Waste (ILW) since the 1950's. Dreadnought once defuelled was classified as ILW it was not unreasonable to assume therefore, that this would be the ultimate disposal method. The process of defuelling and preparing Dreadnought for disposal[27] was planned to commence at Chatham in 1982/83.

3. The beginning of the 1980's had witnessed growing international opposition to sea dumping and by 1982 this policy was beginning to run into delays. On 11 February 1982, in response to a written question, the Minister (AF) announced that Dreadnought was to be taken out of service and following defuel and de-equip, she would be laid up at a secure mooring. Following this announcement Dreadnought's work package was changed to accommodate the requirement to store her afloat.

4. The Disposal of Nuclear Submarines Working Party (DNSWP), conducted a study in order to recommend suitable sites for afloat storage, pending disposal. On 22 December 1982 the APS to the Minister (AF) announced that Dreadnought would be laid up at Rosyth. It was emphasised in the announcement that "*Dreadnought's stay at Rosyth would be temporary*". Dreadnought successfully completed her tow and on 22 April 1983 she was berthed in the Main Basin at Rosyth.

[27] The present process of preparing a nuclear submarine for laid up storage afloat is known as Defuel, De-equip and Lay Up Preparation (DDLP).

5. The DNSWP under the chairmanship of the CFS Co-ord (N) continued the debate into a long term solution to the problem. The MoD's preferred policy at this time remained sea disposal, however, the London Dumping Convention voted on a moratorium to suspend sea dumping of radioactive wastes until such time that scientific studies into the environmental effects had been completed. The UK took the view that this vote was not binding, and went ahead with organising the 1982 dump. Action by Environmental pressure groups abetted by non-co-operation by the National Union of Seaman ensured that the 1982 dump did not take place. Other options for the disposal of nuclear submarines therefore had to be considered.

THE AMERICAN SCENE

6. In the late 1970s the US Navy recognised that a number of nuclear powered submarines would require inactivation and disposal in the coming years. In accordance with the National Environmental Policy Act, the Navy began to evaluate alternatives for disposal. Two basic options were evaluated.

a. disposal of the defuelled reactor compartment at an existing land burial site, with the remaining sections disposed of either by scuttling at sea or by cutting up for sale (conventional scrapping).

b. disposal by sinking the entire defuelled submarines in deep ocean.

7. The US Navy's 1984 Final Environmental Impact Statement found that either land or sea disposal of the reactor compartment would be environmentally safe and feasible. The decision issued by the US Navy on 6 December 1984, concluded that: "Based on consideration of all current factors bearing on the disposal action of this kind contemplated, the Navy has decided to proceed with disposal of the reactors by land burial". The decision favoured the land option, despite sea disposal being cheaper. The decision was reached following a very open, nation-wide public consultation, which revealed a strong public opposition to sea dumping. In April 1986 the US carried out the first such disposal of the USS Patrick Henry one of their Fast Attack Fleet submarines.

8. The submarine was docked in Puget Sound Naval Shipyard, near Seattle, Washington State. The reactor compartment was cut out, placed on a barge and floated out of dock. The fore and after sections of the submarine were then welded together to form a floating hulk. The reactor compartment and barge were then taken under tow by 2 high-powered Tugs down the west coast to the mouth of the Colorado River, then up the river to the burial ground at Hanford, Washington State, where it was placed in a shallow trench.

9. Since 1990 the remaining fore and aft sections of the hulls of all decommissioned submarines have been completely recycled as part of the decommissioning programme, present policy sees several submarines in the same large dry-dock at once for parallel defuelling, reactor compartment removal, and recycling.

10. Following its decision to conduct land disposal of the reactor compartments the US Navy has safely shipped more than 70 submarine reactor compartments to the Department of Energies disposal grounds at Hanford.

UK DISPOSAL OPTIONS

11. With the MoD's preferred option subject to doubt, and the knowledge of the USA's intentions, the DNSWP began to consider the reactor compartment disposal to Land Option for the UK. In addition, some consideration was given to the "Piecemeal Disposal" Option. Piecemeal involved the cutting up of the radioactive waste within the reactor compartment into pieces small enough for them to be consigned to the proposed National Burial site in standard containers.

Whole Submarine Disposal to Sea

12. Sea dumping remained the MoD's preferred option until the 1993 London Sea Dumping convention finally ruled it out. The MoD spent a considerable amount of time and resources attempting to prove that sea dumping of the entire submarine was the best option, technically and in terms of environmental impact and dose accrued by the work-force. The findings were similar to those in the US, studies on both sides of the Atlantic showed sea dumping to be environmentally safe and low cost. However, these re-assurances could not stem the tide against sea disposal, public opinion strongly influenced by the environmental pressure groups remained against its resumption, this combined with pressure from the International Community[28] made sea dumping of the nuclear submarines politically unacceptable.

Reactor Compartments Disposal to Land

13. Land Storage of the Reactor Compartments option was basically a mirror of the method chosen by the US, without the advantage of having an established burial site in the desert, available for the disposal of reactor compartments. The provision of this site proved to be the main stumbling block to the project. Initially informal discussions with NIREX made it clear that they were not considering large items like reactor compartments on their prospective shallow land burial sites. Later they were persuaded to consider the requirement to dispose of large items such as Power Station heat exchangers, and included such considerations in their search for suitable sites.

14. In anticipation of not being satisfied by NIREX (on both suitability and time-scale) the DNSWP investigated the MoD estate with a view to short listing some possible sites for their own facility.

15. Following the issue of the Rossi Report by the Commons Committee on Radioactive Waste[29], the Secretary of State for the Environment stated that the NIREX shallow land burial sites would only be used for Low Level Waste (LLW); ILW would be stored pending the establishment of a Deep Waste Repository*. This effectively ruled out a NIREX waste site for the disposal of intact reactor compartments which are classified as ILW. Therefore, if

[28] The 1958 agreement between the US and UK further complicated the sea disposal process, because of the risk that the submarine once dumped in deep ocean could become a security breach, if investigated by a foreign power. This allowed the US, fearful that the dumping of a British nuclear submarine could focus unwanted attention on their own disposal program, to exert further pressure on the UK government to suspend sea disposal.

[29] Reference A.

* Refer to statement on long-term management of radioactive waste on front cover of this report

MoD were going to pursue the Land Disposal option it would have to find and commission its own site[30].

Piecemeal Disposal

16. Piecemeal Disposal involved the break up of the Reactor Compartment on completion of the defuelling process in order to separate the radioactive waste from the non radioactive components, LLW could then be disposed of to the Drigg repository, with the ILW stored awaiting the commissioning of the NIREX deep waste site*. All non radioactive material and components could be scrapped in the conventional way. This method of disposal was rejected due to it being far more expensive than the other options and because of its extremely high dose burden. The latter was believed sufficient to render it unacceptable under the ALARA (as low as reasonably achievable) principal, which was enshrined in the 1985 Ionising Radiation Regulations.

STORAGE VERSES DISPOSAL

17. It is significant that the Secretary of State for the Environment, in reply to the Rossi report, said that ILW would be stored pending the establishment of a disposal route[31]. It would therefore be in keeping with declared Government policy if the MoD were to store the reactor compartments containing the radioactive waste pending the establishment of the Deep Waste Repository *. The concept of storage also had other advantages over disposal:

a. The reactor compartment is retrievable - this is popular in the nuclear Industry/Environmentalist world because it means that if the rules or circumstances change, it would be possible to deal with the package in whichever way was considered more appropriate. From the Environmentalist point of view it would also remain as a constant reminder of the burden caused by the Nuclear Industry[32].

b. The reactor compartment can be monitored and maintained as deemed appropriate, and these checks can be witnessed and confirmed by independent assessors, so reinforcing public confidence.

c. Final disposal costs are delayed allowing financial benefits in terms of discounting the future provision.

d. Benefits could be gained as a consequence of technological advances in remote handling, which could considerably reduce the radiation dose burden, received during the final disposal process.

[30] Environmental impact studies carried out in the US have shown that the robust construction of the reactor compartment build to withstand considerable pressure and shock conditions, would withstand the effects of corrosion for at least 600 years before the first pinhole penetration, following burial at the Hanford site.
[31] Statement in reference B, based on reference C.
[32] See Annex D.
* Refer to statement on long-term management of radioactive waste on front cover of this report

e. Sea Disposal may once again become an acceptable method for dealing with ILW[33].

f. In storing the Reactor Compartment, both the quantity of ILW and the level of radioactivity within the compartment would reduce due to the natural decay of radioactive isotopes[34].

18. The MoD looked at three alternatives: Storage on Land, Storage Afloat and Storage on the Sea Bed.

Storage on the Sea Bed

19. The storage or disposal of intact submarines on the Continental Shelf within UK waters was considered from both legal and technical viewpoints. The intention behind the proposal was to avoid difficulty with the London Dumping Convention (LDC). The Convention was found to cover territorial sea as well as international waters. To meet the terms of the convention, storage or disposal would have to take place in the UK's internal waters, i.e. the landward side of the line from which the territorial waters are measured. The only site found suitable was between the Scottish mainland and the Outer Hebrides. Their use would have required authorisation from the Scottish Office under the Food and Environmental Protection Act 1985, and would have involved submitting an environmental impact statement.

20. Technical studies suggested that the method was feasible but costly. The hull would have to be towed to the storage site and lowered to the sea bed. The expense arising chiefly from the marine services work involved, this would primarily occur during recovery of the vessel for final disposal. Further expense would have been incurred if the reactor compartment had to be cut up in a corroded state.

21. It was believed that this method would limit international objections not withstanding some security issues under the US/UK 1958 agreement. However the cost and belief that this method would raise considerable objections especially in Scotland, led to the proposal being rejected.

Land Storage

22. This approach was similar to Shallow Land Burial in that it involved the separation of the reactor compartment from the rest of the submarine and storing it until it can be cut up for disposal to the NIREX Deep Waste Repository*. Three organisations were approached and asked to consider the political and technical feasibility of storing approximately 20 reactor compartments for up to 80 years. The companies involved were BNFL, CEGB (now nuclear electric) and UKAEA. The PSA (MoD) also carried out a study to find suitable sites on MoD Land and a number of potentially suitable sites were found.

[33] It was not until the 1993 London Sea Dumping Convention ratified the moratorium on sea dumping, that the MoD finally abandoned Sea Disposal as its preferred option.
[34] See Annex E.
* Refer to statement on long-term management of radioactive waste on front cover of this report

AFLOAT STORAGE

23. Afloat Storage had by 1990 proved itself to be satisfactory for 7 years. For security reasons it was preferable to use berths at Naval Bases, and initial assessments of berthing space had shown that sufficient space existed to cope with decommissioned submarines at least until the year 2000[35]. At this time afloat storage was attractive, sufficient space was available, and it was low cost especially in the short term. The MoD recognised that afloat storage could be (and has been) interpreted as indecision or the do nothing option. It was also recognised that the financial advantages which afloat storage had over land storage would reduce in the long term, as more berths are required for vessels.

24. With only a few years grace before additional submarines would require decommissioning the MoD took the only option possible under the circumstances, namely to pursue the Afloat Storage Policy, pending a decision on the final disposal route. At this time the NIREX repository was believed to become operational in 2005, with the possibility that it may be able to cope with complete reactor compartments. Sea disposal was not entirely ruled out, and the afloat storage option left this disposal route open. The "wait-and-see" option of afloat storage therefore became accepted policy; to date the Royal Navy has laid up nine submarines in afloat storage with a further two withdrawn from service awaiting DDLP.

25. Since the decision to opt for afloat storage, circumstances have changed considerably. Firstly, in 1993 the London Dumping Convention effectively ruled out sea disposal as a option for nuclear submarines. Secondly, the availability date for the NIREX repository* has been deferred on a number of occasions, and the present planning assumption is that the repository will not be available until 2040 at the earliest. By this time approximately 30 submarines will have been decommissioned and Dreadnought would have been in afloat storage for some 55 years. The decision that ILW within the reactor compartment will have to be consigned to the national Deep Waste Repository *will effectively mean that piecemeal disposal of the reactor compartment will have to take place. In order that the cut up of the reactor compartment meets with the principal of 'ALARP', and also with Government Policy to limit the quantity of waste requiring disposal. The present policy of storing the submarine afloat for at least 30 years, to gain benefit from the decay of short lived radioactive isotopes[36] was adopted by the MoD, to limit both dose burden to the disposal work-force and reduce the quantity of ILW.

THE ISOLUS INVESTIGATION

26. Following a further significant set-back in the development programme for the NIREX national repository facility, Ministerial approval was given in February 1998 to commence an in-house investigation of the options for interim storage of the Reactor Compartments (RCs) and associated hull and structure of UK nuclear submarines following their withdrawal from service. [Information deleted o allow public release of this report.].

[35] This figure has been revised on a number of occasions and the current assumption is that non-tidal berths will be filled by 2012.
[36] See footnote 34.
* Refer to statement on long-term management of radioactive waste on front cover of this report

REFERENCES FOR ANNEX B

A. First Report from the House of Commons Environment Committee, Session 1985-86; "Radioactive Waste"
B. D/DGSR/23/14/4 dated February 1987, Nuclear Submarine Decommissioning: Brief for the Operating Board.
C. Radioactive Waste, The Government's Response to the Environment Committee's Report – Cmnd 9852 – ISBN 0 10 198520 7 – Printed 7/86

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ANNEX C - ASSESSMENT CRITERIA

PRELIMINARY ASSESSMENT

1. For a preliminary assessment, to rule out the least attractive of the options for interim storage, three primary criteria (Viability, Socio-Political considerations, and Finance aspects) were defined, each of which requires consideration of a range of issues as follows. These criteria were applied, by exception, in the assessments in Annexes F and G.

Viability

2. Viability covers the following issues:

a. Technical feasibility. Although some are more straightforward than others, none of the available options for interim storage present insuperable technical difficulties. Some involve greater technical risk than others in areas such as development of the safety case, development of remote handling techniques, etc.

b. Environmental impact (technical considerations). None of the various ISOLUS options would have a significant radiological impact on the environment although shielding and containment requirements would need to be taken into account. However, the associated processes (preparation for storage and preparation for disposal) could carry minor risks of contamination, and eventually there would be a need to decontaminate the storage and processing sites.

c. Legislation/Regulation. The legislative and regulatory considerations are complex and depend to some extent on decisions outwith the scope of the ISOLUS project.

d. Dose Burden for the work-force (“ALARP”), and Quantity of Radioactive Waste. During the period of interim storage the quantity of ILW and the level of radioactivity associated with the Primary Plant will diminish. The dose burden accrued by the work-force, the quantity of ILW and the packaging requirements for the ILW will depend on the duration of interim storage, and on when the other activities in the disposal process are undertaken. The dose burden must be kept as low as reasonably practicable.

e. Flexibility to alter course. Technical innovation and changes in the Socio-Political environment can greatly influence a project’s viability and acceptability. It is therefore important that a project such as ISOLUS which spans many decades can remain flexible enough to be able to adapt to different constraints on the disposal process in future.

f. Time sensitivity (start and duration). Given the current planning assumption that a national Deep Waste Repository * will not be available before 2040, it is desirable for the chosen ISOLUS strategy to be able to accommodate further slippage without the need for significant additional expenditure downstream.

g. Technical Security constraints. There is a need to consider technical security aspects, including the 1958 agreement.

Socio-Political considerations

3. Socio-Political considerations include the following issues:

a. Likely response from Pressure Groups. However sound the technical arguments, autonomous and well organised pressure groups, primarily Greenpeace and Friends of the Earth (FoE), have proved effective[37] in blocking proposals which they see as potentially hazardous to the environment. However, although these groups have not been consulted, the principles which they believe should govern the disposal of nuclear waste are in open literature. These principles are outlined in Annex D and summarised under Public Presentation Issues in the main Report.

b. Public Acceptability/Concerns. Leaving aside fringe protesters, concerns from the general public are likely to arise only in respect of proposals for development of storage facilities in their local area (the "NIMBY" syndrome). Such proposals are more likely to be acceptable to local authorities and the general public if linked to worthwhile local employment opportunities.

c. Acceptability to Parliamentary Groups. [Information deleted o allow public release of this report.]

d. Environmental Impact. Socio-political considerations require recognition of environmental concerns relating to such matters as Sites of Special Scientific Interest (SSIs), visual impact on the landscape, etc.

e. Alignment with Government policy. Relevant Government policy must be taken into account. Also it is important that the option supported on completion of the ISOLUS investigation is not presented in a way which implies the current policy of temporary afloat storage is incorrect or unsafe.

f. Alignment with International policy. Relevant International policy must be taken into account.

g. Alignment with policy of the British Nuclear Industry. Consistency with the decommissioning policy of the British Nuclear Industry (store and decay) is desirable.

h. Historical acceptability. Storage and disposal is most likely to be acceptable to the local population in areas where nuclear submarine work (building and refitting)is undertaken already.

i. Physical Security constraints - related to keeping the protesters off the laid-up submarines or storage site.

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[37] eg Action against the sea-dumping of the redundant Brent Spar oil platform.

