Project Mensa
Flood Risk Assessment

Final Report

23 December 2008

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Flood Risk Assessment

23 December 2008

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Executive Summary

The Ministry of Defence (MoD) is seeking detailed planning permission for the redevelopment of part of the Atomic Weapons Establishment (AWE) site at Burghfield, Berkshire. The proposed development will provide a replacement warhead assembly, maintenance and disassembly facility (known as the 'Main Process Facility' or 'MPF') along with a separate Support Building (SB), a Plant Building (PB) and associated electrical sub stations. The proposed development is required to modernise the existing manufacturing and industrial workspace in a secure environment for the workforce that is necessary to service the continuing work of AWE.

AWE Burghfield and the application site are partially within Flood Zone 3 and defined as having a high probability of flooding, due to a local watercourse: the Burghfield Brook. This Flood Risk Assessment (FRA) is intended to accompany the planning submission to address the requirements of Planning Policy Statement 25: Development and Flood Risk (PPS25). The site is also vulnerable to surface water flooding due to heavy rainfall on the site itself, as is typical for a site of this size. The site is composed of a mixture of permeable and impermeable surfaces and has a significant artificial drainage network.

The PPS25 Sequential Test aims to ensure that development is steered to areas at low risk of flooding. To address this requirement, this FRA asserts that the nature of the existing development, its security requirements and the need for a new modern replacement facility mean that there are no alternative sites that could be used to locate the proposed development. This also leads to the proposed development satisfying the requirements of criteria (a) and (b) of the PPS25 Exception Test, which should be applied when the Sequential Test cannot identify suitable less vulnerable sites.

The main purpose of this document, therefore, is to provide information to satisfy criterion (c) of the Exception Test, that the proposed development will be safe, without increasing flood risk elsewhere and where possible reducing flood risk. This document has drawn on information from a comprehensive modelling study of the Burghfield Brook which has been carried out by AWE's hydraulic advisors at HR Wallingford using modelling techniques. The computational modelling undertaken by HR Wallingford, reviewed and audited by the Environment Agency, has updated the 1 in 100 year floodplain, which includes an appropriate allowance for the effects of climate change and has been termed the 'design flood extent' in this document.

This FRA concludes that the proposed development satisfies criterion (c) of PPS25 because the development will be safe in terms of flood risk during both construction and operation phases. In particular:

- the proposed site layout has been designed, as far as practically possible given other constraints, to avoid the location of the design flood. All the proposed buildings are located outside the post development design flood extent except for the eastern gate house, electrical substation and VIB;
- the floor levels of the proposed buildings are set to a level in excess of 1m higher than the 100 year plus climate change flood level, in line with specific design requirements for the development due to its proposed use;
- two-dimensional hydrodynamic modelling by HR Wallingford has indicated the effect of the proposed development on flood levels on site to be neutral. Nominal changes in flood levels (±) are predicted to occur in the application site as result of the changes in ground level required for the construction project. Outside of the application site, no increases in flood risk are predicted;
- Flood modelling has shown that the proposed development will result in no impacts downstream of AWE Burghfield;
- the construction activities during the proposed seven and a half year construction period have been assessed against the design flood scenario. Those activities considered to be particularly vulnerable to flooding have been located outside of the design flood.

Recommendations are made in this document regarding the risk of flooding during construction;

- a comprehensive surface water management exercise has been undertaken alongside the development of design proposals for the application site. This has resulted in the design of a significant Sustainable Drainage System (SuDS). The SuDS scheme will serve the whole of the proposed development and account for additional impermeable surfaces required during construction. The SuDS scheme has been designed to reduce surface water runoff rates from the site to Greenfield runoff rates, thus improving upon the existing conditions. The SuDS scheme has been designed by Atkins and Mott MacDonald in line with best practice, overseen by leading drainage experts HR Wallingford and coordinated by Mayer Brown.
- the Environment Agency has been consulted with during the production of this FRA, on both the hydraulic modelling by HR Wallingford, and the design of the SuDS scheme. They have had the hydraulic model reviewed and audited by independent consultants.

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Glossary and Abbreviations

Term	Description
ALARP	As low as reasonably practicable
AWE	Atomic Weapons Establishment
DPD	Development Plan Document
Design Flood	The 1 in 100 year flood with climate change allowance
EIA	Environmental Impact Assessment
ES	Environmental Statement
FEH	Flood Estimation Handbook
FFL	Finished Floor Level
FRA	Flood Risk Assessment
MoD	Ministry of Defence
MPF	Main Process Facility
NGR	National Grid Reference
NII	Nuclear Installations Inspectorate
NSPA	Nuclear Storage and Processing Area
PB	Plant Building
PPS25	Planning Policy Statement 25: Development and Flood Risk
ROF	Royal Ordnance Factory
SB	Support Building
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems
VIB	Vehicle Inspection Bay
WBC	West Berkshire Council

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1. Introduction

1.1 Background

The Ministry of Defence (MoD) is seeking detailed planning permission for the redevelopment of part of the Atomic Weapons Establishment (AWE) site at Burghfield, Berkshire. The proposed development will provide a replacement warhead assembly, maintenance and disassembly facility (known as the 'Main Process Facility' or 'MPF') along with a separate Support Building (SB), Plant Building (PB) and associated electrical sub stations. The proposed development is required to modernise the existing manufacturing and industrial workspace in a secure environment for the workforce that is necessary to service the continuing work of AWE.

