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AWE SUMMARY RESPONSE TO ENSREG "STRESS TEST"

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Previous issues of this document are to be destroyed or marked **SUPERSEDED.**

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1 INTRODUCTION

1. Following the Fukushima incident on the 11th March 2011, the Office for Nuclear Regulation (ONR) instigated a range of activities to validate the UK nuclear industry's resilience to such events. This work culminated in the issue of the ONR report "Japanese earthquake and tsunami: Implications for the UK nuclear industry, Final Report", HM Chief Inspector of Nuclear Installations. September 2011. In addition to this the European Nuclear Safety Regulators Group (ENSREG) issued a requirement to European Nuclear Operators to carry out a series of 'Stress Tests' [ENSREG EU "STRESS TEST" 13 May 2011]. These are a specification for a targeted re-assessment of safety margins using a comprehensive suite of risk and safety assessments to be undertaken by all Nuclear Power Plants (NPP). These assessments were to commence no later than the 1st June 2011. These tests cover extraordinary triggering events, such as earthquakes and flooding, and the consequences of any other initiating events potentially leading to multiple loss of safety functions requiring Severe Accident management. The ONR made a commitment to apply the Stress Test requirements to both Nuclear Power Plant and Non-NPP. The ONR will summarise the NPP Stress Test findings and report back to ENSREG. In addition the ONR will also summarise the Non-NPP findings but not report these back to ENSREG. This document provides an unclassified summary of the application of these tests to facilities and plant at AWE.

2. The aim of the Stress Tests, as applied to AWE, are to:-
    - Confirm Design Basis assumptions are still valid
    - Identify AWE resilience via:-
        - Stressing the accident analysis beyond normal assessment (e.g. adding coincident events or by consideration of rarer even more extreme events.)
        - Analysing the effect of stressing or removing mitigation
        - Confirming capability of severe accident management arrangements

2 GENERAL SITE INTRODUCTION

2.1 Site Characteristics

3. AWE provides and maintains the warheads for the UK's nuclear deterrent. The work at AWE covers the entire life cycle of the nuclear warhead from design, to component manufacture and assembly, in-service support (except for deployment), and finally decommissioning and disposal. AWE also has a role in threat reduction.

4. A large number of processes are safely conducted at the AWE sites. The operations carried out typically include:
    - processing and handling of radioactive, toxic and other hazardous metals, liquids and materials and combinations of these, in the production of components. This includes the use of nuclear material, explosives, beryllium and other materials and chemicals;
    - assembly and disassembly of warheads;

- research into the development of these materials and components, testing of their physical and chemical properties and material safety related research;
- measurement and analysis of a wide variety of materials including environmental samples;
- studies of the effects of radiation on materials and equipment;
- recovery and recycling of radioactive materials;
- maintenance, calibration and testing of equipment of site to support safety;
- provision of dosimetry services;
- decommissioning of redundant plant and facilities, the construction of new facilities and alteration of existing facilities and services, management of radioactive and hazardous waste including care and maintenance.

5. The main radioactive materials handled and processed on the AWE sites are plutonium, highly enriched uranium, natural uranium, depleted uranium and tritium. They are usually either in solid form, machined swarf or oxide powders for the metals and tritium in gas form.
6. Operations are undertaken on a batch production basis, almost wholly during standard daytime working hours with nuclear production materials stored over night in safes within the nuclear facilities.
7. Nuclear materials within the facilities are handled mainly in glove boxes and can remain in a quiescent state for months at a time.
8. The sites do not undertake any reactor operations and there are no bulk quantities of highly active liquors, irradiated reactor fuel (hot fuel) or large quantities of High Level Waste stored on site
9. There are many facilities on both sites handling a range of radioactive materials and posing varying degrees of risk. The scope of facilities considered in detail for the Stress Test has been defined by identifying all facilities on both sites that could lead to a Severe Accident, as defined later in this report, in either a design basis event or through possible escalation following a beyond design basis event.
10. Major new-build projects and any re-kits currently underway have been taken into account.