Financial aspects

4. Financial aspects address the following issues:

a. Overall cost. Because of the long time-scales required for the whole disposal process the net present value (NPV) of the cumulative total cost is very sensitive to the assumed discounting rate.

b. Commitment and spend profiles. Similarly, as discounting rate is increased, the NPV of the total cumulative cost is increasingly sensitive to the spend profile, with earlier spend raising the NPV of the total cost.

c. Risk of extra cost materialising. Self explanatory.

d. Affordability. This will be for Ministers to decide when presented with the Investment Appraisal.

CRITICAL SUCCESS FACTORS FOR "PEST" ANALYSIS

5. Having ruled out the less viable options in Annexes F and G, a more rigorous "PEST" analysis of the more viable options is undertaken in Annex H. This assesses each option against Critical Success Factors covering **P**rice, **E**nvironmental impact, **S**ocio-political considerations, and **T**echnical issues.

a. Price (Cost) covers

(1) affordability - the option must be affordable.

(2) cost profile – the cost profile should be manageable.

b. Environmental Impact covers:

(1) physical influence on the environment - the option should have a beneficial environmental outcome.

(2) visual acceptability.

c. Social / Political Issues cover:

(1) acceptability to Local Population on basis of economic benefit weighed against perceived disadvantages.

(2) acceptability to Pressure Groups and the General Population on basis of a balance of environmental and political considerations.

d. Technical Issues cover:

(1) the Maintainability of each option.

(2) the long-term Sustainability of each option given that the NIREX Deep Waste Repository * may be delayed beyond 2040 or may be cancelled altogether.

(3) the dose rate burden associated with implementing each option (does it meet the requirements of ALARP (as low as reasonably practicable)?).

(4) the Protection and Shielding required to prevent hazard to the environment or the General Public and to minimise dose rates to maintenance personnel.

(5) the Flexibility of the option to adapt to new storage methods or disposal strategies.

(6) ease of compliance with current and possible future Legislative and Regulatory requirements.

6. Additional Success Factors are:

a. alignment with the disposal policy adopted by Nuclear Industry.

b. adaptability to optimum storage period of 60 years.

ANNEX D - NOTES ON PRESSURE GROUPS

INTRODUCTION

1. The following extract was taken direct from the Greenpeace Web Site-

> *"Following a meeting with Greenpeace in early May, just 10 days after the UK general election, Environmental Minister Michael Meacher ordered a review of government policy on discharges and dumping into the Marine Environment."*

2. The above extract should dispel any doubts about the influence Pressure Groups, in particular Greenpeace, have on Government and, indeed, International Policy on waste management and disposal. Greenpeace were instrumental in preventing the Sea Disposal of HMS Dreadnought, and continued to be at the forefront of the campaign to stop sea dumping of what they deem to be hazardous waste. The oil industry and Shell in particular will testify to their success (eg, Brent Spar). From 1983 until 1994 the MoD continued to press for the Sea Dumping of Laid Up Submarines, and it is now clear that this wasted a great deal of time

and effort. It was thought that technical feasibility and positive environmental arguments would eventually win the day, but in pursuing this policy the MoD were attempting to hold back the tide. In this politically sensitive climate it is perilous to ignore the policies for waste management put forward by these pressure groups. Engineers tend to look for the best technical and cost effective solution, but if the solution does not stand up to public scrutiny and to some extent flow with the tide of public opinion, it would be extremely naive to believe that it would gain Government wide support and become policy. The third report of the House of Lords Select Committee on Science and Technology[38] has endorsed this view, emphasising the importance of public acceptability if progress is to be made.

3. The following is an attempt to summarise the policy of Greenpeace International, and other influential Pressure Groups. The summary and the subsequent conclusions are based on papers written by members of the various organisations, their individual Internet Web Sites, and comments made in the National Press.

THE PRESSURE GROUPS AND THEIR VIEWS

GREENPEACE

4. Primarily Greenpeace is opposed to Nuclear Power in general and Nuclear Submarines and Weapons in particular. It sees the environmental impact of the former as an unacceptable cost against the benefits gained from the industry, and views the latter as giving no benefit whatsoever.

Advocacy of Storage

5. Greenpeace has a national and international radioactive waste policy which calls for the *storage* of low, intermediate and high level waste *at its site of origin*. It believes that the 'out-of-sight, out-of-mind' approach for radioactive waste is probably the one most conducive to lax management in the future. To substantiate this policy Greenpeace advocate "*a storage depot with as many engineering safeguards, both environmental and security, as possible*". In the belief that keeping waste on an actively guarded site is the best way to ensure societies surveillance of it: *"The decision to dump should only be taken if it is accepted after proper nation-wide consultation"*.

6. Greenpeace believe that the *dumping* of wastes in 'out-of-sight, out-of-mind' areas is not an incentive to the creators of waste to minimise the amount requiring disposal. They believe in the *precautionary principal,* placing the onus on the waste creators to seek alternatives to their current methods of business which will avoid the creation of problematic waste in the first instance. Failing this they believe that the creators should seek to minimise waste creation and then "*seek to find the most socially and scientifically accepted methods of management of the waste. 'Management' does not necessarily mean disposal, but may result*

[38] House of Lords Select Committee on Science and Technology, Third Report, dated 10 March 1999 – Management of Nuclear Waste. (Reference F in main text of this report.)

in the long term on-site dry storage, the option which the majority of environmentalists put forward for all types of radioactive waste".

7. The ALARP (as low as reasonably practicable) principal is criticised by Greenpeace who believe in the alternative - as low as technically achievable (ALATA). The word 'reasonable' in their view is treated far too liberally; it is viewed as unscientific and open to abuse - "*a sop to allow industry to balance profit and work practises against public and worker exposure and environmental contamination"*. Greenpeace has accepted a compromise solution in terms of "best practical technology" as a step in the right direction.

Antipathy to Disposal as "Dumping"

8. The principal that future generations *should not* be burdened with waste created by the present generation forms a principal belief within Greenpeace, although this principal often leads to a certain amount of contradiction, for instance in relation to the store-and-monitor strategy. If a site has to be policed and monitored for hundreds of years then clearly this is a burden on future generations. During these discussions the adage 'it should not have been created in the first place' is often used as a fallback position. In general, however, the policy of store-and-monitor remains intact.

> *"It will be said that by storing radioactive waste, and delaying disposal, we might be placing an even greater burden on future generations. Future generations will condemn us for the numerous toxic substances we have created. If we then rush to dump them because of political expedience they will condemn us even more"*.

9. Public consultation is strongly advocated by Greenpeace at every stage of developing a waste disposal strategy. This is not wholly surprising as Greenpeace leads public opinion to a great extent.

10. Greenpeace also often points to public opinion to reinforce their anti waste-dump stance. It does not subscribe to the belief that areas should be given up for the greater good, and points out that setting aside an unpopulated and unproductive area for a disposal site guarantees that the site will remain unpopulated and unproductive.

> *"The public is not fooled by the use of words such as 'repository' or 'disposal'. The idea that one area be singled out to take a nations radioactive waste is inimical to most people"*.

11. Greenpeace was hostile to the NIREX proposal for a ILW repository* in Cumbria, and campaigned strongly against it. When the proposal was rejected in March 1997, Greenpeace issued the following press release:

> *"At last the Government has come to its senses. Dumping Nuclear waste in a hole in the ground is no solution. This is a victory for the people and environment of Cumbria."*.

* Refer to statement on long-term management of radioactive waste on front cover of this report

12. Greenpeace recognises that the "final solution" for radioactive waste is difficult to achieve but argues that if a problem is too difficult to solve, you cannot claim that it is solved by pointing to all the efforts to solve it.

> *"It might have to be accepted that there is no final solution to radioactive waste. Perhaps society will have to accept that there is no safe, foolproof method of disposal and that if we wish to enjoy the benefits of the practises which give rise to such wastes then we have to accept our responsibility in storing them in perpetuity".*

FRIENDS OF THE EARTH (FOE) SCOTLAND

13. FoE Scotland have been critical of the nuclear regulators, in particular the Scottish Environmental & Protection Agency (SEPA) which celebrated its second birthday on 1 April 1998. FoE's Director in Scotland, Kevin Dunion, considered that *"the honeymoon period is definitely over. We will be happy to praise SEPA when they deserve it, but we will be vigorous in highlighting any failure to protect the environment and people in Scotland*". Mr Dunion goes on to say *"SEPA...must be seen to have real teeth as a regulator if it is to be the watchdog we need"*.

14. The 1998 problems at Dounreay feature in detail on the FoE(S) website. When the news that the NII was to tighten its grip on Dounreay was announced, Mr Dunion responded with *"This is great news for everyone in Scotland. Our long running campaign to stop Scotland becoming the world's nuclear dumping ground is finally starting to pay off"*.

15. It is worth noting, in particular, that FoE Scotland believe that *" The nuclear industry must not be allowed to turn Scotland into the world's nuclear dustbin on the basis of unsubstantiated claims about jobs and profitability"*. Moreover, FoE Scotland consider that 'out-of-sight, out-of-mind' landfilling of radioactive wastes *"is simply leaving Scotland with a massive toxic time bomb on its hands"*.

16. On a more positive note, FoE Scotland welcomed the news that the UKAEA would be proceeding with a £215M-355M clean-up of the notorious radioactive waste shaft at Dounreay, saying, *"Instead of touting the world for the polluting business of nuclear waste reprocessing, the site can become a world centre of excellence in the field of nuclear decommissioning, thus safeguarding jobs"*.

17. <u>Aleksandr Nikitin.</u> The FoE Scotland website covers the story of Aleksandr Nikitin, a former naval captain and top Russian expert on nuclear submarines, and key person on decommissioning, He was jailed (and later released) in 1996 for denouncing the danger of radioactive contamination from Russia's decommissioned nuclear submarines in the Barents Sea. FoE Scotland, however, do acknowledge that scientific reports have so far failed to show increased radiation in the area. Following his arrest, Nikitin was quickly adopted as a prisoner of conscience by Amnesty International and hailed as a hero by environmental groups. Aleksandr Nikitin's story was published in the Mail on Sunday in January 1999.

SCOTTISH CND

18. Scottish CND's Internet Website opens with a direct quote from a previous Under Secretary of State (J. Peters) to the House of Commons Defence Committee which reads:

> *"The Admiralty decided - God bless it - to go into nuclear propulsion for submarines in the early 1950's... . There were quite enough problems to contemplate at that time without thinking too much about what on earth we should do with it when we were finished with it".*

19. This group appear high on emotion and low on fact, and in general criticises without offering alternative solutions of their own. Their language is emotive and alarmist and attempts to build a perception that the Navy takes unacceptable risks, and has little or no waste disposal strategy. The Diaries of Alan Clark are used in order to strengthen this claim and they use the defects on the Steam Generators transition weld as evidence of naval risk taking, *".....continued to operate Polaris Submarines despite the Trouser-leg problem".*

20. On the issue of nuclear waste from the decommissioned nuclear submarines, Scottish CND are critical of the MoD:

> *" Basically the MoD still do not appear to know what they will do with the huge quantities of nuclear waste which the nuclear powered submarine programme will leave behind".*

21. With its aim of ending nuclear power and weapons of mass destruction in general, it is in the group's interest to highlight and exaggerate any defects which befall the Nuclear Fleet. They imply that decommissioning has occurred in some instances due to insurmountable problems with the reactor.

> *" HMS Swiftsure - scrapped during refit, related to reactor problems;*
> *HMS Valiant - not yet defuelled, had a reactor incident then scrapped".*

22. The problem of decommissioned nuclear submarines is overstated in their literature, *"after the used fuel has been removed, huge amounts of radioactive waste still remains".* Scottish CND question how this waste will be dealt with and quote a figure of £225 million as the cost of keeping the present laid up submarines in afloat storage. They also state that interim storage of reactor compartments on land may be proposed as a possible solution.

> *"If the underground store is delayed the waste may be removed from the submarine and packaged somewhere probably on site (in the dockyards) until the store is ready. Alternatively the MoD may still be considering removing the whole reactor compartment and storing it on land"*

PLYMOUTH NUCLEAR DUMP INFORMATION GROUP (DIG)

23. DIG is a voluntary, non-party political pressure group which formed in 1988 when the MoD planned to build a radioactive waste storage dump in the city of Plymouth. Its aim is to research and inform on issues related to military radioactive wastes and materials in

Plymouth. This incorporates the transportation of nuclear materials and wastes, the expansion and storage of radioactive materials and waste in the city (including nuclear submarine spent fuel), worker and public protection in 'normal' and 'abnormal' (accident) conditions, and the scrapping and storage of decommissioned nuclear powered submarines and reactors in Plymouth.

24. DIG claims that Plymouth is the most 'nuclearised' city in Britain. It believes that the Government's policy on the disposal of radioactive materials 'continues to flounder' and that 'confusion and contradiction' on radioactive issues remains since *"the MoD found they could no longer use the ocean as a ready dustbin for their nuclear rubbish"*. On a more positive note, DIG recognises that there is no simple solution to the nuclear problem and aims to become better informed on nuclear issues through networking and the exchange of information with other military nuclear sites and submarine ports, particularly those in the USA, Russia, France and China.

Nuclear Waste Conference: 'Problems in Store'

25. DIG has always been strongly critical of plans for deep disposal. The DIG website carries a summary of a national Nuclear Waste Conference (titled 'Problems in Store') which was held in February 1998 following the collapse in 1997 of the NIREX plans for a national deep waste disposal facility for nuclear waste at Sellafield. It would appear that the Conference was attended by groups and council representatives from all over the country to address 'the persistent problem of what to do with Britain's growing radioactive waste as the Government continues to formulate its policy'. DIG states that military waste like that from nuclear submarine refits at Devonport Dockyard was a particular focus of attention as it is feared that military sites could become nuclear waste dumps in lieu of a national site.

26. Speakers at the Conference included Professor Sir John Knill who chaired the Government's independent Radioactive Waste Management Advisory Committee (RWMAC) for seven years until 1995; Dr. Helen Wallace of Greenpeace; Jamie Woolley, a principal solicitor for Sheffield City Council and legal advisor to the National Steering Committee for Nuclear Free Local Authorities, who gave evidence at the 1996 NIREX inquiry; and George Wall, a radioactive waste management representative from AWE at Aldermaston.

27. It is reported by DIG that the future provision for the long and short term safe storage of civil and military radioactive waste was discussed in a series of workshops which highlighted problems of living close to nuclear installations and the fears about health and the lack of local democracy. DIG raised concerns of storing large quantities of radioactive waste close to large urban centres like Plymouth. Attention was also paid to how public trust could be achieved by more openness from the producers of radioactive waste; Plymouth was particularly singled out as a local authority actively engaged in promoting public awareness of nuclear safety issues. DIG also advised the Conference of the recent, welcome moves by the Navy to engage in more open dialogue with the local communities.

28. As reported by DIG on its website about the Conference:

> *" DIG was able to put Plymouth's case about the problems we have with the Navy's nuclear waste very clearly and forcefully. It was obvious from the Conference that everyone is now under pressure; the producers of the nuclear*

waste, the regulators of the nuclear industry and the communities that find themselves living with nuclear emissions and facilities on their doorsteps. A national, sustainable solution on what to do with radioactive waste, how and where it should be kept is one that will require wide consultation, co-operation and agreement. The short-sighted politically-driven solutions put forward by NIREX have failed and we need to move on in partnership to safeguard our environment and health".

DIG views on Decommissioned Nuclear Submarines

29. In respect of decommissioned nuclear submarines, DIG favours the removal of the submarines to a secure remote coastal site with the prospect of storing the reactor sections of the submarines intact in dry, above ground, monitorable conditions at either a new designated site or at an existing civil nuclear location well away from any centre of population.

30. DIG has always been keen for the Government to instigate a study to examine the options of long-term disposal/storage of the Navy's nuclear submarines.

"The old government's attitude was one of dithering uncertainty over the eventual fate of these radioactive relics. When their plans to sea dump these hulks was blocked by international treaty, their only alternative was to dump them in Plymouth and Rosyth in the forlorn hope that NIREX would come up with a solution. This short sighted and unlikely plan represented a sad dereliction of responsibility to the people and environment of Plymouth. Now, we expect this problem to be faced head on by the new government and will be seeking resolution as soon as possible."

Kevin Owen, Chairman DIG.

DIG views on the Naval Ammunitioning Jetty

31. DIG also considers that storing large quantities of highly radioactive waste in a city close to munitions, high explosives, fuels and in close proximity to the most densely populated area in the south west of England should not be a long-term option.

"<u>Naval Ammunitioning Jetty puts Thousands at Risk</u>

The Navy's proposal to build a re-arming jetty 1 km upriver from the nuclear Submarine Refit Complex (SRC) for ammunitioning warships and nuclear submarines is causing further concern. It has been revealed that the reason behind the plans is due to the assessment of buildings at the SRC and their ability to withstand explosive blast over-pressures in the event of an accident. The Nuclear Installations Inspectorate have told DIG that,

> *"the NII is concerned with all situations which could pose a potential hazard to nuclear activities within the (nuclear) licensed site at Devonport. It is beginning discussions with the licensee, DML, on the potential hazard posed by weapons and explosives."*

NII 11/2/97.

In an attempt to appease the NII the Navy plans to shift the problem further upriver close to the town of Saltash and opposite housing estates on the Plymouth side of the River Tamar."

[INFORMATION DELETED O ALLOW PUBLIC RELEASE OF THIS REPORT.]

32. [Information deleted o allow public release of this report.].

33. [Information deleted o allow public release of this report.]