Atkins Limited was commissioned to prepare this Flood Risk Assessment (FRA) for the purpose of the development and planning application whilst AWE consulted with the Environment Agency. All flood modelling was carried out by HR Wallingford as part of an assessment commissioned directly by AWE. (Ref. 2).

1.2 Document Context

Planning Policy Statement 25: Development and Flood Risk (PPS25) (Ref. 1) sets out the Government's objectives for achieving sustainable development through the avoidance and management of flood risk. PPS25 aims to ensure that flood risk is taken into account at all stages of the planning process to avoid inappropriate development in areas of flood risk. This Flood Risk Assessment (FRA) is required under PPS25 (Ref. 1), which states that a FRA is required to support planning applications for development located in Flood Zones 2 and 3; and all developments in Flood Zone 1 which have areas in excess of 1 hectare (ha). The AWE Burghfield site contains areas covered by all three Environment Agency Flood Zones 1, 2 and 3, all of which cover part of the application site.

This FRA is intended to (i) support an application for planning permission for the proposed development; and (ii) support an environmental impact assessment (EIA) and associated Defence Exempt Environmental Appraisal (DEEA) for the proposed development. An accompanying study defining the current and future risk of flooding to the whole of AWE Burghfield has been carried out by AWE hydraulic advisors HR Wallingford in collaboration with AWE drainage engineers (Ref. 2). This detailed modelling study was designed to satisfy Nuclear Site Licence requirements. The modelling study has involved the production of a detailed hydraulic model of the Burghfield site and its associated watercourses and drainage routes. The HR Wallingford/AWE flood modelling is summarised in this FRA document, and its findings are used to refine the existing information on the risk of flooding to AWE Burghfield and the proposed development.

1.3 Terminology

Throughout this document, flood events are defined by their likelihood (probability) of occurrence. The rarity of flood events is described using 'return periods' whereby a flood event is defined by the chance of that flood being equalled or exceeded in any one year. For example, if a flood event has a 1 in 100 year return period, it means that there is a 1 in 100 chance of that flood being equalled or exceeded in any one year and that the flood has an annual probability of 1%.

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2. Proposed Development

2.1 The Existing Site

2.1.1 Site Description

AWE Burghfield, in which the application site is situated, is located approximately 0.5 kilometres (km) east of Burghfield village and 6 km to the south west of Reading (see Figure A1 in Appendix A). The National Grid Reference (NGR) for the centre of AWE Burghfield is SU 680 680 and the site covers an area of approximately 87 hectares (ha). The topography of the site slopes from 49 metres above ordnance datum (m AOD) in the north, to 40m AOD in the south.

AWE Burghfield occupies the former site of a Royal Ordnance Factory (ROF), dating from 1940. It is, in part, an operational nuclear licensed site (under the Nuclear Installations Act 1965) and is operated by AWE plc. It contained in excess of 300 buildings and structures used for a variety of industrial processes. Most of the buildings on the site are surrounded by embankments and bunds dating back to the use of the buildings for the manufacture and storage of ordnance. Several residential properties are located beyond the secure fence line adjacent to the western edge of AWE Burghfield, approximately 800m from the proposed development. Many of the properties fall within the ownership of AWE plc and were originally built to house ROF employees.

Access to the AWE site is from the north-west, via a private road called ‘The Mearings’, which connects to the public highway at Reading Road/Burghfield Road, some 600 m to the north-west of the Main Gate. The Main Gate is directly linked to Pingewood Gate (to the east) by a wide two-lane road within the boundary of AWE Burghfield. AWE Burghfield is surrounded by a high security fence and is subject to strict security controls. Public roads bound the eastern, southern and western edges of AWE Burghfield.

A small stream known as the Burghfield Brook is located along the southern and eastern edges of AWE Burghfield; running along an artificial channel, which at its nearest point is 110 m south-east of the application site. This stream flows in a north easterly direction.

2.1.2 Existing Site Management

Currently, AWE Burghfield is manned by a team of emergency response personnel, lead by the Burghfield Emergency Controller. This Burghfield Emergency Control team is based out of two independent command posts on site and a dedicated vehicle. The team provide immediate response to and management of hazards and emergencies on site by way of announcements on loud speakers. Under conditions of the AWE nuclear site licence, regular emergency drills are carried out to ensure that all emergency personnel and associated support staff are fully trained in emergency procedures. There are two flood contingency plans in place at AWE Burghfield, one for during and one for outside normal working hours. Both of these plans are provided in Appendix D. These plans describe the series of actions which are undertaken by the Burghfield Emergency Control team upon receipt of local flood warnings, forecasts of heavy rain or local observations of conditions on the site.

2.2 Proposed Development Description

As shown in Figure A1 and Figure 2.1 below, the proposed development will lie near the centre of the AWE Burghfield site.