2.1.1 AWE (A) Site

11. The AWE (A) Site is a Nuclear Licensed Site located in Berkshire immediately east of the A340, approximately 15 km south west of Reading, 11 km north of Basingstoke and 13 km east of Newbury. The site is adjacent to the northern extreme of the village of Tadley. The Nuclear Licensed Site is extensive, covering 2.6 km^2 and is built on the site of a disused airfield. The site has been occupied in support of the UK nuclear deterrent since 1950 and contains research laboratories, manufacturing facilities, radiation generators (e.g. x-ray machines), a post operational pulsed nuclear reactor, buildings undergoing staged decommissioning and construction, and supporting infrastructure. AWE occupies two main sites which although large in size have a relatively small nuclear installations component.
12. The Detailed Planning Zone (DPZ) of 3 km radius from the centre of the AWE (A) Site (National Grid Reference SU 600 637) includes the villages of Tadley and

Aldermaston, Baughurst, Pamber Heath and Silchester, plus several business parks with several hundred employees. The outskirts of the urban areas of Newbury, Basingstoke and Reading are within 15 km. AWE liaises with the local council to provide leaflets to the households in the AWE(A) DPZ.

13. The prevailing wind direction is from the south-west. The site is not over any major geological faults. No seismic events with a magnitude sufficient to damage conventional well built constructions have been recorded in several centuries. A site specific seismic characterisation has been undertaken for the AWE sites.

14. The AWE (A) Site is near the western end of a long round ridge of heathland running west-south west from Burghfield Common at an elevation of ~100m above sea level. To the north the land falls to the valley of the River Kennet, while to the east and south is a range of smaller valleys and to the west the valley of the River Enborne.

2.1.2 AWE (B) Site

15. AWE (B) Site is located in Berkshire immediately west of the A33, approximately 5 km south of the centre of Reading. The site is within 2 km of the M4 Motorway and the service station between Junctions 11 and 12. The Reading-Basingstoke railway line passes within 1 km of the eastern site of the site. The nearest villages are Burghfield and Grazeley Green, within 1.5 km of the site. The larger village of Burghfield Common is 2 km to the south-west, while to the north of the motorway lies the outskirts of the extensive suburban area of Reading. The whole AWE (B) Site covers an area of 1.05 km^2. The Nuclear Licensed Site forms a small proportion of this area. The site has supported radioactive work for the UK nuclear deterrent since 1954 and contains laboratories, manufacturing facilities, radiation generators (e.g x-ray machines), buildings undergoing staged decommissioning and construction, and supporting infrastructure.

16. The Detailed Planning Zone (DPZ) of radius 1.5 km (centred on the AWE (B) Site, National Grid Reference SU 684680) includes parts of Grazeley Green. All the surrounding areas are subject to continuing development of residential housing and various industrial and commercial properties.

17. The prevailing wind direction at AWE (B) Site is from the south-west. The site is not over any major geological faults. No seismic events with a magnitude sufficient to damage conventional well built constructions have been recorded in several centuries.

18. Numerous small water courses thread through this flood plain area, ultimately leading to the River Thames. The Burghfield and Crookham brooks have the closest approach and the former passes through the eastern part of the site. Other water bodies are situated around the site: the closest is Millbank Pond (1 km to the south). This last water body and some wooded areas have also been designated as Sites of Special Scientific Interest. The AWE(B) site is at an elevation of ~ 45m above sea level.

2.2 Scope of the Stress Tests Applied at AWE

19. Only those facilities with the potential for a radiological consequence, following an extreme event, in excess of the defined severe accident criterion, are considered within the AWE response to the ENSREG Stress Tests. The potential consequences of a severe event are based upon the inventory in the facility and the potential escalation following a beyond design basis event.

3 METHODOLOGY

20. In response to the ENSREG EU "STRESS TEST" 13 May 2011 AWE has produced this report for release into the public domain; it details the methodologies applied in developing the response and summarises those main results and findings for both licensed sites.