IMPLICATIONS FOR ISOLUS OPTIONS

CONTINUED AFLOAT STORAGE

Storage at current sites

34. The continued afloat storage of laid up nuclear submarines is not an option favoured by either Greenpeace or DIG, the latter mainly because it directly affects Plymouth. All pressure groups consider this policy as being no policy at all. This opinion is echoed in paragraph 37 of the RWMAC Report[39]. In Rosyth this strategy will come under increasing pressure when the economic benefits due to nuclear submarine refitting at Rosyth Royal

[39] RWMAC (Radioactive Waste Management Advisory Committee) Report dated December 1997. (Reference C in main text of this report.)

Dockyard end early in the next decade. A strong movement against nuclear proliferation in Scotland is being fuelled by pressure groups, encouraged by the SNP's stance against any part of Scotland being used as a potential site for nuclear waste.

35. The use of new areas within Devonport for the storage of laid up submarines should be limited to basins and alongside berths. The utilisation of moorings offshore could cause further problems for the Naval Ammunitioning Jetty, and may bring pressure from DIG and Greenpeace, who could perceive that the submarines are not being properly maintained and are no longer secure. They would also be highly visible and would therefore assume a higher profile in the eyes of the public.

Storage at other Naval Bases

36. Naval Bases which do not have any history in either operating or maintaining the nuclear submarine fleet, such as Portsmouth, would appear to be a very unwise choice of venue for laid up submarines. The local population have gained no economic benefit from their operational life, and would gain only minor benefits from their subsequent long term afloat storage. It would present an open door for the pressure groups, who could rely on widespread "NIMBY" support if they chose to oppose this option. Any attempt to bring laid up submarines to Portsmouth would be likely to cause condemnation and bring unwanted attention on the whole afloat storage strategy.

37. The Naval Base areas around Coulport and Faslane have a local population used to having operational nuclear submarines and weapons in their area but their utilisation for the storage of laid up submarines would attract further opposition from Scottish pressure groups. It is doubtful whether the MoD would wish to attract adverse publicity in an area where so much is at stake. [Information deleted o allow public release of this report.]

Storage at Commercial Yards

38. In general, the arguments against the use of Portsmouth as an afloat storage area can apply also against using commercial yards for the afloat storage of laid up submarines. One exception would be VSEL at Barrow-in-Furness. The return of the laid up vessels to their place of building fits well with the Greenpeace recommendation that nuclear waste should be stored at its place of origin. In addition the population of Cumbria is one of the most nuclear aware communities in the country and the local economy of Barrow continues to gain considerable benefit from the nuclear submarine fleet.

Remote Sites

39. The utilisation of remote sites, or areas remote from centres of population, for the storage of laid up submarines afloat is not generally supported by environmental pressure groups. Greenpeace remains opposed to the remote site option regardless of the method of storage used, believing that it promotes an out-of-sight, out-of-mind policy to waste management and questioning whether security could be sufficiently guaranteed. Using remote areas of Scotland for the storage of laid up submarines would be in line with DIG views, but vigorously opposed by all other Pressure Groups and the SNP.

LAND STORAGE

Land Storage at current afloat storage sites

40. The land storage of Reactor Compartments at sites where the waste was generated appears to be generally in line with the views of many of the pressure groups, including Greenpeace (see paragraph 42). Greenpeace advocates a store-and-monitor strategy in a secure area, *"to remind producers of their responsibility"* . In Devonport this strategy would attract objections from DIG, however it too supports the general concept of land storage (paragraph 0), but away from centres of population, specifically Devonport.

Storage at other Naval Bases

41. As with afloat storage, using Portsmouth Dockyard for the land storage of Reactor Compartments on land would attract considerable criticism from the local population and pressure groups. Greenpeace could object on the grounds that the waste is being stored away from the area of waste generation; DIG, because it is in an area of high population. The use of Faslane or Coulport would be high risk for similar reasons to those in paragraph 0, although it would seem to be broadly in line with Greenpeace Policy.

Storage at Commercial Yards

42. Land Storage at commercial yards would carry similar risks to those outlined in paragraph 0 above, though again the possible exception would be VSEL at Barrow-in-Furness as it would appear to suit the Greenpeace policy of storage at the place of origin. In addition the land storage option would not take up valuable berths in a commercial yard, it would be less obtrusive than afloat storage and therefore attract less attention, and most importantly the work involved in removing the Reactor Compartment and scrapping the remaining vessel could provide economic benefit to the local community.

Remote Sites

43. The conclusions of paragraph 0 apply to remote Land Storage sites.

PLANNING FOR INDEFINITE STORAGE

44. It is possible that a tide of opinion is rising against the Nuclear Waste Repository *concept and the risk must be recognised that it will be delayed beyond the present planned date of 2038. It could be argued that a strategy for the disposal of Nuclear Submarines which relied solely on the realisation of the Deep Waste Repository was not taking the present climate of public opinion into account, and once again the MoD could be accused of attempting to hold back the tide.

45. Although it would not be sensible at this stage to rule out a Deep Waste Repository, it would be prudent to devise a strategy which was flexible enough to adapt to: either, store-and-monitor for an optimum decay period (or until a disposal route exists, if later), then break up and dispose of the radioactive waste; or, store-and-monitor for the foreseeable future.

ANNEX E - NATURAL DECAY OF RADIOACTIVE ISOTOPES

RADIOACTIVE DECAY

1. Following final reactor shutdown and defuel, radioactivity within the Reactor Compartment (RC) declines rapidly, due to the natural decay of radioactive isotopes. These isotopes are contained within the structures of the reactor compartment, and are caused by intense neutron bombardment which occurs throughout the commissioned life of the reactor. Not surprisingly the level of radioactivity increases as it nears the centre of the Reactor Pressure Vessel (RPV), the closest point to the reactor core. In addition, corrosion and wear products transported by the primary coolant, become irradiated during their passage through the core. These particles plate out on system internals to form a fine film of radioactive CRUD, the primary radioactive constituent of which is Cobalt 60. This isotope produces hard gamma emissions and its biological hazard is exacerbated by the fact that, because much of the CRUD is deposited outside the RPV, the high energy emissions from the Cobalt 60 are not attenuated by the RPV's significant biological shield. This lack of shielding means that the CRUD is by far the largest contributor to the Average Radiation Level (ARL) within the RC. The domination of Cobalt 60 is illustrated by plotting a decay curve of the background radiation level over time, comparisons show that its decay curve virtually mirrors that of Cobalt 60 (see Figure 1).

WASTE QUANTITIES

2. In 1988 RR&A (Reference A) produced a document which gave a radioactive inventory for the individual structures within the RC. This document “Whole Plant Disposal - Assessment of Radioactive Inventory” allowed the MoD to estimate, for a decommissioned submarine 1 year after final shutdown, the quantities of radioactive waste within the RC and its radioactivity level (and thus its classification). By using a standard decay calculation it was then possible to predict the changes to the quantities and classification of radioactive waste within the RC over time, and therefore quantify the benefits of store and decay.

EFFECTS OF DECAY

3. Recent work (reference B) carried out in support of the NIREX Radioactive Waste Inventory (reference C) has shown that the quantity of ILW will reduce by approximately 64 tonnes during the first 30 years of storage, with only 18 tonnes of ILW estimated to be remaining after that time. In addition, because the average background radiation within the reactor compartment is dominated by Cobalt 60 with its half life of 5.3 years, the background radiation level within the reactor compartment reduces significantly over this time period.

PRACTICAL CONSIDERATIONS

4. The estimates of radioactive waste quantities at the 30 year point show substantial gains in the quantity and radioactivity of waste requiring disposal after this storage period. It should be noted, however, that these gains continue to accrue for a number of years after the 30 year point. If a new method of interim storage is chosen, which is less time sensitive than the present Afloat Storage method, it is highly likely that an increased interim storage period would reap positive benefits both in terms of the costs involved in the dismantling, packaging and transportation of the waste, and minimising the dose burden to the dismantling work force. For example, Reference D shows that after a storage period of 60 years there would no longer be a requirement to machine away the Stainless Steel Cladding from the RPV before disposing of the vessel as Low Level Waste. Not only would this eliminate the need for expensive machining of this item during the packaging process, but it would reduce the total dose burden associated with disposal of the waste by a factor of 10 compared with disposal after 30 years

5. In addition, due to the packaging and transport regulations associated with the shipment of the NIREX 4 metre box, a storage period of about 50 years will be required before the submarine's remaining ILW can be disposed of to the repository* in two 4 meter boxes. Before this time, the shielding requirement is such that either a greater number of 4 metre boxes would be required per submarine, or a further storage period for the waste within the container would be necessary before it could be shipped to the repository.

CONCLUSION

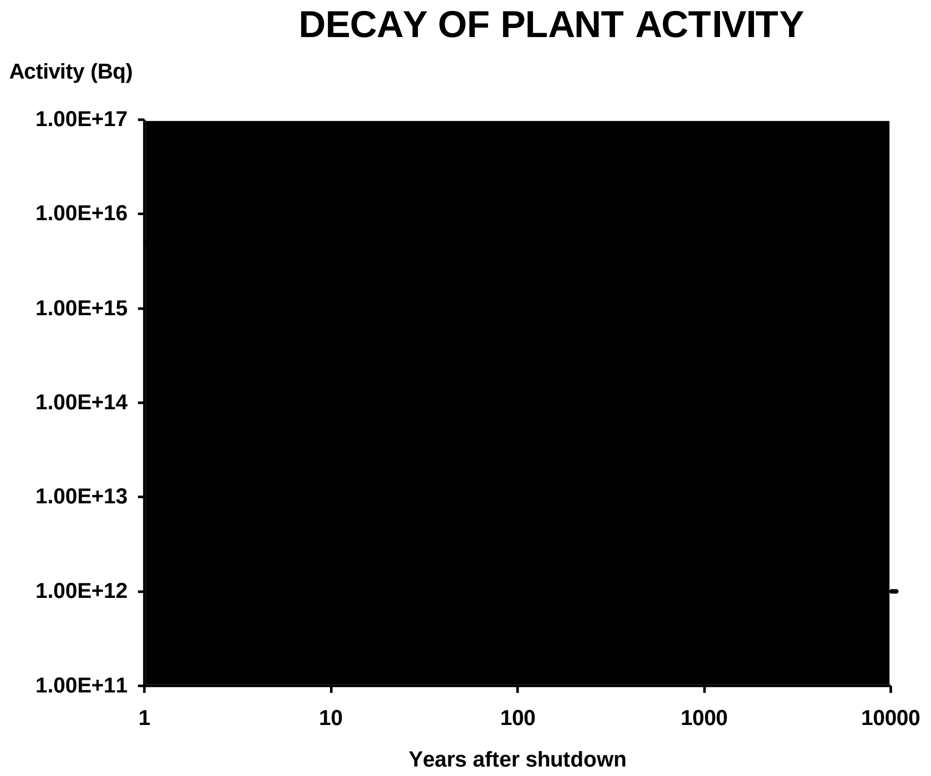
6. The foregoing considerations indicate that, while 30 years of interim storage is advantageous, considerable accrual of further benefit would result from storage for 60 years in total. Thereafter, there would be very little further gain unless storage was continued for so long that it might effectively be regarded as indefinite. Thus, 60 years is the optimum duration of interim storage.

REFERENCES FOR ANNEX E

A. RRA/9439 TH132.3 dated December 1988
B. SSA/SM552/1887/3559 dated 20 May 1998
C. DETR/RAS/99.009, UK Nirex Ltd T/REP/20539 – The 1998 UK Radioactive Waste Inventory: 3rd Draft Main Report dated May 1999, forwarded under cover of Electrowatt-Ekono (UK) Ltd letter MJP/17408.700/404 dated 6 May 1999.
D. Interim Land Storage of Submarine Reactor Compartments: Cost of Dismantling and Packaging Reactor Compartments (the 'Electrowatt study') - draft report Mouchel Reference: DMRW/21045 dated 18 January 1999, under cover of D/DEO/N0300/05230 dated 26 January 1999.

* Refer to statement on long-term management of radioactive waste on front cover of this report

FIGURE E1



For the first 100 years the dominant radio-nuclides are Fe55 ($T_{1/2}$ - 2.7 yrs), Co60 ($T_{1/2}$ - 5.3 yrs) and Ni63 ($T_{1/2}$ - 100 yrs).

Between 100 and 1000 years Ni63 becomes dominant.

After 1000 years the dominant radio-nuclide is Ni59 ($T_{1/2}$ - 76 000 yrs).

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ANNEX F - AFLOAT STORAGE

INTRODUCTION

1. The current MoD policy regarding Nuclear Submarines at the end of service is to conduct a Defuel, De-equip and Lay up Preparation (DDLP) as soon as possible, subject to the constraints of maintaining the operational fleet. On completion the submarine is stored afloat for a minimum of 30 years to take advantage of the natural decay of radioactivity (see Annex E). Following this storage period the intention is to break up the vessel, with the non-radioactive structure being disposed of as scrap and the radioactive waste packaged for disposal, Intermediate Level Waste (ILW) at the Deep Waste Repository * (DWR), or Low Level Waste (LLW) at Drigg.

2. The deferral of the planned availability date for the Deep Waste Repository to 2040, has cast doubts on the viability of the Afloat Storage strategy. The MoD was criticised in the RWMAC report as appearing to have no policy, and as the number of Laid-up submarines

[*] Refer to statement on long-term management of radioactive waste on front cover of this report

continues to grow, the current non-tidal storage space at Devonport will be filled before the waste repository* is available.

3. The current storage areas for the decommissioned submarines is the Main Basin in Rosyth and 3 Basin at Devonport. The DDLP of Renown is currently the final nuclear work planned for Rosyth, with its completion, decommissioning of the nuclear site will commence in accordance with the "Sale of the Dockyard" Agreement[40]. A total of 7 vessels will then be stored at Rosyth. All subsequent DDLPs will take place in Devonport where at present 3 vessels are laid-up and the fourth, Valiant, is due to complete DDLP in 2002. The capacity of 3 Basin will be exhausted by 2012.

4. This Annex:

a. reviews the current afloat storage space.

b. considers other interim afloat storage venues and assesses their suitability.

c. recommends the favoured options for allowing interim afloat storage to continue until the deep waste repository* is available.

d. concludes the findings and lists the preferred options. It also considers the impact the delay to DWR has on the interim afloat storage and discusses the strengths and weaknesses of the strategy.

LOCATION OPTIONS FOR INTERIM AFLOAT STORAGE

Definition of Options

5. The location options for Interim Storage afloat are:

a. continued use of the current non-tidal Basins at Devonport and Rosyth;

b. berthing in a tidal basin at Devonport;

c. tidal berths on the sea wall in Naval Dockyards and Bases;

d. tidal moorings (not alongside) within the boundary of a Naval Dockyard or Base;

e. tidal or non-tidal berths in a commercial yard.

f. remote berths and moorings;

[40] Rosyth Dockyard Sale - Principal Agreement (1996)
[*] Refer to statement on long-term management of radioactive waste on front cover of this report

* Refer to statement on long-term management of radioactive waste on front cover of this report

Assessment - General Considerations

Technical Issues

6. The afloat storage of decommissioned nuclear submarines does not present major technical difficulties, although certain venues would cause more problems than others. The main issues are security (from unauthorised entry), maintenance, prevention of damage, and preserving the ability to remain afloat.

7. The choice between an alongside berth, mooring offshore and berthing in tidal or non tidal basins has been debated on a number of occasions in the past. There are no over-riding technical concerns, although exposed berths will increase the risk of collision, which could make development of a safety case difficult. Off shore moorings would also cause a marginal increase in the cost of the lay-up workpackage, due to the requirement for more robust securing arrangements. Poor weather could cause access problems especially at exposed locations.

Legislative and Regulatory Issues

8. The Legislative and Regulatory background, and possible future developments, are described in the main paper. The impact for possible future afloat storage options is discussed in the following paragraphs.

<u>Removal of Crown Exemption from RSA93.</u>

9. The effect of removing Crown Exemption from RSA93 (which is expected by about 2005) would be minimal for submarines laid-up afloat, as it will be necessary only to replace the Letters of Agreement with Formal Authorisations under RSA93.

<u>Removal of Crown Exemption from NIA65.</u>

10. Licensing a site used for the afloat storage of nuclear submarines has a number of difficulties associated with it:

a. NIA65 states that "*a nuclear site licence shall not be granted to any person other than a body corporate and shall not be transferable*". The MoD has never applied for a nuclear site licence and at present there is no mechanism for creating a body corporate within the organisation. It is likely therefore that the MoD would prefer to pass control of the submarines to a contractor, who would then need to apply for a nuclear licence. For some sites it may be difficult to find a contractor willing to undertake this commitment at an acceptable cost to MoD.

b. Creating a licensed site is expensive.

c. De-licensing the site is also costly and would be complicated by the fact that a body of water has been licensed.

11. Additionally there are risks associated with the possibility of MoD losing Crown Exemption from the two Acts, the impact of which will vary with the different location options considered at paragraph 5 as follows.

12. Sea wall berths, and tidal moorings within naval bases, would cause difficulties in terms of demonstrating satisfactory control of the vessels. Presenting an acceptable hazard assessment, which would need to include the vessels' security would also be more problematic at this type of location. No precedent exists for the establishment of a licensed site around off-shore moorings, the exercise could prove to be impracticable. De-licensing would also be raise concerns, as it would be difficult and expensive to conduct a practical survey to show that no environmental hazards remained within the area.