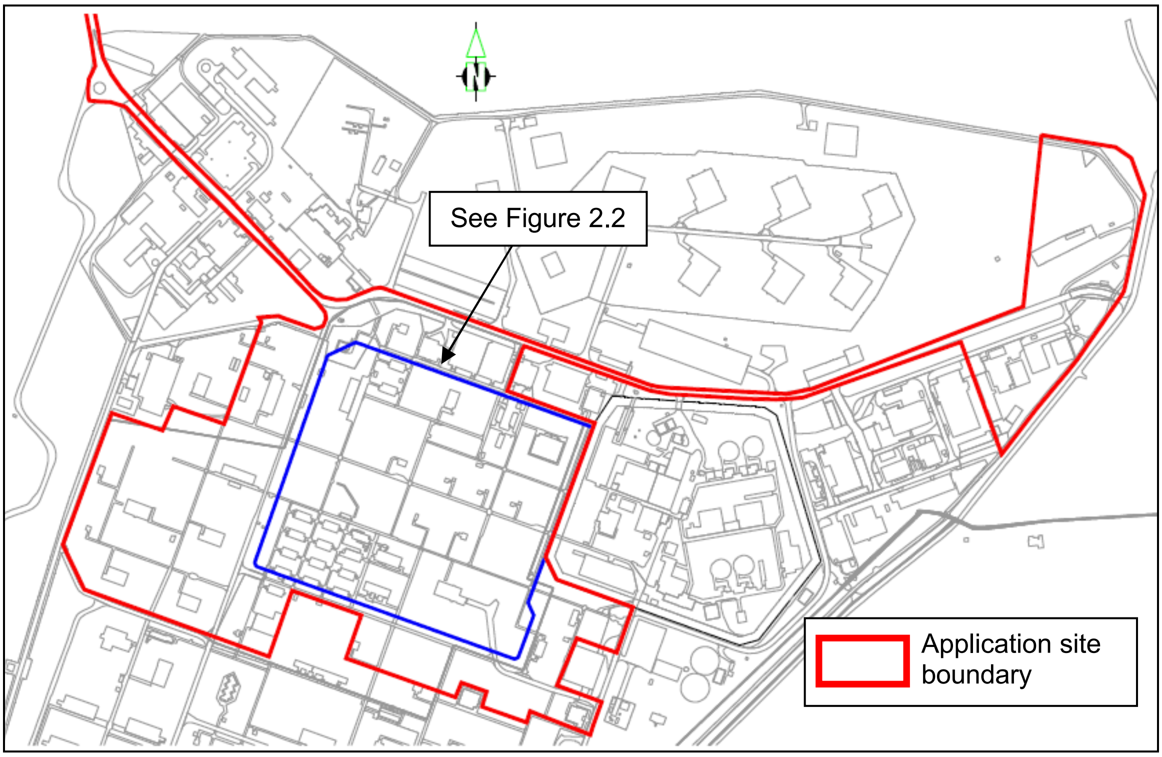

Figure 2.1 – Application site boundary within AWE Burghfield (see Figure A1 in Appendix A)

The proposed development will comprise the following elements together with supporting infrastructure:

- a Main Process Facility (MPF): This will be a single storey structure with a maximum height of 12m above site ground level. It will comprise a series of "functional areas" each housing a discrete part of the assembly (or maintenance/disassembly) process. These rooms and the connecting corridors will all be enclosed within a single reinforced concrete envelope. The MPF will also be surrounded by an external lightning protection system comprising catenary cables supported on a series of 14 steel towers;
- a Support Building (SB): This will be a smaller building located immediately to the north of the MPF but not structurally connected;
- a Plant Building (PB). This will comprise a steel-framed industrial-style unit which will house the building services plant. An uncovered compound situated at the east end of the building will enclose a cooling plant;
- electrical Substations. The housing for the electrical sub-stations will be of the same palette as the MPF;
- gate houses;
- vehicle Inspection Bays (VIBs) adjacent to the MPF; and
- car parking. Located to the north east of the MPF and other buildings, lying either side of Trident Way at Pingewood Gate. Includes areas for HGV marshalling.

Apart from the PB, the VIBs and the gate houses the proposed buildings (see Figure A2 in Appendix A) will be located within a secure nuclear licensed compound (defined by a double perimeter security fence) as shown in Figure 2.1 and illustrated in Figure 2.2. This area will be a Nuclear Storage and Processing Area (NSPA) and will hold a Nuclear Site Licence granted under the Nuclear Installations Act 1965. The proposed development will also include a number of Sustainable Drainage Systems (SuDS) ponds, referred to later in this document.