3.1 Definitions

21. ENSREG EU "STRESS TEST" 13 May 2011, define a "*stress test*" as:

> A targeted reassessment of the safety margins of nuclear power plants in light of the events which occurred at Fukushima: extreme natural events challenging the plant safety functions and leading to a severe accident.

22. In order to interpret the stress test specification to support its application to AWE, which is a non-power plant site, AWE redefine a "*stress test*" as:

> A targeted reassessment of the safety margins of nuclear *facilities at AWE* in light of the events which occurred at Fukushima: extreme natural events challenging the plant safety functions and leading to a severe accident.

23. It is important to note that a severe accident of the magnitude of the event at Fukushima is not possible at the AWE sites. Therefore, within the application of the stress tests, a "*severe accident"* for the AWE sites is defined as:

> An off-site radiological hazard which can give rise to best estimate Committed Effective Dose Equivalents (CEDEs) in excess of 5 mSv.

24. This definition is in line with the requirements of the Radiation Emergency Preparedness Public Information Regulations (REPPIR) 2001 for implementing an off-site emergency plan. To put 5mSv into context an adult abdominal CT scan can give doses of up to 10 mSv.

25. A process that is pivotal to demonstration of safety at AWE is the definition of "Design Basis Accidents". This term is used throughout this report and is defined as:

> A Design Basis Accident is a postulated accident which is dependent upon the risk that the specified facility poses. The facility must be designed and built to withstand the Design Basis Accident (or at least risks reduced to as low as reasonably practicable) without loss to systems, structures and components. Therefore if a facility has a large inventory of material capable of giving a large consequence, without any mitigation, then the design has to show how it can respond to more infrequent, worse events. For example if it holds a few grams of material it may only have to be designed to withstand the same earthquake as a normal industrial premises, however, if it holds multiple kilos of material it would be designed to withstand a much more severe/energetic earthquake.