13. If berths or moorings were utilised in remote locations, the problems associated with authorisation under the Acts represent an even higher risk in terms of demonstrating control, security, hazards and licensing.

14. When choosing a suitable location for the lay up of decommissioned submarines, it is imperative that the risks involved with regulation and legislation are considered and the implications of authorisation under each Act fully understood, before the final choice of storage site is made.

Environmental and Socio-Political Issues

15. The direct Environmental impact of the laid-up submarines is extremely low, but their perceived impact is far more important. For this reason a balance needs to be struck between keeping the vessels at a low profile, and at the same time not being seen as attempting to disguise the issue.

16. Offshore moorings are far more visible to the general public than alongside berths and could become the focus of attention for environmental pressure groups. It would be extremely difficult for MoD to maintain positive public opinion in the face of continuous and sustained attack from anti-nuclear protesters. Even if the technical case was beyond reproach, keeping highly visible vessels ("hulks") offshore could become unsustainable in the face of rising public unease.

17. Decommissioned submarines at moorings (areas of water containing buoys for mooring vessels away from an alongside berth), even if within the protected waters of a naval dockyard, would be extremely difficult to secure from unauthorised entry. The most likely aim of any potential miscreant would be political embarrassment, but the motives could be more malicious. It is probable that the security risk of offshore moorings could only be countered by permanently manning the vessels, at increased cost. It could be argued that an alongside berth also would leave the vessel susceptible to unauthorised entry. This would be so if the chosen berth was in an unsecured area. However, for submarines in service, berthed within the secure perimeter of Naval Dockyards, security measures have proved to be adequate to prevent entry. Although these vessels do have armed sentries, which decommissioned submarines do not have, these guards are very rarely called upon to prevent entry. In addition, operational vessel have open hatches allowing easy access, which laid up submarines do not have.

Financial aspects

18. Compared with exposed berths or off-shore moorings, enclosed berths (in tidal or non tidal basins) will provide better protection against the weather, and also facilitate relatively easy access for inspection and maintenance. Maintenance costs of the submarines will therefore be lower but their could be dredging costs for the basin.

19. Weather and increased exposure to wind and spray would exacerbate the maintenance requirement, and although some maintenance could still be carried out at the trot, it would be complicated by the necessity to transport power for lighting and tools either by ship or barge to the location.

20. Mooring offshore would minimise disruption to naval base activities and release valuable alongside berths for other purposes. Therefore, the opportunity cost of moorings will be discussed on a site specific basis later in the paper.

Assessment - Generic Site Options

Berthing in non-tidal Basins at Devonport and Rosyth

21. At present the Main Basin in Rosyth holds 7 decommissioned submarines, 6 have completed DDLP and the final vessel Renown is due to complete it's DDLP in about 2002. The size of the Main Basin at Rosyth is sufficient to accommodate a considerable number of additional hulls with little impact on BRDL's business in the short term. The actual number of additional vessels capable of being stored has not been determined due to the Sale of the Dockyard Agreement[41], which precludes the berthing of any further laid-up submarines in the main basin after nuclear refitting work ceases at Rosyth.

22. At present 3 vessels are stored in 3 basin Devonport, this number will rise to 4 in 2002 with the completion of Valiant's DDLP. 3 Basin, like the main basin in Rosyth provides the submarines with secure, sheltered, non tidal berths. As the Royal Navy's remaining submarine refitting yard, Devonport also provides the infrastructure and expertise necessary for their continued maintenance. The maintenance of the vessels can be undertaken during windows in the submarine upkeep programme, which proves cost effective. 3 Basin remains the property of the crown and therefore no direct charge for the occupation of the berths will be incurred.

23. Devonport has berthing space for no more than …. [information deleted to allow public release of this Report] ….. submarines, depending on the level of acceptable disruption for docking movements[42]. If all future submarines are laid-up at Devonport, the current Long Term Review (LTR) indicates …. [information deleted to allow public release of this Report] ….. [that,] in order for afloat storage to remain a viable option for additional vessels beyond 2012, it is necessary to identify alternative sites.

24. Utilising 5 Basin for the long term storage of increasing numbers of laid-up submarines would be incompatible with its use as the main working basin of a commercial

[41] Rosyth Dockyard Sale - Principal Agreement (1996)
[42] [Footnote deleted to allow public release of this Report.]

dockyard. It is also the main access to the dockyard repair areas and dry docks, with Capital Ships and RFAs transiting to their refit and repair areas, and it provides access to the Nuclear Submarine refit and refuelling areas for both SSN and SSBN (Trident).

Berthing in a tidal basin at Devonport

25. 4 Basin in Devonport could be utilised to store up to 11 laid-up submarines, which would effectively extend the available afloat capacity until 2037. The basin is tidal and consequently the submarines could ground at low tides. The impact of this would be two fold: It is possible that some damage could be incurred to the lower sections of the ballast tanks if the bottom of the basin contained hard objects or rocks. The basin would have to be checked and prepared if necessary to allow the submarines to ground on a relatively soft surface. Secondly, the cathodic protection anodes could become buried in mud and this would impair their ability to suppress corrosion. It is not believed that either of these disadvantages present insurmountable problems, simple modifications to the cathodic protection system could ensure its continued capability in this situation, and surveys would ensure that any damage to the ballast tanks due to grounding is minimal. If, for what ever reason, grounding of these vessel was considered to be unacceptable, dredging would be required on a regular basis and consequently the cost of storage would increase. Storage in a tidal basin would cause slight increase to the cost of the maintenance, as ropes and hawsers would require checking on a daily basis.

26. The utilisation of 4 Basin for the purpose of storing decommissioned submarines would result in some problems for present users. DML currently use the North Wall of 4 Basin for surface ship maintenance, with the West Wall reserved as a berth for the Devon Samson Floating Crane. Serco Denholm currently utilise the East Wall to berth the majority of their Tugs and the southern end of the West Wall for their Fleet Tenders. The Royal Navy uses the South Wall for surface ship maintenance.

27. In considering the options available in paragraph 5 to allow afloat storage to remain viable beyond 2012, this option appears to be the most attractive. Storage in 4 Basin would carry penalties in terms of some additional maintenance and the opportunity cost of the berths. These latter could be high because 4 Basin is currently well used. There may also be a dredging requirement, although this is believed to be unlikely. The submarines would not have a direct environmental impact, the situation is similar to that of the vessels already stored in 3 Basin. They would be no more visible than they are in current storage sites. The policy would undoubtedly attract censure from pressure groups particularly the Plymouth Dumping Information Group (DIG) who are against the further storage of decommissioned submarines, in the Devonport area (see Annex D). The criticism currently being levelled at the afloat storage policy would continue and be exacerbated by the use of an additional site, however, this is true of every option and is therefore dealt with further in the *conclusions* section of this paper. The local economy benefits considerable from the maintenance and decommissioning of nuclear submarines, so it is likely that any disapproval from the local population would be manageable. Finally, the technical challenges associated with this storage option would not be significantly greater than those of 3 Basin, and it is noted that preliminary action has been taken already at Devonport to authorise the use of 4 Basin for storing laid-up submarines when and if required[43].

[43] Reference A

Tidal berths on Sea Wall in Naval Dockyards and Bases

28. Sea Wall Berths within the Naval Dockyards and Bases is clearly finite and will carry an opportunity cost when used for the storage of Decommissioned Nuclear Submarines. Space could be found in Devonport and the Clyde, and if necessary a finger jetty could be constructed for the purpose, although this would add to the cost of the option.

29. In Devonport this type of berth is considered to be less desirable than the utilisation of 4 Basin. The submarines would be more visible, have less protection from the elements and be at a greater risk from collision damage. The cathodic protection system could also be damaged by boat traffic either directly or by wash affecting the suspension arrangements (“fishing rods”) used to secure the anodes. These arrangements, which allow their easy access for inspection and replacement, may need to be changed and would probably result in the anodes being fitted directly to the steel, inspection could then only be carried out by divers.

30. Alongside berths in the Clyde area are not considered a viable alternative to either 4 Basin or alongside berths at Devonport. The reasons for this are covered in *Site Specific Options* from paragraph 50.

31. To conclude, this option is viable, especially in Devonport, although it appears less attractive than the option of using 4 Basin.

Tidal moorings (not alongside) within the boundary of a Naval Dockyard or Base

32. This method of storage would have a visual impact on the local environment and, even in areas where the local economy benefits from the operation, servicing or decommissioning of nuclear submarines, this strategy is still likely to cause some consternation amongst the local population. It would undoubtedly result in criticism and increased attention from pressure groups, which could also have detrimental “knock on” effects on other operations and projects in the area (see Annex D). For example an increase in Devonport’s nuclear profile at a time when the TRIDENT refitting programme is due to commence and a new Naval Ammunitioning Jetty is being planned for the Hamoaze, would not be viewed as beneficial.

33. This type of mooring would afford the vessels less protection from the weather, and all equipment and essential supplies would need to be transported to the mooring, increasing the cost of maintenance. Although this option would not carry the same opportunity costs as the alongside berths previously discussed, because many offshore trots are currently in disuse, there would be set up and maintenance charges which would be costed to the laid-up submarines.

34. Off shore moorings would also raise security problems even within the confines of a Naval Base or Dockyard. It is highly likely that this could only be overcome by permanent manning of the vessels. The risk of collision would also be increased as could the consequences of such an incident, because of the risk of the vessel breaking its moorings.

35. Overall the storage of laid-up submarines in this way is considered less attractive than the options described above.

Tidal or non tidal berths in a commercial yard

36. The storage of laid-up submarines does not generate high cash flows. It is therefore extremely unlikely that a commercial yard could be found which would be able to store, maintain, and conduct 10 year dockings at a price which would be comparable with those of a Naval Dockyard. Without the benefit of the defuelling contract, which is only available to Devonport, a commercial yard would be risking adverse publicity for a revenue stream of little more than about… [information deleted to allow public release of this Report] …per submarine over 10 years.

37. The storage of nuclear waste in any form is an extremely emotive issue; for any yard to adopt such a strategy it must have the backing of a large percentage of the local population which can only be derived through economic benefits and familiarity with nuclear matters. The only commercial yard which could conceivably fit this category would be VSEL, it would also be broadly in line with the waste management policy favoured by Greenpeace, i.e. *storage of waste at its place of origin* (see Annex D). The area also has a tradition of building nuclear submarines and the local population clearly receives considerable economic benefit from their continued use.

38. [Information deleted to allow public release of this Report.]

39. For these reasons this option will not be pursued further at this stage.

Remote Berths and Moorings

40. Potentially there are many sites within the UK, remote from dockyards, Naval Bases, and centres of population, which could be prepared for the storage of laid up submarines. Technically any reasonably sheltered waters with sea access, a minimum depth on berth at Dead Low Water Spring Tides of 30 ft and of suitable size, could be used as a storage site. The coastline of Scotland has a large number of suitable sites, Orkney (Scapa Flow) could easily provide moorings for all present and planned nuclear submarines at the end of their operational lives.

41. However, a storage area which could be linked with an “out of sight out of mind” strategy would attract enormous criticism from environmental pressure groups who are opposed to the storage of any radioactive substances in remote locations (see Annex D). In addition this storage area could be perceived to contradict the MoD’s assurance that afloat storage is safe and poses no hazards to the surrounding environment. Public perception could conclude that the submarines must be a hazard otherwise they would not be stored in remote areas. It is also highly likely that the local population, small though it may be, would resent the lay up of submarines in their vicinity. Little benefit to the local economy would arise from this storage strategy, as the bulk of submarine maintenance would have to take place remote from the storage area. The 10 year dockings would require an infrastructure only available in an established dockyard and therefore towing charges would be incurred. A maintenance group capable of carrying out inspections and general preservation tasks would have to be set up near the site. Certain maintenance tasks such as checking draft marks and securing arrangements would be required on a daily basis.

42. Ensuring the vessels’ security at remote berths also would present considerable problems, Pressure Groups have displayed their ingenuity and ability to access platforms in

remote areas on numerous occasions e.g. Brent Spar. It is doubtful whether security of the vessels could be provided in a cost effective manner outside the established confines of a military establishment or Naval Dockyard.

43. To conclude, the problems associated with the remote afloat storage of nuclear submarines is considered to be insurmountable. Remote Berths do not compare favourably with the other options listed in paragraph 5; the general deliberations above show that under the 4 key considerations of Price, Environmental, Social/Political and Technical issues, utilisation of this type of storage can be dismissed from further consideration.

Assessment of Specific Site Options

Berths or Moorings in Portsmouth Dockyard and Harbour

44. Although there are many possible berths or moorings in Portsmouth , the Naval Base, which does not have a history in either operating or maintaining the nuclear submarine fleet, would appear to be a very unwise choice of venue for laid-up submarines. The local population have gained no economic benefit from their operational life, and would gain only minor benefits from their subsequent storage. It would be an easy target for the pressure groups, who could rely on widespread "NIMBY" support if they chose to oppose this option. Any attempt to bring laid-up submarines to Portsmouth would be likely to cause widespread condemnation and bring unwanted attention on the whole afloat storage strategy.

45. As the Socio-Political problems are believed to out weigh the benefits of additional storage space which Portsmouth could probably offer, this venue will not be considered further at this stage.

Berths at Rosyth

46. The main basin in Rosyth has been used for the storage of decommissioned submarines since 1983 with the arrival of Dreadnought. On completion of Renown's DDLP the total number of submarines laid-up in Rosyth will be increased to 7 vessels. The defuelling of Renown is the final nuclear work planned for the Dockyard and under the Dockyard Sale Agreement MoD has agreed that only submarines which undergo DDLP in Rosyth would be stored there.

47. There is little doubt that the Main Basin at Rosyth remains a suitable site for afloat submarines, it provides a non-tidal, sheltered location within a secure area. The dockyard provides ready access to maintenance facilities, which could if required, keep the submarines safely afloat indefinitely.

48. The main basin in Rosyth is very large and could certainly accommodate additional vessels with little impact on business in the short term. Edinburgh Radiation Consultants have stated in a report for the local authorities[44] that if the nuclear submarines currently stored in Rosyth were increased to 12 (there are 7 at present), the environmental impact would be very small and the additional dose to the general public would be insignificant.

[44] Reference B

49. The Main Basin is, however, the property of BRDL, and, although to date the company has made no charge for the berthing of laid-up submarines, there is a significant risk that this situation may change, especially with the cessation of nuclear refitting work.

50. The capability and suitability of Rosyth to continue as a submarine decommissioning dockyard is not in doubt while the infrastructure necessary to conduct a DDLP and maintain the vessels in afloat storage remains in place. The historic association with nuclear work and the positive benefits to the local population in the form of jobs and revenue, would probably outweigh any protests by the anti-nuclear groups and NIMBYs. However, Rosyth ceases to be a nuclear submarine refitting yard after the completion of Renown's DDLP in about 2002, and the current facility would require a considerable investment, to brought up to a similar technical standard to that of the D154 facility in Devonport, before an extension to the nuclear licence could be granted. Even if this investment was forthcoming, it is doubtful whether DDLPs alone, at a fraction of the cost of a refit, could sustain an infrastructure capable of maintaining a nuclear site licence to conduct defuelling in a cost effective manner. [Information deleted o allow public release of this report.]

51. Without positive benefits to the local economy, afloat lay-up in Rosyth of submarines which have been defuelled in Devonport would undoubtedly be met with strong opposition from Pressure Groups and the local authorities.

52. In conclusion, the use of berths at Rosyth for storing future laid-up submarines is of limited viability.

53. In addition, it should be noted that continued afloat-storage of the existing submarines at Rosyth will give rise to difficulties once the nuclear capability is lost. The 10-yearly maintenance dockings will still require a dock on a nuclear licensed site. Although this license would not require the same stringent standards required by a nuclear refuelling dock, it will still require some degree of nuclear capability to be retained in the Yard.

Berths in the Clyde Area

54. Areas within Clyde Submarine Base (Faslane) and Coulport could be set aside for the storage of laid-up submarines. Specific areas are discussed below. Coulport and Faslane Naval Base would provide acceptable levels of security and competent staff and equipment are available to conduct annual maintenance.

55. However, with the sale of AFD60 (Floating Dock), the only facility capable of conducting the 10 year annual docking is the shiplift, although it could only be used for this purpose if the Transfer Ashore Facility (TAF) was instigated. Without this facility available for 10 year dockings, the shiplift programme would not be able to uphold its primary objective, which is to support the operational fleet. The investment required to activate the TAF are detailed in Babtie/YARD Report on the Shiplift Transfer Ashore Facility (circa 1991). Some cost savings may be possible due to a less stringent safety case being required for laid-up submarines which no longer contain a fuelled reactor.

56. Faslane and Coulport has a local population familiar with nuclear issues who also gain economic benefits from its continued use as the Navy's main operational base for the deployment of nuclear submarines, although these benefits are largely derived indirectly via the service sector. However, as does Rosyth, this area suffers vigorous opposition at present

from Pressure Groups and Political Parties regarding any increase in radioactive waste storage in Scotland (see Annex D).