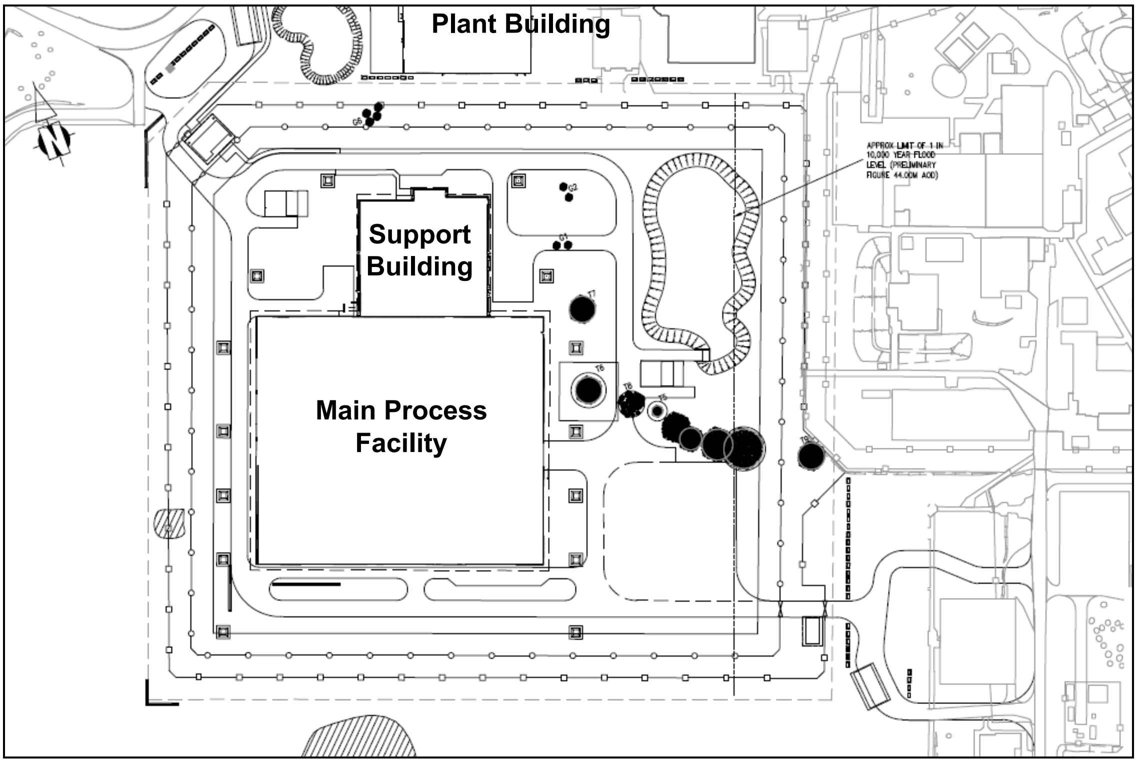

Figure 2.2 – Layout of proposed NSPA

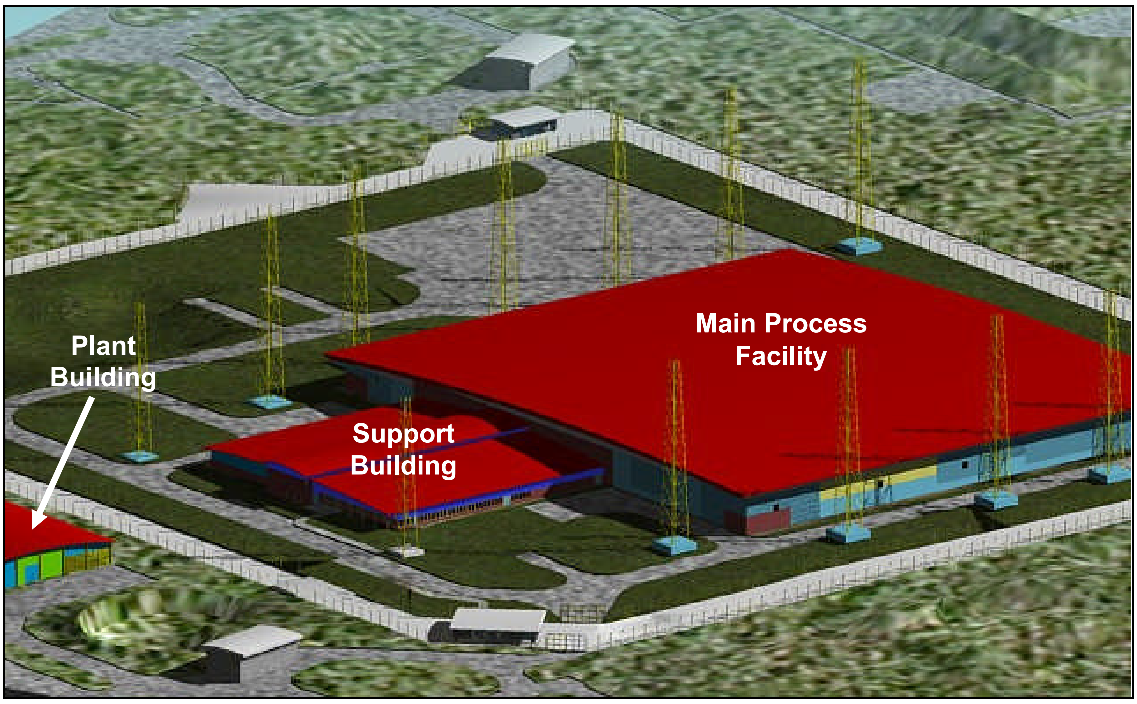

Figure 2.3 – Indicative illustration of proposed development viewed from NW

Under normal operating conditions the proposed development will be occupied by 160 operational staff transferred from existing facilities at AWE Burghfield. No net increase in staff is anticipated and no new jobs will be created.