3.2 Approach taken to respond to the Stress Test

26. The following process (Figure 1.) was developed to generate the Stress Test response for AWE:

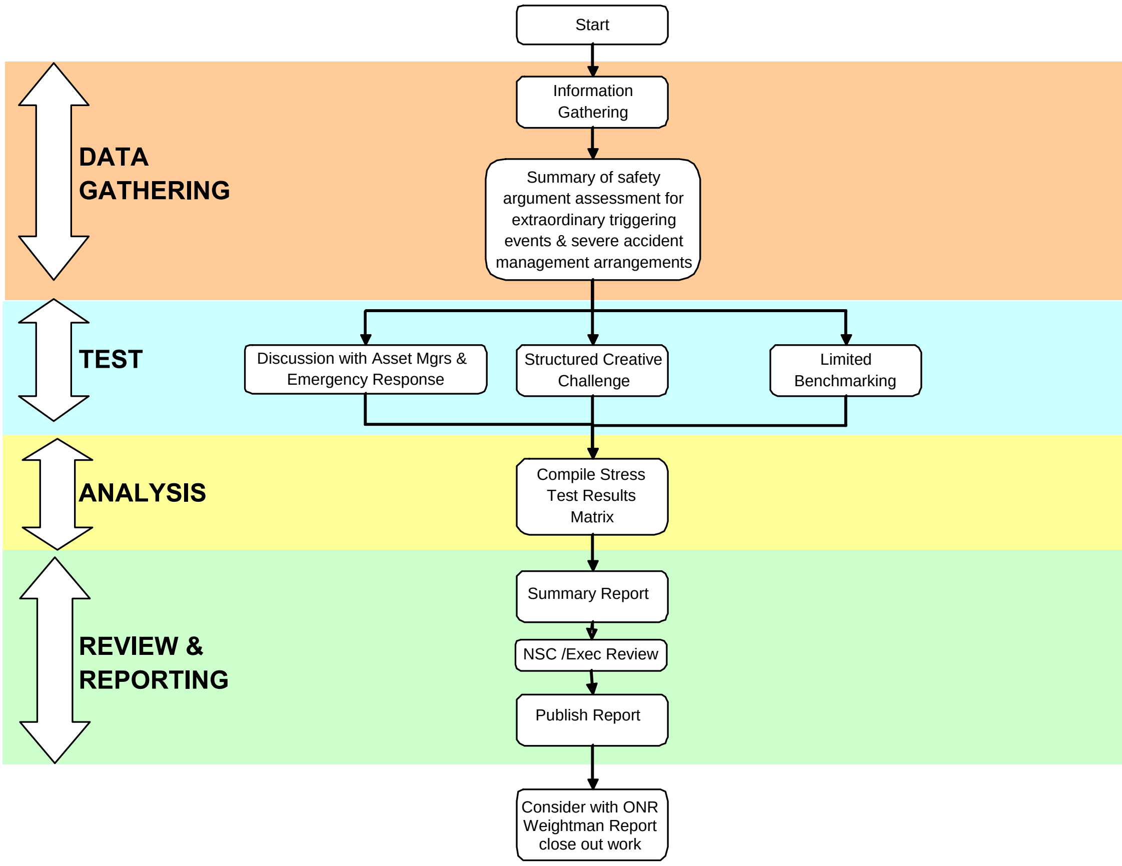

Figure 1: AWE Stress Test Response Process

27. This robust process ensured a proportionate, accurate and sufficiently challenging test of the current facilities and arrangements at AWE.

3.2.1 Scoping

28. The project carried out a period planning and definition in order to focus the interpretation of the Stress Test for the AWE sites and set a clear plan for the project.

29. The scope of facilities that would be considered in detail were defined by:

- Identifying all facilities on both sites that could lead to a Severe Accident in either a Design Basis event or through possible escalation following a Beyond Design Basis event. This included consideration of major projects currently underway with defined requirements and those projects already considered and required by recent Periodic Reviews of Safety (PRS).

30. Within the ENSREG Specification, reference is made to specific facilities (e.g. spent fuel ponds, boiling water reactors) and process (e.g. ultimate heat sink) which are specific to nuclear power reactors. Since AWE is not a nuclear power reactor site, these types of facilities and processes are not present and are therefore not a relevant. Therefore, no further reference to these facilities / processes is made within this report.

31. The scope of conditions for the Stress Test were identified and agreed as:

- Normal operations

- Silent hours
- Extended normal operations for specific facilities
- Maintenance activities that have the potential to increase vulnerability of the sites
- Hazardous material transport operations (inter & intra site)
- Non Routine operations.

32. In order to develop a list of specifications or 'test criteria' from the ENSREG specification, due cognisance of the above conditions was taken to ensure a wide and comprehensive application of the stress tests to AWE sites.

33. As part of the planning and definition phase, success criteria for the Stress Test specification responses were defined. This allowed for a clear and traceable analysis of the Stress Test findings that would ultimately determine whether AWE had passed or failed the Stress Test.

3.2.2 Data Gathering Phase

34. Following the Planning and Definition phase, a data gathering exercise was conducted that included reviewing and summarising existing relevant material, notably the site and facility safety cases, periodic reviews of safety, emergency response plans and contingency studies.

3.2.3 Testing Phase

35. A multi-assessment approach was developed to test the AWE facilities and arrangements. This involved Formalised interviews, Creative Challenge workshops and benchmarking with other Non-NPP Licensees.

3.2.4 Analysis Phase

36. With the testing complete, the findings from the Asset Interviews, Creative Challenge and Benchmarking Exercises were analysed against the stress test criteria.

3.2.5 Review & Reporting Phase

37. The stress Test findings have been taken through the usual AWE review and governance processes.

3.3 Scope of Response to ENSREG Stress Tests

38. The ENSREG stress test specification requires severe accident management issues associated with the following to be considered;

- means to protect from and to manage loss of core cooling function;
- means to protect from and to manage loss of cooling function in the fuel storage pool;
- means to protect from and to manage loss of containment integrity.