57. Clyde has no history of decommissioning and lacks a suitable docking facility at the Naval Base[45]. This, combined with the present climate of hostility towards the storage of nuclear waste in Scotland, make this venue less desirable than Devonport on grounds of costs and risk. However, it remains a credible option and its potential storage sites are described below. It should be noted that the offshore moorings in these areas would have inherent disadvantages similar to those described in paragraphs 0 - 0.

Moorings in the Clyde Area

58. It would be possible to modify existing trots in the Gare Loch to accommodate 10 laid-up vessels. Some mooring equipment would be required from stock but the majority would be able to be recovered and could be used to make moorings at No. 1 and 2 trots, suitable for interim afloat storage. Trot C33 could also be modified to a second class "head and stern" mooring.

59. The Trots lie close to shore on the opposite side of the Gare Loch to the Naval Base. The moorings are well protected from the prevailing weather conditions with high ground to the east and west. The vessels would be highly visible, and although this is a secure area with regular patrols, it would be difficult to guarantee security without permanently manning the vessels.

60. An additional storage area has been identified south of Coulport, and the existing, but currently swamped NATO moorings in Loch Long could be reactivated to accommodate submarines for short periods whilst maintenance is carried out on the permanent berths. This area is less attractive than the Gare Loch trots; they are more exposed, costs involved in setting up and maintaining the trots would be higher and security would be more difficult, due to the larger patrol area and the remote terrain around Loch Long.

61. The cost of setting up the moorings in the Gare Loch is estimated at …. [information deleted to allow public release of this Report] ….., in Loch Long set up costs would be in the region of …. [information deleted to allow public release of this Report] …...

Berths in Devonport

62. The suitability of Devonport as the favoured option for continued afloat storage has been discussed at length in previous paragraphs, with 4 Basin being the preferred option for additional vessels. Both this option and sea Wall Berths in Naval Bases and Dockyards carry opportunity costs i.e. the berths could be used for another purpose.

Moorings in the Hamoaze at Devonport

63. In general there are sufficient moorings at Devonport to accommodate 4 SSBNs or SSNs plus 6 further SSNs at Carew point, utilising N4, N5, N6 and N7; with the possibility that N12 and N13 could be retained to use as a backup mooring for periods when the

[45] Commercial Docks may be available.

permanent moorings require maintenance. Modifications and activation costs would be in the region of … [information deleted to allow public release of this Report] … .

a. **N3** - This berth could accommodate 2 x SSBN/SSNs, at present the mooring is swamped and would require refurbishing prior to use. This berth is regarded as unsuitable for berthing laid-up submarines as it is close to the recommended track for transiting vessels, it also has poor protection from prevailing weather fronts and is within easy view of the general public at Looking Glass Point.

b. **N4** - Could accommodate 2 x SSNs, this mooring is also swamped. Although it is considered more suitable than N3, being better protected and less visible. However, it may conflict with vessels making way astern as they exit Western Mill Lake jetty.

c. **N5** - Will berth 2 x SSNs, this mooring is available with minimal preparation and is considered to be a suitable trot for laid-up submarines.

d. **Carew Point** -At present this mooring is in use as a Light Carrier mooring and would therefore carry an opportunity cost. It could accommodate 2 x SSNs and is considered to be a suitable berth.

e. **Capital Ship Trot 2, N8, N9, N10, and N11** - These Trots are positioned in the centre of the River, consequently they will have little protection from the weather and are highly visible. The berths are serviceable, but are currently used as ammunitioning berths, each Trot will accommodate 2 x SSNs.

f. **N12 & N13** - These moorings are rarely used and so could be utilised to accommodate 2 x laid-up submarines without penalty. However, the trots are close to populated areas and would be visible from Saltash, Riverside and the Tamar Bridge. In general the berths are considered unsuitable due to the above and their proximity and possible interference with the future Remote Ammunitioning Facility Tamar (RAFT).

g. **N6 & N7** - These moorings are not used at present and would require reinstating prior to use. The Trots are considered to be the most suitable, they are off the normal transit route (therefore low collision risk), relatively well sheltered from the weather and less visible than other river moorings in the area.

AFLOAT STORAGE - GENERAL CONSIDERATIONS

64. The introduction to the main paper outlines the origins of the afloat storage strategy. Originally adopted as a temporary measure following a moratorium on the Sea dumping of Intermediate Level Waste, the strategy of storing vessels afloat for 30 years prior to disposal developed over a number of years and finally became policy when the London Dumping Convention ratified the moratorium in 1993. The storage period adopted takes advantage of the decay of key isotopes (see Annex E). A number of key radioactive isotopes will decay significantly over the first 30 years, ie Cobalt-60, although further advantages could be gained from a longer period of storage. The optimum storage period is discussed in the Main Paper.

65. Afloat storage is an attractive option and has a number of advantages when the interim period is limited to 30 years. It has very low start up costs and the maintenance liability over the first 30 years is relatively low. The first decommissioned submarine Dreadnought would have commence break up and disposal in 2012, consequently, afloat storage space would not have become a major issue and the accusation that afloat storage strategy was to have no strategy, would have had less credibility. Storage beyond 30 years is more problematic, additional storage space will need to be found, 30 year docking charges will be incurred and the number of submarines laid-up will increase considerably. Large numbers of laid-up vessels present a number of problems:

a. Public perception will begin to conclude that afloat storage is the final solution; the visual environmental impact will increase, exacerbate Socio-Political problems and attracting criticism from pressure groups.

b. The opportunity cost of berths increases.

c. The impact of the 10 year dockings on the rolling docking programme becomes increasingly significant, dry docks and associated infrastructure are often in short supply, often operating a full capacity in support and maintenance of the fleet. This is illustrated in the following figures. (8 weeks in dock has been assumed for *all* dockings. This is likely to be an optimistic assumption for the 30-year dockings.)

/ Figure F1a

Figure F1a - Number of dockings per year to maintain present and committed laid-up submarines - Indefinite Storage

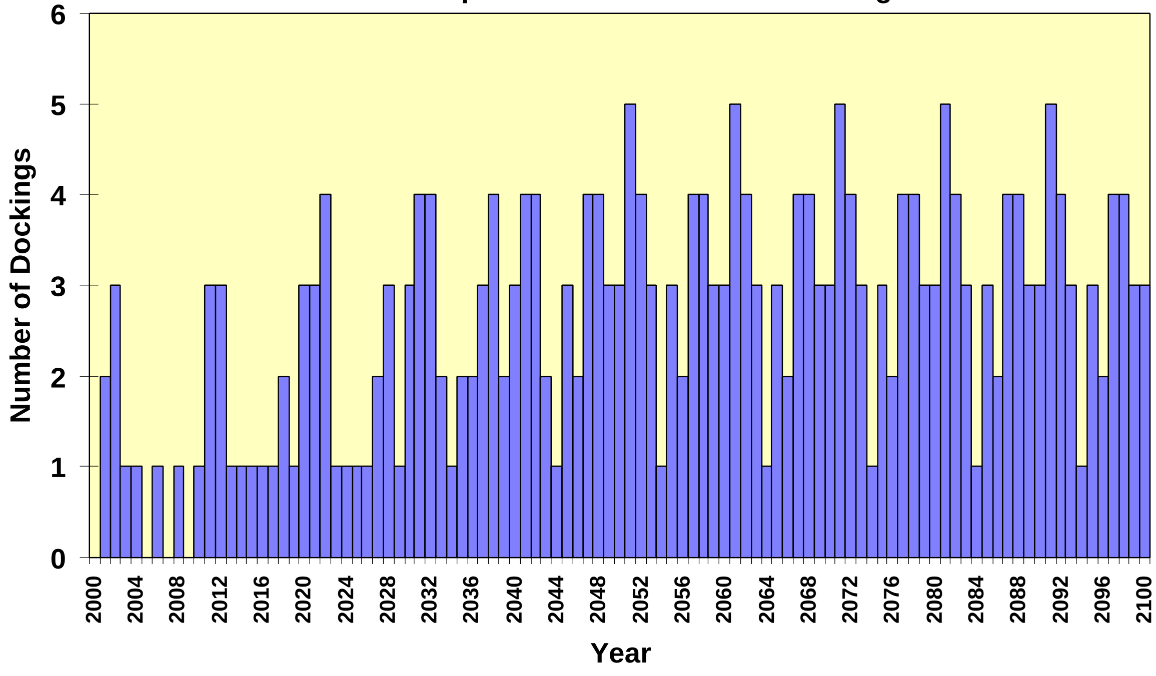
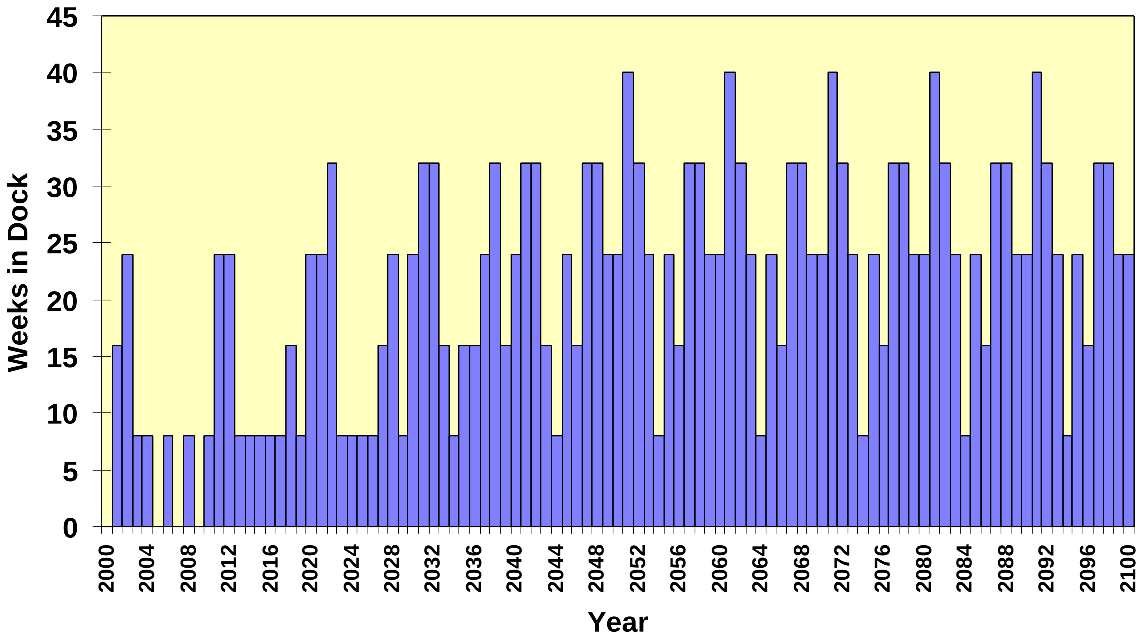


Figure F1b - Weeks in Dock required to maintain present and committed laid-up submarines - Indefinite Storage



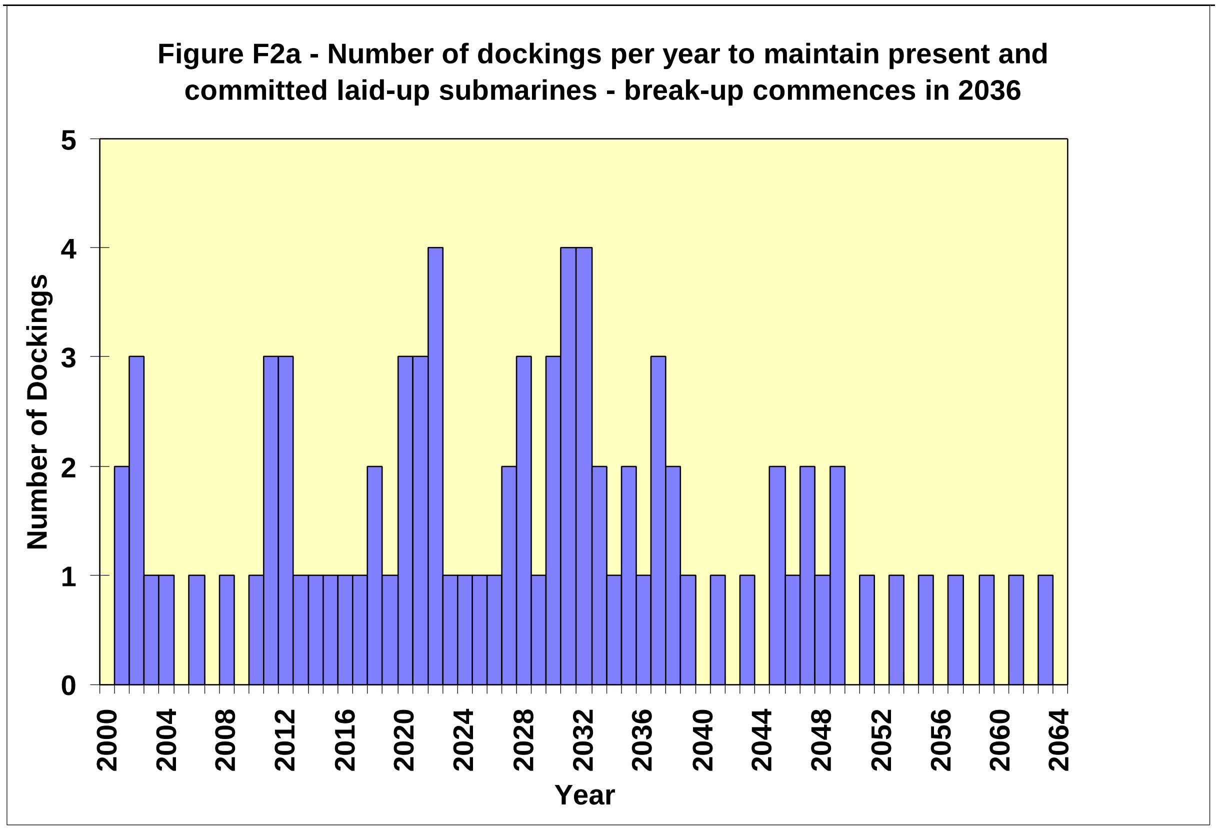


Figure F2a - Number of dockings per year to maintain present and committed laid-up submarines - break-up commences in 2036
Number of Dockings
Year
0
1
2
3
4
5
2000
2004
2008
2012
2016
2020
2024
2028
2032
2036
2040
2044
2048
2052
2056
2060
2064

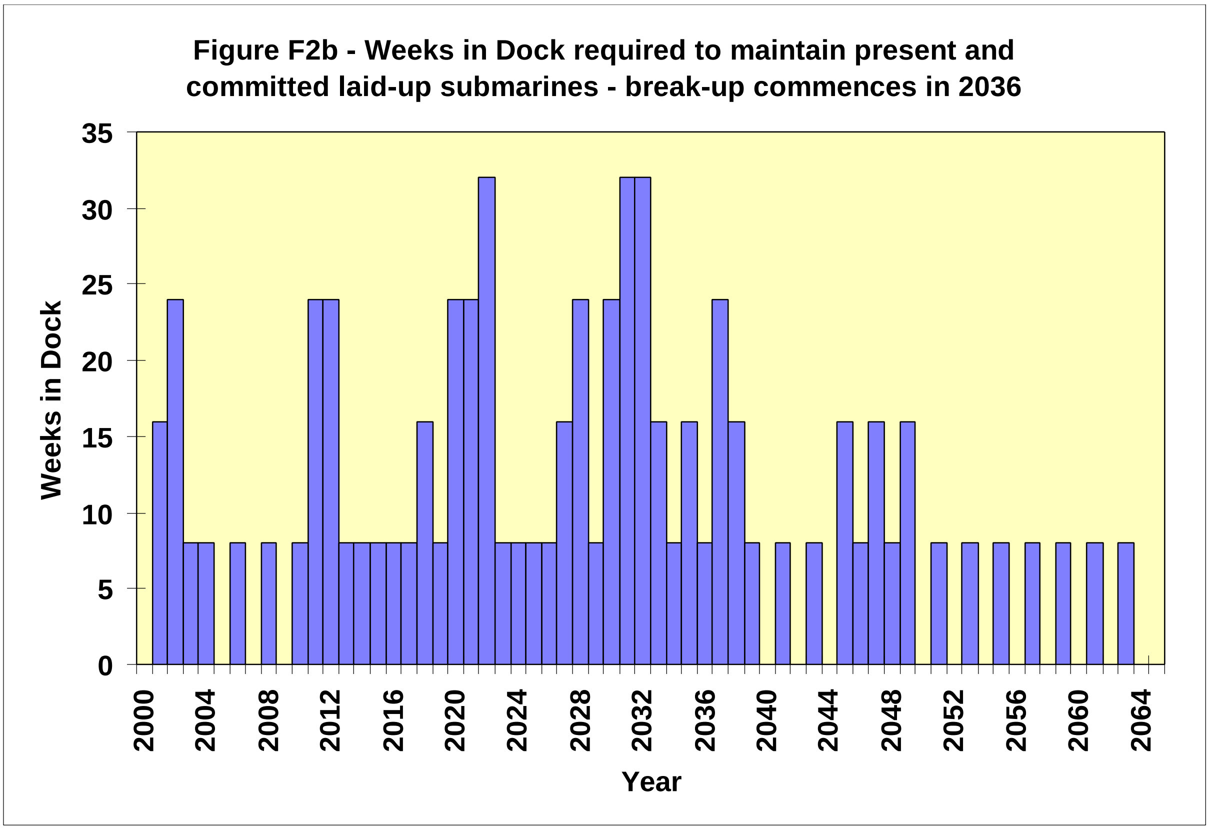


Figure F2b - Weeks in Dock required to maintain present and committed laid-up submarines - break-up commences in 2036
Weeks in Dock
Year
0
5
10
15
20
25
30
35
2000
2004
2008
2012
2016
2020
2024
2028
2032
2036
2040
2044
2048
2052
2056
2060
2064