Construction of the proposed development is envisaged to require a period of seven and a half years, from May 2009 to December 2015. A construction enclave will be set up to isolate construction activities from the rest of AWE Burghfield. This enclave will be used to house all temporary construction activities. The significant construction activity required to facilitate the proposed development will require the covering of large parts of the application site with impermeable surfaces, some of which will be reinstated to open ground at or below the level of the existing topography once construction is complete.

2.3 Site Clearance

Due to the legacy of the previous use of AWE Burghfield as a ROF, and the resultant number of disused buildings and blast embankments, a significant site clearance process has been carried out on-site. The removal of all existing buildings within the boundary of the construction enclave and the re-grading of the site to existing site ground level has already taken place.

Site clearance was undertaken by AWE Site Remediation Group. Demolition falls under permitted development in terms of planning regulations and has been carried out under appropriate standard practices and codes of conduct. The DEEA clearly specifies the nature of this site clearance with respect to the EIA process and baseline year for assessment. As in the DEEA, **this FRA considers the cleared site as its baseline 'existing' condition**. However, in line with the principles of PPS25 (Ref. 1) the analysis on floodplain changes also assesses the effects of the site clearance by analysing for the initial condition to provide a complete picture on all changes that have or will occur due to the development (see Section 6).

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2.4 Proposed Development Summary

Table 2.1 summarises the main elements of the proposed development.

Phase	Proposed Development Component	Description
Site Clearance	Site Clearance (completed)	Permitted works involving clearance of existing buildings from the construction enclave location and levelling of ground by removing existing embankments. Resulting in the baseline 'existing' condition on the application site.
Construction	Construction	• enabling works, including general site preparation, construction of hard standing areas and SuDS scheme and erection of security fencing and the construction enclave. • substructure installation. • concrete and structural steelwork superstructures. • fit-out and completion.
Operation	Main Process Facility (MPF)	Building housing assembly/disassembly process. Series of 'functional areas' situated within a single reinforced concrete 'envelope'.
	Support Building (SB)	Smaller than the MPF, housing all support staff and activities not required to be located within the MPF.
	Plant Building (PB)	Located to the north of the MPF and SB, housing building services plant.
	Electrical Substations	Two substations will be located to the north and south-east of the construction enclave.
	Gatehouse and Vehicle Inspection Bays (VIBs)	A VIB and an associated gatehouse will be located to the east of the MPF.
	Pingewood Gate Area	The separate north-west area of the application boundary, to be used for car parking and HGV marshalling and including an electrical intake substation.

Table 2.1 – Proposed development summary

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3. Planning Policy Requirements

3.1 Planning Policy Statement 25: Development and Flood Risk

Through the application of PPS25 (Ref. 1), the Government requires that local planning authorities apply a risk-based approach to development control. PPS25 details a 'Sequential Test' which classifies land into one of three Flood Zones, as summarised in Table 3.1. These three Flood Zones are derived ignoring the presence of man-made flood defences. Flood Zone 3 is also sometimes sub-divided, in line with PPS25, into Flood Zone 3a (high probability) and Flood Zone 3b (functional floodplain) (see Table 3.2).

Flood Zone	Equivalent Return Period (years)	Annual Probability of Flooding (%)
1. Low Probability	>1000	River and tidal < 0.1%
2. Medium Probability	1,000 – 100 1,000 – 200	River 0.1 – 1.0% Tidal 0.1 – 0.5%
3. High Probability	< 100 < 200	River > 1.0% Tidal > 0.5%

Table 3.1 – Summary of PPS25 Sequential Test (Ref. 1)

PPS25 specifies that the suitability of all new development in relation to flood risk should be assessed by applying the Sequential Test. The application of the Sequential Test should demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or the land use proposed.

The Sequential Test gives preference to locating new developments wherever possible in Flood Zone 1 (Low Probability). If there are no reasonably available sites in Flood Zone 1, the flood vulnerability of the proposed development should be taken into account when locating development in Flood Zone 2 and then Flood Zone 3. PPS25 provides guidance on assessing the vulnerability of land uses in relation to flood risk and classifies new developments into one of five categories. PPS25 details the compatibility of each land use classification in relation to each of the Flood Zones as summarised in Table 3.2.

	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	✓	Exception Test Required	✓	✓
Zone 3a	Exception Test Required	✓	×	Exception Test Required	✓
Zone 3b	Exception Test Required	✓	×	×	×
Key: ✓ Development is appropriate subject to passing the Sequential Test. × Development should not be permitted.					

Table 3.2 – Flood Risk Vulnerability Classification (Ref. 1)

Following application of the Sequential Test, if it is not possible for a development to be located in zones of lower likelihood of flooding while remaining consistent with wider sustainability objectives, the Exception Test can sometimes be applied. There are three conditions which must be fulfilled before the Exception Test can be passed. These conditions are as follows:

a) It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment (SFRA) where one has been prepared. If the DPD (Development Plan Document) has reached the 'submission' stage the benefits of the development should contribute to the Core Strategy's Sustainability Appraisal;

b) The development must be on developable previously-developed land or, if it is not on previously-developed land, that there are no reasonable alternative sites on developable previously-developed land; and

c) A site-specific Flood Risk Assessment must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

The Environment Agency is a statutory consultee on planning applications for sites at risk of flooding or for all sites greater than 1 ha.