39. There are no operational reactors on the AWE sites. The HERALD and VIPER reactors are both shutdown and all nuclear fuel has been removed from the reactors. The only nuclear fuel remaining at AWE is fuel that has been removed from the VIPER reactor and which is currently stored in the facility. This fuel has undergone virtually no irradiation due to the operational characteristic of the VIPER reactor. Damage to the

fuel will not lead to any significant radiological releases. There is also no decay heat from this fuel and it does not require cooling.

40. Therefore, of the three severe management issues identified by ENSREG, only '*means to protect from and to manage loss of containment integrity*' is relevant to AWE.

41. The AWE stress test response does not therefore consider the severe accident management issues associated with loss of core cooling, loss of containment integrity after fuel damage or loss of cooling function in the fuel storage pool.

4 RESULTS / FINDINGS

4.1 Earthquake

42. The AWE (A) and AWE(B) sites lie in a region of southern Britain characterized by a low seismic activity. The sites have been assessed to produce Site Specific Seismic Characterisation studies. Significant, damaging, earthquakes therefore have a very low frequency of occurrence at the AWE sites. Design basis earthquakes have been defined for both the AWE sites and the ability of the major radiological facilities to withstand the design basis earthquakes has been assessed in the safety cases for those facilities.

43. The facility safety cases demonstrate that the major radiological facilities are capable of withstanding their defined design basis earthquake with, at the worst, only minor damage to the facility structure or internal containment structures. This level of damage does not lead to the potential for a severe accident.

44. The effects of earthquakes of intensities greater than the design basis earthquake are also assessed in the facility safety cases and have been re-considered by the stress test process. The potential damage to the facilities would increase as the challenge moves toward less and less frequent earthquakes of greater magnitude. This damage may result in the potential for an off-site dose in excess of the 5 mSv severe accident criteria, however the dose would not be comparable with the magnitude of dose produced from nuclear reactor severe accidents.

45. Extreme weather following a seismic event, such as wind or snowfall, may damage already weakened buildings and may delay or disrupt the emergency response. The effect would be similar to a beyond design basis seismic event in that a Severe Accident, as defined in this report, could result but there would not be a significant escalation in consequences.

46. Should there be an extreme earthquake event following flooding or loss of power, the major radiological facilities would be in a safer condition as operations would have been suspended and operations made safe, meaning that there would be less radioactive material in process operations having been put into even more secure storage locations.

47. The effects of earthquakes of intensities greater than the design basis earthquake are also assessed in the facility safety cases. The potential damage to the facilities would increase but without a step change in radiological release.

48. Some of the major radiological facilities on the AWE(A) and AWE(B) sites were constructed over 25 years ago. Replacement facilities are currently being designed and built. These replacement facilities are being designed to withstand the design basis earthquake with no potential for a radiological release. Moreover they are being designed to withstand earthquakes significantly more severe than the design basis earthquake and for there to be no cliff-edge effects (e.g. sudden collapse).

49. Coincident events that might occur with a severe earthquake such as a loss of off-site power or services to the facilities would not cause any escalation of the damage to the facilities.

50. There is no potential for a consequential flooding event, from external sources, at the AWE sites following an earthquake as the sites are inland and there are no large bodies of water external to the sites that could have an impact on the sites.

51. If there were to be an earthquake affecting the AWE sites, the response in each facility would be to make operations safe. All radioactive material would be placed in safe storage locations. If there were to be damage to a facility, AWE would implement its emergency response arrangements. These have sufficient capability to carry out the necessary responses to such an event even if off-site emergency assistance were to be unavailable due to the potential demands from emergencies elsewhere.

4.2 Loss of Off-Site Power

52. Loss of off-site power at either of the AWE sites would not create any immediate nuclear consequence, however it would be desirable to reinstate power for control and response purposes. Work in the major radiological facilities would be suspended and operations would be made safe. The facilities are capable of remaining without off-site power for a considerable period of time without any adverse effect.