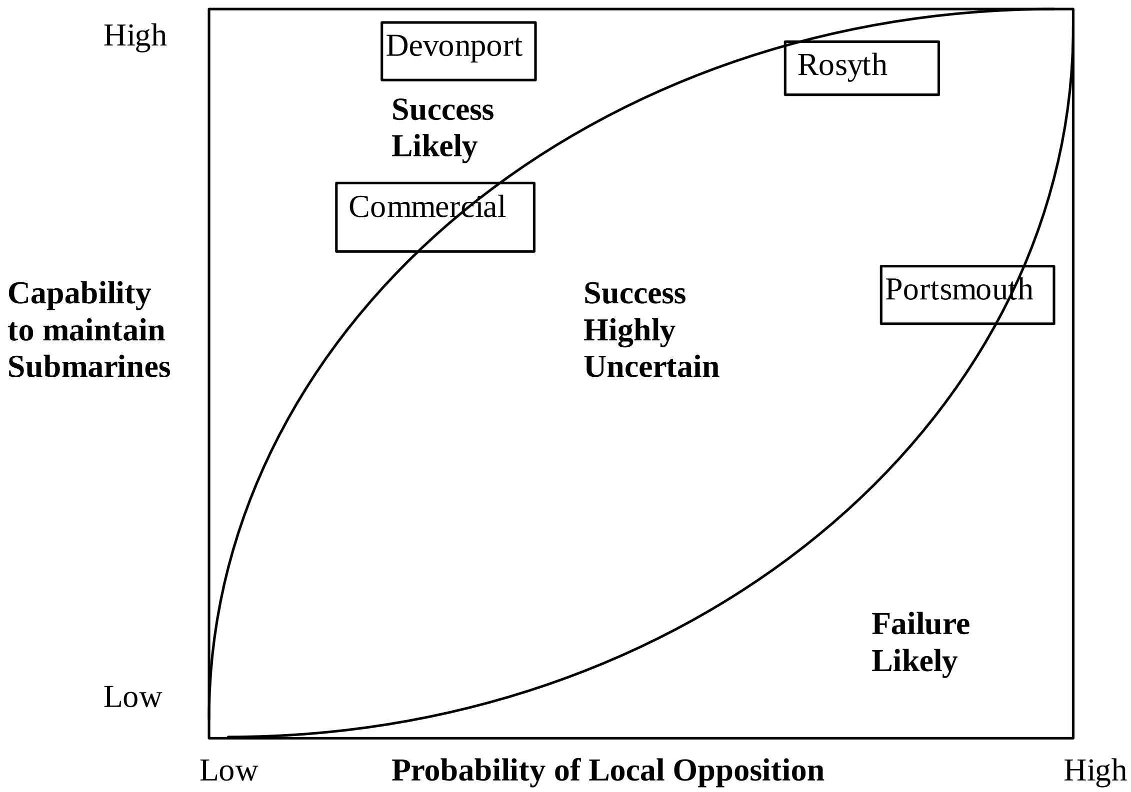
66. Afloat storage is time sensitive, as the length of time in storage increases the disadvantages outlined above become more severe. In this context, any delays to the DWR availability date, currently 2040, will cause further significant problems for an afloat storage strategy. The DWR* availability date has moved right on a number of occasions, it is possible that it will do so again or be postponed indefinitely.

67. The problem of the Rosyth vessels should also be recognised. The Dockyard will cease to gain benefit from the refitting and decommissioning of nuclear submarines in the near future, when this happens it is likely that demand for their removal will grow. [Information deleted o allow public release of this report.]. Contingencies should be put in place to limit this risk, either by planning for the movement of the vessels to another location or early break up and storage of the waste in another form (Annex G). It should be noted that if it became necessary to move the vessels to Devonport the available storage space in 3 Basin would be exhausted immediately.

CONCLUSIONS

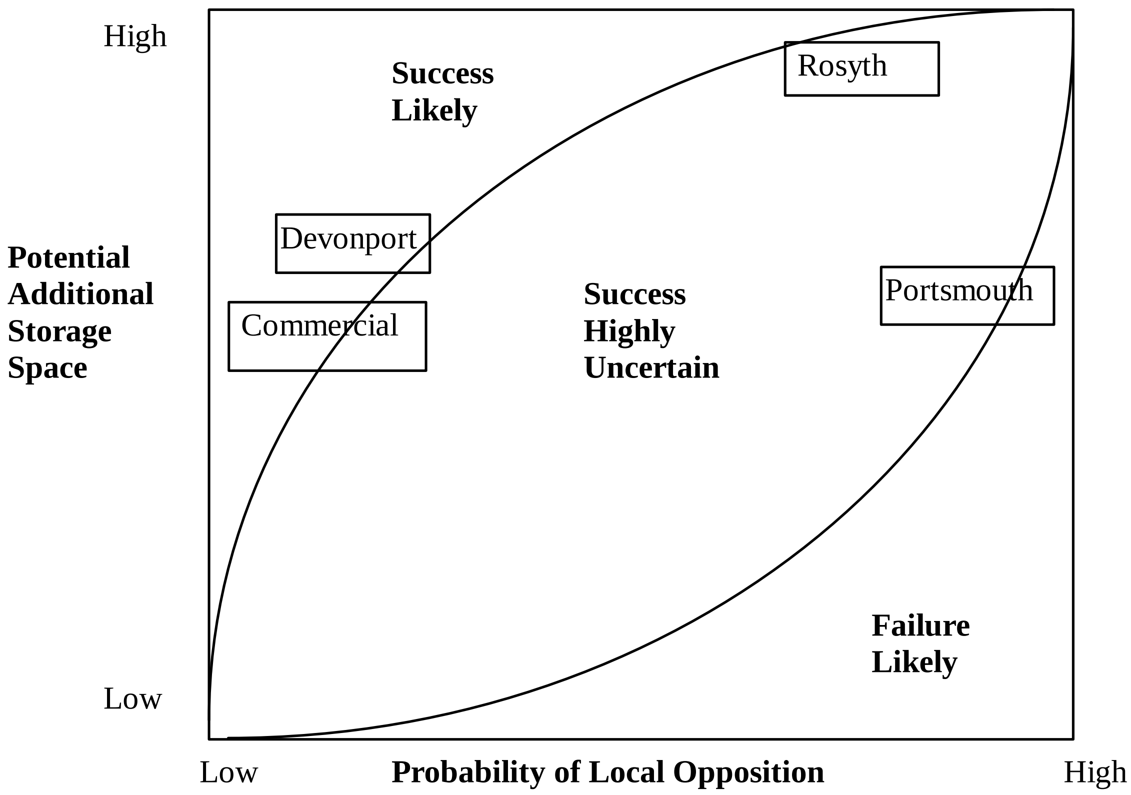
68. The foregoing assessment of alternative afloat storage sites is illustrated in the following sector diagrams:

Maintenance and Docking facilities



* Refer to statement on long-term management of radioactive waste on front cover of this report

Potential Additional Storage Space



69. If the decision is taken to continue with the afloat storage option, the order of preference to supply the extra berthing space necessary is as follows:

a. The utilisation of **4 basin at Devonport** for the storage of laid up submarines would increase capacity by 11 vessels, allowing available storage space to last until 2037. 4 basin is adjacent to 3 basin which already stores 3 vessels, the additional visual environmental impact will therefore be negligible. The area gains economic benefits from the nuclear submarine fleet and therefore NIMBY and Pressure Group protestations should be manageable. Vessels stored in this area should not incur costs significantly greater than those stored in 3 basin. Storage of vessels in this basin does not present serious technical difficulties.

b. **Sea wall berths at Devonport**, would cause additional maintenance and opportunity costs, there would also be an increased risk of collision when compared with basin storage. Despite this Devonport clearly would be the favoured venue: Rosyth is no longer an option due to the Dockyard sale agreement; Clyde has limited maintenance facilities and the policy would attract considerable criticism from pressure groups, political parties and local community groups. Further, the Clyde's lack of history in the decommissioning field make it a risky venue. Sea wall berths at Devonport would not be ideal but would present lower Socio-Political risks than the other venues and less technical and environmental problems than off shore moorings.

c. **Off Shore Moorings at Devonport**. This option is by no means ideal. Weathering of the vessel at the exposed moorings increases the maintenance load of the laid up submarines. In addition, maintenance will be required on the moorings itself, requiring the vessel to be temporary moored elsewhere. There will also be an increased risk of collision and security from unauthorised entry will be difficult to guarantee without permanently manning the vessels. The option has many disadvantages and it is only marginally favoured over berths in Clyde due to Socio-Political issues and the fact that the infrastructure to conduct 10 yearly dockings is readily available.

70. However, although this Annex identifies solutions to the problem of limited afloat storage space, the shortcomings of afloat storage as a strategy for the future still remain. These shortcomings are detailed in the Main Paper and in other Annexes which address Cost and Public Perception issues. Annex G identifies the benefits of storage on land as an alternative to afloat storage.

REFERENCES FOR ANNEX F

A. E-mail from PMNA Devonport 13 May 1999, 11:25
B. Edinburgh Radiation Consultants Report on Decommissioning of Nuclear Submarines at Rosyth Naval Base, unreferenced and undated. Sponsored by Dunfermline District Council and Fife Regional Council and published about 1993 or 1994.

ANNEX G - LAND STORAGE

INTRODUCTION

1. The current MoD policy for Nuclear Submarines at the end of their service lives is to conduct a Defuel, De-equip and Lay up Preparation work package (DDLP) as soon as possible, without adversely affecting the support of the operational fleet. On completion the submarine is to be stored afloat for a minimum of 30 years to take advantage of the natural decay of radioactivity. It is then intended to break up the vessel, with the non-radioactive structure being disposed of as scrap and the radioactive waste packaged and sent to a deep waste repository * (DWR) for disposal. This interim storage period allows substantial advantage to be gained from the significant decay of highly radioactive isotopes such as Cobalt-60 and Iron-55 over 30 years (see Annex E).

2. However, delays to the planned availability date of the national DWR (now assumed to be 2040) coupled with recognition of the benefits of storing for at least 60 years, provided the incentive to look for acceptable alternatives to afloat storage which are less time sensitive, comparable in terms of cost and radiation dose rates, and present a credible and low risk disposal strategy.

RATIONALE FOR LAND STORAGE

3. A large proportion of the maintenance costs associated with afloat storage are incurred through preserving the laid-up submarines ability to float and ensuring that corrosion is kept under control. Simply taking the submarines out of the water would reduce the problems of escalating maintenance costs, and eliminate the issue of finding new afloat storage space.

4. There are a number of possible land storage options, the scope of the preparatory work and the requirements of the storage site will vary significantly for each of the choices listed below:

a. storage of intact Submarine on Land;

b. storage of Reactor Compartments on Land;

* Refer to statement on long-term management of radioactive waste on front cover of this report

c. land Storage of Primary Plant components (RPV + PST)[46] as unpackaged ILW;

d. storage of packaged ILW on land.

5. [Information deleted to allow public release of this Report.]

6. The following sections discuss each of the options as listed above.

STORAGE OF INTACT SUBMARINES ON LAND

DEFINITION OF OPTION

7. Dry lay-up of an intact submarine, following defuelling, would require the submarine to be installed for the period of storage in a dry-dock facility or on a hard-standing in the vicinity of a suitable slipway or synchrolift.

8. Possible sites for this could include:

a. RD57, the discontinued Vanguard Class refitting facility at Rosyth[47];

b. a hard-standing in the vicinity of the synchrolift at VSEL, Barrow;

c. a transfer ashore facility in Faslane.

ASSESSMENT OF OPTIONS FOR LAND-STORAGE OF INTACT SUBMARINES

9. Storage of a complete submarine on land is feasible. It would eliminate the need for periodic dockings and require less work to prepare the submarines for lay-up. Compared with the land storage of separated RCs there could also be marginal savings in the work required to prepare for lay-up.

10. However, their weight and size would make manoeuvring the vessels on land extremely difficult. The area needed to hold the vessels would need to be large and, due to the size and weight of the intact submarine, access from sea would be the only practical method of transporting to the Land Store. Although the 10 yearly docking would no longer be necessary, some preservation of the structure would still be required to prevent the submarine casing and ballast tanks from becoming dangerous and unstable. The outward appearance of the vessel would quickly deteriorate if left open to the environment,

[46] Reactor Pressure Vessel (RPV) Primary Shield Tank (PST)
[47] Reference F.

consequently painting would be required on a regular basis unless the vessels were housed in a covered weather-proof enclosure.

11. Further, against the rather tenuous advantages, intact land storage has many disadvantages. These can be summarised by considering the possible sites listed in paragraph 0 above:

a. The RD57 project was not completed. Consequently, extensive and expensive work would be required to make it suitable for use as a submarine storage area. Continuous pumping would be required to keep the facility dry and, without adequate subdivision of the dock area, stored vessels would have to be wetted to admit each additional vessel.

b. The Faslane Synchrolift had an area set aside behind it which was originally intended for use as a transfer ashore facility, where operational submarines could undergo extensive maintenance. Although this facility reached the design stage, it was not taken forward. It could be adapted into a storage facility at a cost of around …. [information deleted to allow public release of this Report] …although the number of hulls that could be stored would be limited to approximately four.

c. Similar space constraints would apply to the accessible area in the vicinity of the VSEL synchrolift, and its use for submarine storage could compromise its prime purpose as a shipbuilding facility. Civil works to allow storage of intact submarines are likely to be prohibitively expensive.

12. Land storage of intact hulls would be contrary to the Civil Nuclear Industry decommissioning policy of staged size reduction (three stage decommissioning). The visible environmental impact of these vessels would be significant at most locations and it is likely that the strategy would be perceived as a problem postponed for future generations to solve. Use of Scottish sites would also be particularly inimical to the Scottish lobbies (see Annex D).

13. Storage of the entire vessel on land would still leave the MoD open to the accusation that it *had no strategy*, there seemingly being little strategic difference between afloat and land storage with this option.

14. On the basis of this assessment the storage of the entire submarine on land is not considered a viable proposition and it is therefore dismissed as a credible option.

STORAGE OF REACTOR COMPARTMENTS (RC) ON LAND

INITIAL POSITION

15. Providing there is not too long a delay between defuelling and commencement of RC cut out, the submarine will no longer require the entire "afloat lay-up package" and therefore some savings from the current cost of a DDLP will be made. Also as the strategy is to store the radioactive waste within the RC for long enough to allow significant radioactive decay, decontamination of the plant would not be required[48]. This is in line with the present afloat storage strategy.

OVERVIEW OF PROCESS

16. Once defuel is complete, the cut out of the RC and subsequent scrapping of the remainder of the vessel could take place at any suitable location. Separation of the RC is reasonably straightforward and would utilise techniques already in common use in shipbuilding and refitting. The system pipework and cables protruding through the RC bulkheads could be sealed individually, or achieved by welding a steel canning plate of appropriate grade and thickness to the ends of the compartment to ensure containment is maintained.

17. A cradle would need to be fabricated and welded to the underside of the separated RC, to provide support for the compartment during transport and also at its storage site. The ability to manipulate and transport the prepared RC to a storage site is not in doubt, however a number of different methods could be employed, the choice being largely governed by geographical and logistical issues.

18. The scrapping of the remainder of the vessel could be carried out in parallel with RC separation at the cut-out site or at a different location following separation. The latter course would necessitate either the welding together of the two halves of the submarine, so that it could be towed to a new location, or using a lift ship or barge to transport the separated hull sections. In either case it is unlikely that the cost of scrapping could be recouped by the sale of the metal.

19. Following cut-out it is envisaged that the RCs will be stored at one or more locations in a simple weather-proof building. The facility would need to be accessible by sea as land transport would be practical only over short distances. The storage area should be secure and be able to facilitate the routine inspection and monitoring of the RCs. Plans should also

[48] Whether decontamination of the primary circuit is necessary prior to storage preparation may be debated on the grounds of "ALARP". The present policy, on quantified cost-benefit arguments, is that MODIX (decontamination) is *not* carried out for boats undergoing DDLP in preparation for lay-up afloat. Similar arguments would apply to preparing an intact RC for land storage (provided it were intended to store the RC for a period in excess of 30 years before further processing) because the majority of the work involved in cutting out the RC is done outside the RC and there is little dose related benefit in carrying out decontamination.

be in place to allow the building of a Break Up and Packaging facility on the site so that final disposal of the radioactive waste can take place when the optimum storage time has elapsed and the DWR is available.

20. Selection and approval of a Land Store site is likely to present some difficulties due to the need to take account of many differing interests.

21. The following sections address:

a. location options for RC Cut Out;

b. process options for RC Cut Out (including disposal of residual hull and structure);

c. transport of the RC to a storage site;

d. the specification for a land-store site; and,

e. location options for a land-store site.