3.2 The Proposed Development

3.2.1 The Flood Map

Figure 3.1 below shows the publicly available Flood Map provided by the Environment Agency; Flood Zones 2 and 3 are shown in light blue and dark blue respectively. The proposed development contains areas in all three Flood Zones.

PPS25 states that when a development falls within more than one Flood Zone, development proposals should be treated as falling into the higher risk Flood Zone when defining the scope of a FRA. This FRA aims to meet the requirements of PPS25 for a site within Flood Zone 3, classed as having a high probability of flooding. These requirements are discussed in Section 3.2.3.

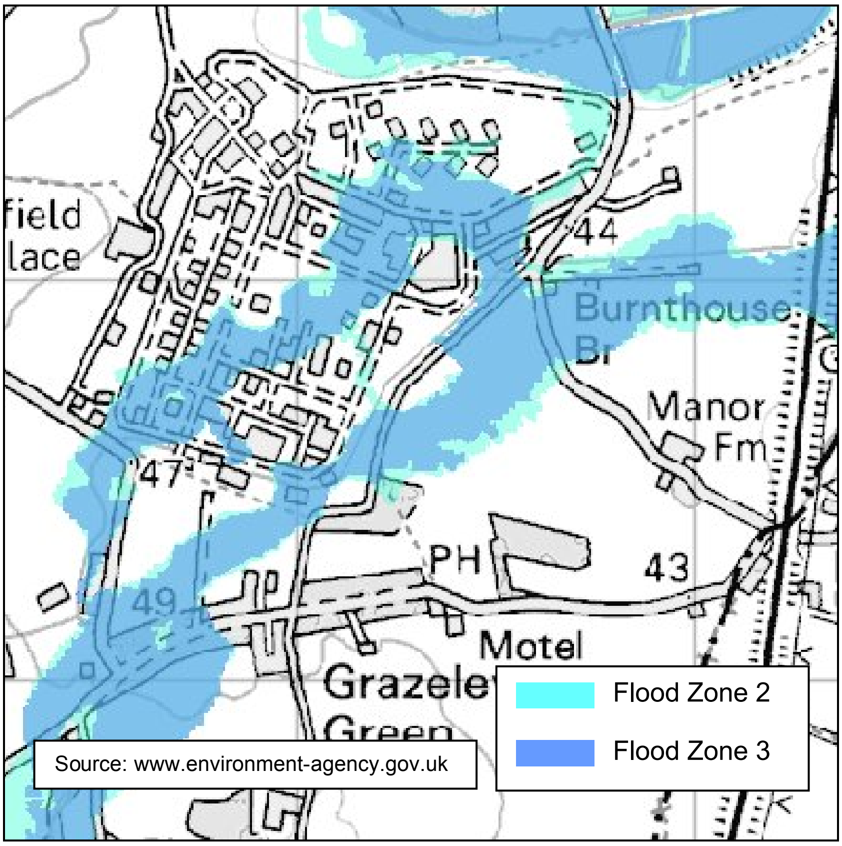

Figure 3.1 – Flood Zones, AWE Burghfield

3.2.2 The PPS25 Sequential Test

The proposed development is essential to allow the continuing work of AWE, which is of national and international significance. The AWE Burghfield site has been historically owned and operated by the MoD since the 1940s. The existing licensed NSPA is located at AWE Burghfield adjacent to the proposed development boundary. The proposed development will continue the operations currently carried out in the existing NSPA. As such, the development is required to be located in the proposed location, adjacent to the existing NSPA and within an existing secured site. It is therefore considered that the proposed development satisfies the PPS25 Sequential Test for the following reasons:

- the proposed development has to be located adjacent to the existing historic development on the site, which significantly pre-dates current planning policy with regard to flood risk.
- the proposed development is required to fulfil the nationally and internationally important strategic role of AWE as defined by central Government at the highest level.
- the proposed development is a MoD defence installation according to Table D.3 of PPS25 (Ref. 1) and is therefore compatible in Flood Zone 3.
- it is not be feasible to locate a similar site of sufficient size (AWE Burghfield covers approximately 87ha) with sufficient existing security arrangements and be sufficiently close to the existing AWE facilities.

3.2.3 The PPS25 Exception Test

Given the information set out above, and the location of the proposed development partially within Flood Zone 3, it is a requirement of PPS25 (Ref. 1) that the three criteria of the Exception Test are passed.

It is considered that criteria (a) and (b) are satisfied by the information provided above. The proposed development is of national and international significance and is located on a site with a significant brownfield heritage.

In order to satisfy criterion (c) of the Exception Test, it must be proven that the proposed development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall. The operational requirements of the proposed development are such that safety and security are of paramount importance in all proposed activities. The regulatory requirements placed upon the activities carried out by AWE require the assessment of risk to be far in excess of normal planning policy. This FRA document, however, details how these requirements translate to fulfil the requirements of PPS25 and identifies specific measures to mitigate the risks posed by potential flooding to the development and its occupants.