53. Uninterruptible power supplies are provided to the major radiological facilities and these provide power to the systems necessary to conduct the local response plans, for a period of time following the loss of power. Local diesel generators will provide the necessary power in the longer term to support the emergency arrangements should the loss of power be prolonged.

54. Should the back up diesel generators not be available to support the emergency arrangement, AWE has mobile emergency control vehicles at each site that can be used to coordinate the site emergency response. Additionally should an installed back up generator be unavailable provision is provided for a mobile generator to be connected. This ensures resilience to support emergency arrangements.

55. A series of improvement projects to the electrical backup capability have been identified and these are currently being implemented. This will increase the resilience of the AWE sites to loss of off-site power.

4.3 Flooding

56. The Design Basis Flood has been well defined and understood for both AWE sites. The design basis flood for both sites occurs as a result of high rainfall inundation and associated runoff from surrounding land. As both sites are located at least 30 miles inland they are not vulnerable to tsunamis or tidal surges. There are no dams in the vicinity of the sites.

57. The Design Basis flooding events have been modelled by computer codes for very rare extreme rainfall durations covering 1 hour, 4 hour and 12 hour periods. These models are pessimistic and inherently cater for changing weather patterns arising from global climate change. The predicted flood levels produced by these models form the basis for the assessment of the risk from flooding specific buildings.

58. The flood levels produced by the various models have been used to assess the consequences that may occur within the existing nuclear facilities/buildings and are also used as a design input for any new build projects. The assessments have shown

that the existing nuclear facilities assessed cannot have Severe Accidents (as defined in this report) as a direct result of flooding scenarios.

59. The Stress Test process also considered the effects of increasing flood depths beyond those predicted by modelling. Certain existing facilities incorporate flood protection into their designs (e.g. bunds, raised stores etc). A breach of these defences, from extending the postulated flood depths, is undesirable from an operational perspective. However, the consequences of such an event would not be sufficient to trigger the Off-Site Emergency Plan or constitute a severe accident.

60. Criticality from flooding at AWE is modelled assuming fully flooded scenarios (i.e. the nuclear material completely submersed in water) and arrangements are put in place, wherever practicable, to ensure safety even when fully flooded, therefore in most instances actual flood depth is largely irrelevant. However, where scenarios at AWE can be stretched beyond the design basis by considering multiple extremely rare events coincident to the extreme flood to the extent where fully flooded criticality may be theoretically possible, the doses offsite would still not be of the magnitude to constitute a Severe Accident.

61. The stress test process also considered the effects of the extreme flooding scenario in parallel with other extreme natural phenomena to ensure that there is resilience in the facility response and emergency response arrangements.

62. Extreme floods have been considered with additional subsequent events (for example loss of power or seismic event) and no large step change in consequences was predicted.

63. Design basis flood scenarios at AWE do not carry the same time pressures as those nuclear power plants in coastal areas (e.g. from tsunamis). The design basis flood events all result from inundation and runoff and there will be time available to respond. This response has been scrutinised through the Creative Challenge Processes carried out as part of the stress test assessment to validate that the no "Severe Accident" conclusion remains valid even with the removal of mitigation.

4.4 Other Severe Events

64. Other severe weather conditions that could affect the facilities on the AWE sites have been considered, including high winds and extreme snowfall. The safety cases for the major radiological facilities demonstrate that an earthquake places more loading on the structures than these other events and that there is no potential for a severe accident due to extreme weather. The stress tests have shown that stretching the magnitude of the severe weather affects does not result in a step change in consequences.

4.5 Emergency Arrangements

65. The AWE sites are nuclear licensed sites and are therefore required to have adequate arrangements for dealing with any accidents or emergencies arising on the site and their effects. AWE facilities have individual response plans that detail the actions to be taken to make each facility safe in the event of an emergency. Each site has site wide emergency arrangements that detail the organisation and infrastructure that is in place on each site to deal with an emergency. In the event of the emergency being declared an "off-site emergency" the arrangements also detail the organisation/arrangements for implementing the off-site responses.