LOCATION OPTIONS FOR RC CUT-OUT

Definition of Options

22. There are two generic categories of location options for RC Cut Out:

a. at a site with suitable dock (or synchrolift) facility where submarine work is undertaken now; or,

b. at a commercial dock (or synchrolift) where nuclear submarine work would be new business.

23. The former category covers the two Royal Dockyards, Devonport and Rosyth; the build yard, VSEL at Barrow in Furness; and the Naval Base at Faslane. Each of the potential candidates would have a variety of capital plant available which will influence their preferred method of achieving RC cut out; similarly their differing geographical locations will influence their chosen method of transport to the storage site.

24. In the latter category the DEO report, reference A, has listed a number of potentially suitable sites where it may be feasible to undertake the work, but it would be premature to discuss specific sites at this stage.

ASSESSMENT OF OPTIONS FOR RC CUT-OUT LOCATION

Faslane

25. The requirement to keep the synchrolift at Faslane available to support the running SSBNs militates against using it for prolonged work on the laid-up submarines. This is seen as sufficient reason to dismiss this option as non-viable and so its technical feasibility has not been investigated in detail. It should be noted, however, that there is currently no facility for rolling a vessel to a hard-standing and although it may be possible to activate the Transfer Ashore Facility (TAF), a considerable investment would be necessary.

Devonport and Rosyth

26. Both DML and BRDL have undertaken studies to determine the scope and cost of the work needed to cut out the RC, prepare it for land storage, and dispose of the residual hull and structure. Several process options are identified, described in detail in the BRDL and DML reports[49]. None involves significant technical risk. Further, such work, as a continuation of the core business of submarine refitting in these yards, would be likely to excite only minimal public concern[50], and resolution of the legislative and regulatory issues (see later section) would be relatively straightforward whatever way these apply. **Devonport and Rosyth are therefore assessed as viable options.**

27. However, it should be noted that, although Rosyth is a viable option for RC cut-out, it ceases to be a nuclear submarine refitting yard after the completion of Renown's DDLP in 2002. The current facility would require considerable investment to bring it to a standard similar to that of D154 in Devonport, before an extension to the nuclear licence could be granted. Even if this investment was forthcoming, it is doubtful whether defuelling alone, at a fraction of the cost of a refit, could sustain an infrastructure capable of maintaining a nuclear site licence for defuelling in a cost effective manner. Therefore under the current policy of reverting to a single yard nuclear refit capability, the possibility of utilising Rosyth for defuelling after 2002 is assumed to be no longer an option.

VSEL at Barrow-in-Furness

28. An earlier proposal by VSEL indicated that the build yard would be a suitable site for RC cut-out although the vessels would need to be defuelled elsewhere. VSEL is undertaking a specific study in support of ISOLUS (Interim Storage of Laid Up Submarine), although this will not be reported until April 99. [Information deleted to allow public release of this Report.] **VSEL is assessed as a viable option.**

[49] References B and C.
[50] However, once the submarine refitting work there has ended, Rosyth may attract some public opposition on decommissioning issues.

Other Commercial Yards

29. Although Devonport, Rosyth and Barrow-in Furness stand out as eminently well suited to the RC Cut Out task and at present each holds a nuclear site licence, Defence Estates has carried out an initial investigation into other commercial companies that could carry out this work. They are listed at in the DEO report at reference A. However, while it is feasible to carry out this work in a commercial facility unconnected with nuclear work it is unlikely that it would receive support from the general public or the pressure groups. Thus, although sites may offer the potential for cost saving, their use may require many more obstacles to be overcome. Specific sites should be investigated in more detail in a later phase of the study if the land storage option is pursued. Meanwhile, as a generic option, the use of other commercial yards is **assessed as likely to be technically viable**.

PROCESS OPTIONS FOR RC CUT-OUT

Definition of Options

30. RC Cut-Out. In References B and C, the BRDL and DML RC cut-out processes are described in detail. Except as mentioned in the following assessment, these differences are not sufficient to warrant separate analysis at this stage.

31. Disposal of the residual hull and structure. BRDL and DML describe a number of different methods and procedures for breaking and recycling the residual hull and structure. In essence the choices are: to dismantle completely in the RC Cut Out dock (this is likely to be a different from the dock used for defuelling in Devonport); or to remove the residual hull and structure to a specialist breaker for dismantling and recycling. Because of the uncertainties associated with the latter, the options are compared on the basis of complete break-up in the RC cut-out dock.

Assessment

32. The process of RC cut-out and disposal of the residual hull and structure is technically straightforward and would be viable at any of the identified site options. However the following differences between the sites would affect the implementation of the processes:

a. Significant work on separation of the hull and structure could not begin until defuelling is complete and the Reactor Access House (RAH) has been removed. At DML the defuelling docks are at a premium, and RC Cut Out and disposal work would therefore need to be undertaken in a less valuable dock.

b. As is described in reference D, the BRDL and VSEL sites have sufficient space to allow the setting up of a land store for the RCs within the vicinity of the Cut Out area, allowing a reasonably straight forward transfer. At Devonport there is no such space in or immediately adjoining DML's land, and it would be therefore be necessary to transfer it off site.

DISPOSAL OF THE RESIDUAL HULL AND STRUCTURE

33. Dismantling and recycling of the residual hull and structure would be governed by the normal environmental regulations concerning disposal of wastes (particularly asbestos, PCBs, etc.) but otherwise it would present no significant technical difficulties. Although the process would set a precedent in the UK in that no nuclear submarine has yet been broken up, the techniques employed would be no different from those carried out in the course of normal refitting work; they would simply be on a larger scale.

34. Compared with the cost of break-up at the RC Cut Out site, some cost savings might be achieved by removing the residual hull and structure to a specialist breaker for dismantling and recycling. Removal could be achieved by blanking or welding-together the two ends of the submarine for transport by tow, barge or heavy lift ship. It would also be possible to cut up the remains of the vessel into suitable sized sections to allow bulk transport to a breakers yard for final disposal.

35. All those scenarios are equally feasible. The choice would be made by the company conducting the cut out, who would presumably choose the most cost effective method. No further assessment will be made at this stage for the following reasons:

a. Costs associated with disposal to a specialist breaker cannot be ascertained with any confidence given the number of options and the uncertainty over what would be the destination for scrapping.

b. The BRDL and DML reports suggest that the residue would have negligible commercial value to a breaker in this country. This cannot be confirmed without approaching such breakers directly, but it is consistent with the US report on submarine disposal[51] which advises that the return on recycled scrap amounts to only 3% of the cost of recycling.

c. A specialist breaker in UK, having removed high value scrap, would be likely to find break-up of the remaining steelwork uneconomic. It therefore could be a very protracted operation, which would be undesirable from the public perception point of view.

d. Disposal to a specialist breaker overseas could result in potential technical security objections which would need to be clarified and resolved.

36. Use of specialist ship-breakers could be investigated further at a later stage if the land storage option is pursued, but, more appropriately, it would be left to the prime contractor to resolve, using the specialist breaker as a sub-contractor if he so desired.

[51] Reference G.

TRANSPORT OF RC TO STORAGE SITE

Definition of Transport Options

37. The method of transporting the separated RC would be influence by the location of cut-out venue and eventual storage site.

38. If the storage site is remote from the cut-out site the most likely means of transport would be by sea. Due to the weight and size of the RC, transport on land would be ruled out unless it was for relatively short journey over a level site.

39. The following methods for sea transfer have been investigated:

a. Towed Barge

b. Con Dock Type of Vessel (Container - Dock - RO/RO Vessel)

c. Flotation Collars (or similar)

d. Movement over land

Assessment of Transport Options

Towed Barge

40. A purpose built Tow Barge could be used, this would be docked alongside the submarine and the RC slid sideways onto the barge and secured in place. The barge complete with the RC would then be towed to the storage area by at least 2 ocean going Tugs (a standby tug would be required). The barge would need to meet a number of stringent safety criteria including intact and damaged stability.

41. On arrival at its destination the barge would be placed on a discharge slip and water would be added to the barge compartments in a controlled sequence to ground the barge firmly on a gravel slip bottom. This would allow the barge to be level with the top of the slip allowing the RC to be removed.

42. This process has been successfully used in the USA for over 70 RC movements.

Con Dock Type of Vessel (Container - Dock - RO/RO Vessel)

43. A Con Dock (Container - Dock - RO/RO Vessel) is a shallow drafted vessel. The special feature of this type of vessel is its ability to load general, bulk cargoes by roll-on/roll-off units and to load floating units by semi-submersible dock operations. As the vessel is self propelled it may be easier to effect long distance transfers by this method, and gaining a safety case for transportation may be simplified.. Cost savings could also be possible through hirings.

Flotation Collars

44. If the RC is required to be moved a short distance such as across 5 basin in Devonport it would be possible to achieve this by an attached flotation device (collars or similar) and towing it to the required area.

Movement over land

45. The movement of the RC over land to a storage site close to the Cut Out facility does not pose any insurmountable problems. It could be achieved by airbags, water skates or wheeled transport depending on the distance to be moved. Moving the RC from the dock to land could be achieved by shiplift, heavy lift gantry or by pulling up a slipway. These procedures are described further in the BRDL and DML reports (references B and C).

SPECIFICATION FOR A LAND-STORE SITE

46. The land store site could be in the vicinity of the Cut Out yard or at a remote location.

47. The exact design of the store would depend on the condition and topography of the chosen site. However for the purposes of this study DEO have carried out a costing exercise based on previous reports, Project 1156 and BRDL Study BNT/835-200/93. The detailed costings are in reference A.

48. The main requirements for a store are:

a. a receipt facility from sea;

b. a haul road built from (a) to the land store;

c. a covered building with condition-monitoring facilities;

d. shielding may be required although this is unlikely;

e. a water run off catchment facility so that monitoring can be carried out;

f. accommodation for security attendant (building would normally be unmanned); and,

g. physical security i.e. PID, CCTV fencing illumination etc. The extent of security will depend on the location, it may already be within a secure establishment.

LOCATION OPTIONS FOR LAND-STORE SITE

Definition of options for location of Land-Store site

49. At Reference D DEO identifies a number of possible sites for the land storage of separated RCs:

a. Commercial Sites at or near viable cut-out venues:

(1) Rosyth

(2) Devonport

(3) VSEL, Barrow

b. MoD sites at or near cut-out venues

c. Remote Commercial sites

d. Remote MOD sites

Assessment of Land-Store Site location options

Commercial Site at Rosyth

50. Previous studies have indicated that there are suitable sites within the vicinity of BRDL estate to store RCs from the decommissioned submarines currently at Rosyth (7 in number). The BRDL study into RC cut-out, reference B, indicates that a suitable store could be sited by the active waste accumulation facility (AWAF). If a larger site was required for 20+ RCs, an area of land to the North of RD57 could be utilised and sites which are becoming vacant, following the rationalisation of BRDL's present businesses, may also provide suitable areas. Siting the store at Rosyth would have the following advantages:

a. It would be on or close to licensed site;

b. Health Physics would be on hand for monitoring;

c. it would be within a secure area;

d. it would be in an area where the general public are familiar with nuclear issues;

e. there would be no requirement for sea transport if the RC was separated at Rosyth.

51. With the cessation of nuclear refitting work at Rosyth, the nuclear capability will be quickly eroded. It would therefore, be preferable if the option could commence while the nuclear expertise still resides at the dockyard. Whilst pressure groups might complain about

Rosyth being used as a “nuclear grave yard” and, after Devolution, Scotland becoming a “nuclear dustbin”. This could be balanced to some extent by the continuation of limited employment within the dockyard at Rosyth, especially if a programme of disposal could be put in place before the nuclear expertise is eroded. The storage of the RCs at Rosyth would be in accordance with the Civil Industry’s strategy (and the Greenpeace view) of storing at the place of waste-arising.

52. After the optimum storage period (60 years see Annex E) a facility would be required to dismantle the RC. It should be possible to accommodate this facility on land at Rosyth or if policy dictated that this should be carried out elsewhere, transfer of the RCs away from Rosyth would be relatively straightforward.

Commercial Site at Devonport

53. Devonport is a suitable cut out venue, and DML would have the ability to accommodate the whole decommissioning programme including the defuel. However, they have stated that there is no space available for storage of RCs within the DML estate. Some MoD sites in the area may be suitable, and the advantage of utilising these within the vicinity of the Dockyard would be similar to those described above, for Rosyth. In addition, as nuclear work is planned to remain at Devonport the expertise in this type of work will remain, and be supported by continuing core nuclear work, including refits. The disposal element will therefore be additional to the core business and use similar assets; it could therefore be conducted during quiet intervals to the dockyards refit programme, which may lead to cost savings.

54. The pressure group DIG (Plymouth Nuclear Dump Information Group) have indicated that they would oppose any storage of RCs at Devonport, which they believe should be stored at a remote location. However, this is in contradiction to other pressure groups who advocate storage at place of arising (Annex D) and as with Rosyth, storing the RC at Devonport would satisfy this general criterion. In addition, the local population have gained, and unlike Rosyth, will continue to enjoy, considerable benefits from the continued upkeep, and decommissioning of nuclear submarines. This vested interest for the local economy will aid public acceptance of the strategy.

55. As Devonport will retain a nuclear capability into the foreseeable future, expertise should be available for dismantling the RCs when required in 30-60 years time.

Commercial Site at VSEL, Barrow

56. VSEL Barrow would be a suitable venue for cutting out the RC. As the country’s only builder of nuclear submarines, it has the ideal infrastructure and the expertise necessary for this type of work. Decommissioned vessels could be transferred via the shiplift to Devonshire Dock Hall or a suitable adjacent hand-standing where cut out of the RC could take place. Transportation to the storage site could be over land using multi-wheeled load movers, or by water to the storage site. No exact location has been identified although there is a considerable amount of suitable land available in the area.

57. All the advantages applicable to the Rosyth option apply to VSEL. As Vickers has no defuel capability any submarine undergoing processing would have to be transported from Devonport. This could be achieved by towing or by heavy lift ship, the advantage of heavy lift ship being that a number of vessels could be transported in one go. As with Devonport, VSEL already has a core business and therefore the advantages of being able to utilise an existing workforce during lull periods and making use of existing tools and equipment apply equally to VSEL. Furthermore, Vickers is very prone to periods of low workload due to periodic nature of their core business, so the two disciplines of shipbuilding and submarine break-up should complement each other very well; synergy between the two tasks clearly exists.

58. As VSEL built the submarines, storage of the RC could be seen as *storage at the point of origin*, which would be in accordance with the Civil Nuclear Industry's strategy and the favoured view of some Pressure Groups. As the Cumbria community have had the economical benefit of nuclear submarine construction and they would continue to reap the benefit of additional work provided by disposal they may be more receptive to accepting this type of work over a venue that has no history of nuclear work. Vickers being in the vicinity of Sellafield would ease the disposal of low level radioactive waste … at a future date. [Information deleted to allow public release of this Report.]

MOD Site at or near Cut Out Venue

59. It is highly unlikely that MOD would have the resources to run a Land Store Facility so, whilst it is possible that it could be sited on an MOD land, the running of the facility is likely to be contracted out. The regulation of such a facility, being the *storage of bulk matter* would require a licensed site under NIA65, and although Crown exemption currently applies, this could only remain if MoD retained direct control.

60. Work to date has identified some MoD sites at or near two of the viable RC cut-out locations (South Yard, Weston Mill Lake, and Bull Point and Ernessettle at Devonport; and the redundant Oil Storage Depot at Rosyth) but the suitability of using any of this land or other such sites will require further investigation.

Commercial Site Remote from Cut Out Venue

61. Whilst no detailed study has been carried out, DEO has identified sites, worthy of further investigation, which have sea access for receipt of RC. In addition they have identified sites which already have a Nuclear Site Licenses and may be undergoing decommissioning of their own facility i.e. MAGNOX & AGR Power stations. As these sites are generally close to an estuary, transportation of the RC to the site by sea should not present insurmountable problems. Decommissioned power stations have their waste stored on site until there is a known disposal route for the remaining radioactive waste. This is combined with their policy of store and decay, *safestore,* which means that total decommissioning will not take place until the optimal decay period has been reached, making such a site suitable for the storage of RCs. The RCs could then be broken up at the same time as the rest of the Power Station waste, as long as the storage period was at least as long as the RCs optimal storage period. Such a site also has inherent advantages, as the

monitoring, maintenance and security resources are already available. Nuclear work is accepted in the area (and indeed is already there) and some jobs lost since the power station ceased operation could remain to implement the storage strategy.

62. There is also the possibility of storing the RC complete at Sellafield. It is close to the sea and therefore would be suitable for sea transportation. Sellafield is a licensed site, it has all the relevant monitoring facilities and would be an ideal site for eventual cut up and packaging of waste. It also has long term economic viability and therefore, it is highly likely that it will maintain a nuclear competent workforce over the storage timescale.

MOD Sites Remote from Cut Out

63. DEO has carried out a scoping study (reference D) to identify possible MOD sites suitable for storage of RCs. If approval is given to investigate land storage further then detailed site selection would be need to be conducted.

64. An example is MELLON CHARLES (AULTBEA) which was identified in previous studies as being suitable. It is in a remote part of Scotland (Loch Ewe) in a sheltered location and has access from the beach-jetty. Previously used as a boom defence depot, it is now used for adventure training.