3.3 Specific Nuclear Safety Requirements

The safety of the proposed facility is paramount and is subject to rigorous analysis at all stages of its design life. A Nuclear Safety Case has been developed in order to demonstrate that the risks to operators, other workers and the general public, together with the environmental impacts associated with the proposed design, construction, operation and decommissioning are tolerable and as low as reasonably practicable (ALARP).

The Nuclear Safety Case uses a series of detailed hazard identification workshops to identify accidents and hazards in increasing detail as the design develops. In depth hazard management measures are applied to ensure all risks are mitigated to an ALARP level. All documentation and processes have been developed in line with AWE safety procedures and industry wide guidance.

The Nuclear Safety Case is written for the Nuclear Installations Inspectorate (NII) (who are a sub-division of the Health and Safety Executive) and the Nuclear Weapons Regulator (MoD regulator). The proposed facility will ultimately be licensed by the NII. Due to the operations to be undertaken in the facility, authorisation will also be required from the Nuclear Weapons Regulator.

The requirements placed upon AWE by the NII when designing, constructing and operating the proposed development are such that safety and security are of the utmost importance, including the safety of the development with regard to the flood risk to the site.

4. Sources of Flood Risk

4.1 Overview

PPS25 requires that FRAs consider the risks from all sources of flooding that may affect a development site. This chapter describes each source of flood risk in turn and the potential to affect the application site. Section 4.2 includes information taken from the Burghfield Modelling Study carried out by HR Wallingford (Ref. 2). Since the original modelling and FRA, a model audit has been carried out for the Environment Agency by their consultants Halcrow Group. All feedback from this review has been incorporated into the model used herein.

4.2 Flooding from Rivers

As previously indicated, the application site is at risk of river (fluvial) flooding due to the proximity of the Burghfield Brook. The application site is partially within Flood Zone 3 according to the current Environment Agency Flood Map, and is considered to have a high probability of flooding, within the predicted flood extent of a 1 in 100 year return period flood event.

The Burghfield Brook drains a predominantly rural catchment, with a catchment area of approximately $8km^2$. The brook is a tributary of the River Kennet, which ultimately flows into the River Thames. Some 450m upstream of AWE Burghfield, the Burghfield Brook is joined by the Lockram Brook, which contributes the majority of the upstream catchment area.

The path of the Burghfield Brook originally crossed the land that is now part of AWE Burghfield, including the application site. The brook was, however, diverted around the south and east of AWE Burghfield in an open channel just inside the external fence. The old bed of the brook was filled in and some ground level re-profiling carried out, but the original route of the brook is still slightly lower than adjacent ground. It is along this historic flow path that floodwaters are predicted to spread when the capacity of the re-aligned channel is exceeded following heavy rainfall.

As it leaves the AWE Burghfield site, the Burghfield Brook passes under Burnthouse Bridge and then flows in an open channel for 700m before passing through a culvert under a railway line. The Burghfield Brook joins the larger Foudry Brook just downstream of the railway. It then passes under the M4 motorway embankment at a total distance of 2.5km downstream of the site.

Historically, parts of AWE Burghfield have been affected by flooding from the Burghfield Brook, for instance on the 20th July 2007. During exceptionally high flows, the brook has been observed to overtop its left bank along the southern boundary of AWE Burghfield, where the brook is constrained by a number of small bridge crossings. Overtopping is also known to have occurred as the brook leaves the site and is constrained by a further road crossing.

4.3 Flooding from the Sea

The development site is located inland and is not at risk of flooding from the sea.

4.4 Surface Water Flooding

Due to the size of the site, the proposed development is at risk of surface water flooding (Pluvial) caused by heavy rainfall exceeding the infiltration capacity of natural ground or surcharging existing drainage facilities. This is a risk typical for a site of this size. The proposed development will result in a net increase in impermeable surfaces on the site.

Existing surface water drainage on the site is served by a complex network of French drains, culverts and concrete channels, reflecting the historic development of the site and its former use as a ROF. There is no information available detailing the capacity of existing drainage systems on the site, although it is believed to be crossed by an estimated 15km of pipe, the majority of which have diameters of up to 225mm, with some lengths up to 525mm in diameter.

4.5 Flooding from Groundwater

There is no historic record of flooding due to rising groundwater on the site. Geologically, the site is composed of London Clays overlying Bagshot sands, so the risk of groundwater flooding on site is considered to be minimal.

4.6 Flooding from Reservoirs, Canals and Other Artificial Storage

There are no reservoirs, canals or other artificial stores of water the failure of which could pose a flood risk to the development site.

4.7 Summary

The proposed development is at risk from flooding from two key sources: fluvial flooding from the Burghfield Brook conveying floodwaters onto the site from the catchment upstream and pluvial flooding from within AWE Burghfield itself under heavy rainfall.

Chapter 5 of this document assesses the risks from these two sources of flooding in relation to the proposed development.

Chapter 6 details mitigation measures that will be carried out as part of the proposed development to mitigate these risks and ensure that the development remains safe from flooding throughout its lifetime.