66. AWE has the necessary staff on site or on call at all times to respond to an emergency. Both sites have emergency control centres that will be activated if an emergency occurs. Both sites have a back up emergency control centre, as well as mobile control

vehicles. These emergency control centres act as a base to coordinate and manage the emergency response but, unlike reactor sites, they are not required to provide remote control of any of the facility operations/processes. AWE has its own fire and rescue service on each site and stocks of emergency equipment available on each site. As well as on-site radiological monitoring capability AWE also has the capability to monitor radiological releases off-site.

67. The object of the emergency arrangements is to ensure the implementation of effective measures to protect persons (both on-site and off-site), the environment and property from the consequences of any emergency that might occur on the sites.

68. AWE's response capability is demonstrated by carrying out emergency exercises at both individual facility level and at site level.

69. A severe earthquake or other natural event could prevent external emergency services from being available to respond to an incident on the AWE sites. However the AWE sites have sufficient capability on site to respond to accidents in particular the availability of the fire and rescue service who also man the site ambulances. Medical support is available on site during working hours.

5 CONCLUSIONS

70. AWE arrangements already incorporate many of the fundamental principles of the ENSREG stress tests. In that:-

- All high hazard nuclear facilities at AWE are subject to a periodic and systematic review and reassessment of their safety cases in line with NII Licence Condition 15 Periodic Review. These reviews include an engineering assessment of the engineering controls and building infrastructure to ensure they remain capable of reducing the risks from all internally and externally generated faults to as low as is reasonably practicable. The Periodic Review of Safety (PRS) assessments cover all of the faults within the design basis of the facilities in addition to assessing the sensitivities associated with any cliff edge effects from beyond design basis events.
- In some instances where facilities are coming to the end of their design life they are being replaced by new facilities. These facilities are being designed and built in accordance with modern standards requirements which take account of best practice and lessons learnt within the international nuclear industry, including the lessons from the Fukushima incident. The tools used to design and assess the suitability of these newly designed facilities include the assessment of beyond design basis accidents to ensure that appropriate margins to failure, resulting in severe accidents, are in place.
- As part of the Site PRS AWE has reviewed the nuclear facilities interactions across the sites as well as ensuring that the physical and managerial infrastructures are in place to support normal operations and accident conditions. These provisions include utilities such as electricity and water as well as emergency response capabilities such as the AWE Fire Rescue Service (FRS) and medical response.

71. As AWE does not have any nuclear power plant or stored nuclear fuel requiring decay heat removal on its site and therefore extreme external events cannot lead to Fukushima type consequences.

72. AWE's Stress Test Process has confirmed that:

- the inputs used for the Design Basis Accident parameters (i.e. amount of rain, strength of earthquake etc) are valid.

- the validated Design Basis Accident challenges are suitably mitigated by the design of the facilities and the associated safety systems they incorporate.
- if the mitigation to these Design Basis Accident challenges are in themselves stretched that there isn't a sudden large step change in accident consequence.
- if the Design Basis Accident challenges are stressed/stretched by adding challenges together or increasing the input (i.e. assuming more extreme earthquakes or floods than the previous cut offs) that there isn't a sudden large step change in accident consequence.
- because AWE accident conditions do not naturally escalate after the initial event, challenging/stretching the emergency response arrangements, (e.g. multiple events, loss of transport routes or communications, coincident events like flu pandemic etc) does not result in a sudden large step change in accident consequence.

73. Any considerations that have arisen from the stress test process, which may improve AWE resilience beyond the current position, which has been demonstrated to already reduce risks to As Low As is Reasonably Practicable, will be referenced in AWE's response to the "Japanese earthquake and tsunami: Implications for the UK nuclear industry, Final Report" and its associated recommendations. The AWE response is due to be delivered in June 2012.