65. The siting of a store in this type of area involves similar inherent disadvantages to those described in paragraph 0. Whilst they have the advantage of being MOD owned they could come under pressure from the general public and pressure groups. The use of such sites could be criticised by Greenpeace under the *out-of-site out-of-mind adage,* the local area would not have a history of nuclear work and little economic benefit could be gained. “NIMBY” pressure could therefore be considerable.

66. [Information deleted to allow public release of this Report.]

67. [Information deleted to allow public release of this Report.]

68. [Information deleted to allow public release of this Report.]

69. [Information deleted to allow public release of this Report.]

70. [Information deleted to allow public release of this Report.]

71. [Information deleted to allow public release of this Report.]

72. [Information deleted to allow public release of this Report.]

73. [Information deleted to allow public release of this Report.]

LAND STORAGE OF PRIMARY PLANT COMPONENTS AS UNPACKAGED ILW (RPV/PST)

DEFINITION OF OPTION

74. This option entails the complete break up and disposal of the hull and structure of the submarine[52]. Components classified as Intermediate Level Waste (ILW) would be prepared for storage in an ILW store either on site or at Sellafield; Low Level Waste (LLW) would be packaged and despatched to Drigg for immediate disposal.

75. The primary circuit will have been decontaminated, confining the majority of the ILW to the RPV & PST[53]. Otherwise, there is a possibility that other components in contact with primary coolant water (Steam Generator (SG) headers, Main Coolant Pumps (MCPs) and pipework) could be contaminated with radioactive deposits (known as "CRUD") and have activity levels above the threshold of LLW. With aggressive decontamination much of the primary pipework and components would below the activity threshold for free release.

76. If the submarine has not undergone DDLP it would be docked down and prepared for defuel. Whilst this work is underway the submarine would gradually be cut into small sections suitable for transport. On completion of defuel the primary circuit pipework (not including RPV would undergo an aggressive decontamination process. This would enable the majority of the pipework to be scrapped as free release material. The RC would be cut up and the RPV/PST would be removed and transported to a purpose built store or transported to Sellafield for storage.

ASSESSMENT OF OPTION

77. Despite the decontamination process, the level of background radiation inside the RC would be higher, as would the "hot spot" activity in the vicinity of the RPV, than it would be if the optimum storage period was concluded. A case for early break-up would therefore have to satisfy the "ALARP" criterion for dose rate this strategy could be implemented.

78. Storage would be required in a purpose built ILW store [Information deleted to allow public release of this Report][54], the RPV/PST package would have a high activity and may require additional shielding.

79. The nuclear industry decommissioning strategy (three phase decommissioning) does not implement the break up of the biological shield[55] until a period of *"safestore"* has been

[52] The options for disposal of the residual hull and structure are the same as those applying when separating the RC for land store of a complete RC – see paragraph 0.

[53] After sufficiently aggressive decontamination the majority of the Primary Circuit pipework could be scrapped as free release material.

[54] [Footnote deleted to allow public release of this Report.]

completed, removing the RPV would be contrary to this policy and would therefore carry a higher risk.

80. The visual environmental impact would be low, especially in areas where an existing ILW store could be utilised. It would also share many of the RC land storage advantages, in that it would counter the *do nothing* criticism, be less time sensitive than Afloat Storage, have lower maintenance costs, and it would free valuable berthing space.

81. It is possible that RPV/PST package could be transported to Sellafield subject to the development of a suitably shielded container "overpack" for transport. The shielding required to meet the transport regulations for external activity would be substantial, especially within the first 30 years due to the high energy gamma derived from Cobalt-60.

82. As previously stated at paragraph 0 storage at Sellafield would be a distinct advantage as it would be in the ideal position for cutting up when the optimum period has expired. It should be possible to utilise existing facilities on site, as Sellafield has a long commitment to nuclear decommissioning and disposal work, therefore the business risk associated with it ceasing to a viable company over the intervening period is assessed as low.

83. This process could be carried out on a submarine that has been laid up for some time or on a submarine that has been recently withdrawn from service. However, the former would require the primary plant to be surveyed and tested (and possibly repaired) before the decontamination process could start. It is likely that, for submarines which have already been in afloat storage for a considerable time, it would be more cost effective to allow them to complete 30 years of storage negating the requirement for aggressive decontamination.

84. [Information deleted to allow public release of this Report.]

STORAGE OF PACKAGED ILW ON LAND

DEFINITION OF OPTION

85. This option is similar to the previous process but following removal of the RPV/PST package further dismantling and packaging will occur. The process will be carried out in a purpose built facility[56] in order to make it suitable for packaging in the NIREX 4 metre box. Once the packaging operation was complete the 4 metre box containing the waste would be stored pending disposal at a ILW store.

[55] The biological shield consists of lead and water/boronated polythene fixed to the RC structure. It protects the workforce (or the crew in the case of a nuclear submarine) from the high radiation levels produced by a working reactor (reactor at power).
[56] The activity of the RPV/PST would be such that remote cutting methods, probably underwater, would be required.

ASSESSMENT OF OPTION

86. Although this option is technically viable provided the primary circuit has been decontaminated, cut-up of the RPV/PST package would need to be conducted in a purpose built facility, the cost of which is estimated at … [information deleted to allow public release of this Report].

87. This process is dose intensive, and a case under the principles of ALARP would be required before the procedure could be carried out. Gaining acceptance under ALARP is considered high risk.

88. Although "letters of comfort" from NIREX would provide some guarantee that the disposal container for ILW to the DWR would be the 4 metre box. With the DWR still 40 years away, a risk must exist that the present container may not be suitable in the future.

89. The potential gains from cut-up and packaging of the remaining ILW post decontamination are not at this stage considered sufficient to outweigh the disadvantages and risks described above. For this reason the option is not considered viable at present but it would need to be investigated further if raised in future in the context of a PPPI proposal.

LAND STORAGE - GENERAL CONSIDERATIONS

TECHNICAL ISSUES

90. The Reactor Compartment (RC) which houses the radioactive elements of the Naval Nuclear Steam raising Plant, is extremely well shielded and robust. Built to withstand the pressures and stresses associated with operating at high speed whilst at great depth, the pressure hull which surrounds the compartment could remain an effective enclosure for radioactive waste for many hundreds of years without the need for external preservation. In addition the RC contains shielding designed to allow a crew to live and work in adjacent compartments, whilst the reactor is at power. This combination of strength and high quality shielding combine to make the RC an excellent container for the storage of radioactive waste.

91. The removal of the RC from the vessel would allow the remaining hull and structure to be scrapped in the conventional way, removing the majority of the maintenance requirement (associated with afloat storage) and allowing the recycling of a substantial part of the submarine. Its circumference is bounded by high quality QT35 steel of substantial thickness (Pressure Hull), the ends of the RC are bounded by strong watertight bulkheads also manufactured from high quality steel. Although these bulkheads are penetrated by numerous system pipework and cables, containment could be easily re-instated by welding steel canning plates of suitable thickness and quality to either end.

92. An RC stored in a relatively simple weatherproof building would be virtually maintenance free. The Reactor Systems contained within the RC are of necessity very high quality low corrosion steels, consequently deterioration would be infinitely slow.

93. Land storage of intact RCs would also allow the disposal strategy to remain flexible, break up and packaging of the remaining radioactive waste could be commenced at the most opportune time, or if deemed appropriate the RC itself could become the final disposal package[57] thus negating the requirement for break up.

94. Immediate cut up of the RC following defuel and decontamination, will result in a higher dose rate to the break up workforce than would be incurred after a period of interim storage. The need for decontamination will also create ILW in the form of contaminated resin[58] and the remaining ILW, namely the RPV and PST will require storage in a fully equipped ILW store. If the RPV/PST requires transportation a shielded container will be required, which it could be legitimately argued, was well provided by the RC structure prior to break up.

95. Although relatively large and heavy, the RC would be no more difficult to transport than the RPV/PST combination. The latter would require an additional shielded sleeve or container to be manufactured before this it could comply with the transport limits for radioactive waste. Although the package would be smaller and lighter than the complete RC, it would still be a considerable size and could well weigh as much as 100 tonnes or more. Unless further dismantling was carried out long distance transport by sea would still be necessary.

LEGISLATIVE AND REGULATORY ISSUES

96. The Legislative and Regulatory background, and possible future developments, are described in the main paper. The impact for possible future land storage options is discussed in the following paragraphs.

97. In a land store site, the control and management of the site would almost certainly be contracted to a private company, as this would simplify the act of licensing and allow existing expertise in the private sector to be utilised.

98. Licensing in this instance should be relatively straightforward; the *body corporate* will hold liability making the option relatively low risk in terms of the effect which crown exemption changes would have upon the strategy.

99. If this strategy was adopted, the cut out, storage, cut up and packaging would be conducted on licensed sites allowing the entire process to be legislated under NIA65 and regulated by the NII. A single regulator would simplify and streamline the policing of the

[57] [Footnote deleted to allow public release of this Report.]
[58] During the decontamination process, contaminated fluid is passed through resin columns, the radioactive particles suspended in the fluid are removed by the resin, which consequently becomes radioactive.

process which would reduce the overall legislative risk to the programme. Only transport and final waste disposal will be legislated by RSA93 with regulation by the EA/SEPA.

ENVIRONMENTAL AND SOCIO-POLITICAL ISSUES

100. The decommissioning policy currently adopted by the nuclear industry is 3 phase decommissioning:

a. Stage 1 is defuelling and transfer of fuel off site;

b. Stage 2 is dismantling and removal of outer superstructure and buildings external to the reactor's biological shield. This stage is normally followed by the "*safestore*" period of up to 135 years depending on the type of reactor[59];

c. Stage 3 is final clearance of the biological shield, internal plant and reactor island, packaging of remaining radioactive waste, and shipment to repository.

This accepted strategy is similar to that proposed for the land storage of Reactor Compartments, with the *safestore* of the RCs being conducted after the removal and scrapping of the forward and after ends of the vessel, comparable to stage 2 above. By devising a strategy which follows the same principals as those adopted as a decommissioning strategy by the UK Nuclear Industry the Socio-Political risks should be reduced.

101. Land storage also seems to find some favour with many Pressure Groups including Greenpeace which appears positively disposed to a store and monitor strategy on land (see Annex D).

102. The viable land storage options will result in the recycling of a large percentage of the residual hull and structure of the nuclear submarines at the time of preparing the vessels for storage. This will find favour with environmental pressure groups, which advocate early recycling to reduce the drain on the earth's resources and the pollution which arises from their extraction[60]. It will also help suppress the present criticisms that the MoD has a "*do nothing*" policy towards radioactive waste issues.

103. Compared afloat storage which for some locations would have a significant visual impact, the viable land storage options will decrease the size of the *package* allowing storage to be carried out in a weather proof building "Dutch Barn"(RC) or an ILW store (RPV/PST).

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[59] Reference H.

[60] Environmental pressure groups point to all the negative consequences of mineral extraction, including the pollution which arises from transporting and smelting the ore.

FINANCIAL ISSUES

104. One of the most positive financial benefits of land storage is that costs will be relatively constant over time. This is especially true of the interim storage of RCs, which are virtually maintenance free when stored in a rudimentary weather proof building. This is in sharp contrast to afloat storage which will have an increasing maintenance charge per unit as the age of the vessels increase. Although land storage will have significant start up costs, over the long term the cost stream will be constant and lower than Afloat Storage. The storage of raw intermediate level wastes (RPV/PST) arising from the immediate break up of the RC would also have a relatively constant stream of costs. The storage building would, however, need to be a fully equipped ILW store [Information deleted to allow public release of this Report]. This will be a more expensive facility to build and maintain.

105. Storage of the intact RCs retains the flexibility to adapt to lower cost alternatives in the future[61] . As this option will allow interim storage to be continued until the optimum benefit[62] from natural decay is gained, final break up and packaging costs will be lower due to the simplification of the process[63]. It is also possible that the RC could constitute the final disposal package without the requirement to break up and package the individual radioactive items. This would be very advantageous both in terms of cost savings[64] and preventing radiation dose to a break-up work force. [Information deleted to allow public release of this Report.]

106. The viable land storage options will occupy a relatively small area of land, in addition it is highly likely that a potential contractor would look to utilise brown site or low value land as the location for the store. This would keep potential opportunity costs involved in the siting of the interim storage to a minimum.

107. There is a risk that the real cost of breaking-up and recycling the residual hull and structure will increase with time because of increasingly stringent regulations for disposal of non-nuclear hazardous waste.

CONCLUSIONS

108. Of the potential land storage options listed in paragraph 83, both Land Store of the RC and the RPV/PST are considered viable options, having a number of advantages over the current Afloat Storage strategy:

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[61] Radiation dose, and the costs involved in RC break-up and waste packaging have not yet been incurred. Safer and cheaper processes may become available.
[62] The point at which the benefits from further radioactive decay are negligible in the medium term.
[63] Lower radiation levels would simplify the break up process and reduce the requirement for biological shielding of the final waste package. In addition, the machining of the RPV cladding would no longer be necessary after an interim storage period of 60 years.
[64] Break up and packaging costs would be saved

a. Both of these options would result in early recycling of the majority of the vessel, this would considerable reduce the maintenance requirement, have a positive environmental impact; counter the criticism that the MoD have a "*do nothing*" policy; and reduce the risk of incurring increased costs for breaking-up and recycling the residual hull and structure in the future.

b. Both options compare favourable, with the *"store and decay"* strategy favoured by many of the environmental Pressure Groups including Greenpeace.

c. The management and control of the stored radioactive waste would almost certainly be contracted to a private company. This would make the licensing of the storage area under NIA65 relatively straightforward and as a consequence the risks associated with possible future changes in Crown exception from NIA65 would be considerably reduced.

d. Both these options would present minimal visual impact as storage would be inside a building.

109. The RC land storage option would only require a rudimentary building (Dutch Barn) for storage. This is because the RC itself would provide all the necessary shielding, containment and protection required for the storage of ILW. The RPV/PST ILW package would need to be held in a conventional ILW storage facility [Information deleted to allow public release of this Report]. On-going maintenance and storage costs would therefore be lower for RC land storage.

110. The RPV/PST storage option requires an aggressive decontamination of the primary plant to be made viable, this process would create intermediate level resin waste, which would require storage until it had decayed to the level of LLW. After this time it would still be necessary to carry out a process which removed the acidic chemicals[65] before encapsulation and disposal to Drigg could take place.

111. Even after decontamination, the dose rate received during RC break up and RPV/PST removal would be higher than that received during RC cut-out. There is therefore a risk that this option could not be justified under ALARP.

112. Storage of the intact RC would allow the strategy to adapt to new innovative proposals for the disposal/storage of radioactive waste. [Information deleted to allow public release of this Report.] The RPV/PST storage option loses this flexibility.

113. Transport regulations specify activity levels and container requirements for the shipment of radioactive waste, the strength and high quality shielding of the RC should make compliance with the regulations relatively straightforward. The RPV/PST package will require shielding and protection to meet the necessary requirements. Although the weight and size of the RC would be considerably greater than the shielded RPV/PST package, sea

[65] MODULUX process as used for MODIX resins.

transport would be required for both and is therefore not considered to present significant difficulties.

114. The year-on-year storage costs of the RCs would be relatively constant and as the option is virtually maintenance free, these costs would not escalate overtime. The option is therefore not time sensitive and consequently storage could continue with little impact on costs. This significantly reduces the risks resulting from further delays or cancellation of the DWR.

115. The 3 phase decommissioning strategy adopted by the UK Nuclear Industry, is similar to that proposed for the land storage of Reactor Compartments. The *safestore* of the RCs being conducted after the removal and scrapping of the forward and after ends of the vessel, is comparable to stage 2 (see paragraph 0). By devising a strategy which follows the same principals the Socio-Political risks should be reduced. The RPV/PST option differs because it breaks up the reactor's biological shield prior to commencing the interim storage period thereby increasing the dose to the break-up work-force .

REFERENCES FOR ANNEX G

A. Mouchel Report DBT/GJS/48299/CMR: " Nuclear Submarine Reactor Compartment Interim Land Storage Facilities: Cost Model Report", dated September 1998, forwarded under cover of D/DEO/N0300/05230 dated 23 September 1998.
B. BRDL Report, forwarded under cover of letter BRDL 4234/3074 dated 30 November 1998, together with subsequent clarification in BRDL letter SAS/99/003 dated 25 January 1999 in response to SSA/SM552/122/1777/2976 dated 14 December 1999.
C. DML Report SBU/ISOLUS/05 dated 7 January 1999, together with MSExcel spreadsheets (in electronic format) giving detailed cost breakdown.
D. Letter D/DEO/N0300/05230 dated 17 August 1998, with enclosures.
E. [Reference deleted to allow public release of this Report.]
F. Unreferenced report dated 10 December 1992 by J Hutchinson: "Use of the uncompleted RD57 site as a venue for submarine lay-up."
G. USGAO report, GAO/NSIAD-92-134 dated July 1992: Nuclear Submarines – Navy Efforts to Reduce Inactivation Costs" (page 22 thereof).
H. National Audit Office Report dated 4 June 1993: "The Cost of Decommissioning Nuclear Facilities", - Part 2: Decommissioning Practice.
I. Report D/DEO/N03037/05230 (Mouchel Reference DMRW/21045) dated 19 March 1999, forwarded under cover of letter D/DEO/N0300/05230 dated 22April 1999.

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APPENDIX G1 - BRDL UNSOLICITED PROPOSAL

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