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5. Flood Risk for the Application Site

5.1 Flooding from Rivers

5.1.1 Existing Information

The Environment Agency Flood Map, shown previously in Figure 3.1, shows indicative flood extents for the present day 1 in 100 year (flood zone 3) and 1 in 1,000 year (flood zone 2) flood events. These outlines have been derived on a national scale as an indicative map of areas at risk and are unlikely to take account of (i) the re-aligned Burghfield Brook and (ii) the complex nature of flow paths around embankments and bunds once flood flows leave the brook and enter the site. To assess the current risk to the proposed development in more detail, further modelling was required and has been undertaken by HR Wallingford.

5.1.2 Historic Flooding

Anecdotal evidence suggests that AWE Burghfield has experienced past incidents of flooding from the Burghfield Brook. Generally, this flooding has occurred due to one of two specific circumstances:

- under-capacity of the re-aligned Burghfield Brook in passing extreme flows, exacerbated along the southern boundary of AWE Burghfield by a small number of bridges which potentially restrict flows when levels in the brook are high; and
- restrictions to flow posed by the bridge at the downstream boundary of AWE Burghfield and culverts further downstream at the road and railway crossings. Anecdotal evidence and modelling analysis suggests that, during high flows, these downstream structures pose a restriction to flow that can cause floodwaters to back up in the Burghfield Brook and overtop the left bank in the north east corner of the site.

When these two flooding mechanisms combine, the old stream bed of the Burghfield Brook conveys floodwaters across AWE Burghfield, passing through the south-east corner of the application site. The numerous embankments, bunds, roads and drains influence precise flow paths of water across the site.

On 20th July 2007, AWE Burghfield experienced flooding exacerbated by both flooding mechanisms described above. Large parts of England were experiencing flooding from a variety of sources due to intense and often prolonged rainfall at the end of the wettest May-July period in the UK since records began in 1776.

The Burghfield Emergency Control team took action to evacuate parts of the site as the flood event evolved, evacuating individual areas as the flooding increased in magnitude. By use of loud speaker announcements, non-essential staff were requested to leave the site, particularly those whose vehicles were parked in car parks at risk from the observed flooding. This on-site emergency response enabled the flooding to be managed such that there were no reports of injury to staff on site, and no need to involve external emergency services. Furthermore, as part of the AWE Nuclear Site Licence, AWE were required to sample and analyse floodwaters and were able to confirm that no radioactive materials escaped from the site due to flooding.

Flooding is also known to have been experienced at AWE Burghfield in October 2000, during another period when a number of locations in England experienced widespread flooding.

5.1.3 Detailed Hydraulic Modelling

Modelling Scope

In order to comply with the specific nuclear-related requirements of the design and operation of facilities at AWE Burghfield as described in Chapter 3, AWE commissioned a detailed flood modelling study of the Burghfield Brook and surrounding area. HR Wallingford has undertaken this work for AWE and has provided results from their flood modelling study for this FRA (see Appendix B for further details). The Environment Agency have undertaken to audit the modelling through their consultants the Halcrow Group. This has lead to an updated model, the results of which are described below.

The principal aim of the AWE/HR Wallingford flood study was to construct a hydraulic computer model capable of representing the complex flow paths across the AWE Burghfield site and the re-aligned channel of the Burghfield Brook. TUFLOW modelling software was chosen for this assessment and the model has been used to define the extent of the 1 in 10,000 year extreme flood event.

The hydraulic model has been calibrated using anecdotal evidence and observations from site, and hence confidence can be placed in its predictions. See ref 7.

AWE requires the definition of the 1 in 10,000 year flood extent in order to appropriately design the proposed development in line with the AWE Nuclear Site Licence and associated Safety Case described in Chapter 3. In addition, the 1 in 100 year flood event has been assessed (including an allowance for climate change) to provide a '**design flood** event' for the purposes of assessing the proposed development against the principles in PPS25 (Ref. 1).

The Design flood refers to the 1 in 100 year flood with climate change allowance.

Details of the technical approach used in the flood modelling are provided in Appendix B. In summary, the following two methods were used to define the hydrological inflows to the model.

Modelling Approach	Description	Use in FRA modelling
Fluvial (river) flooding	• inflows provided by upstream catchment pluvial modelling only; • local runoff provided as convoluted hydrographs; • shows fluvial flood extents through the site.	Defines existing fluvial 1 in 100 year (plus climate change) outline for the purposes of assessing the proposed development against fluvial flood risk and evaluating the need for flood storage.
Pluvial (rain) flooding	• pluvial inflows provided for entire modelled area; • includes rainfall on site itself; • shows widespread flooding on site, due to localised shallow water ponding and overland flow; • flood extents take no account of existing surface water systems or infiltration.	Not used in FRA modelling but considered separately for 1 in 10,000 year flood event.

Table 5.1 – Hydrological scenarios tested

For the purposes of this FRA, in order to take account of the significant surface water management systems existing on the site, and the effect of the proposed SuDS scheme, the fluvial modelling was used to define the design flood extent.

Pluvial modelling has been carried out to provide an assessment of the flooding, and also to provide a check on the accuracy of the fluvial results. The check demonstrated that the differences in predicted water levels on the site are within 50mm.

Definition of Existing 1 in 100 year plus climate change flood extent

Figure 5.1 shows the modelled fluvial flood extent with depths for a 1 in 100 year event plus climate change (the design flood). The extents can be seen in full in Figure A3 in Appendix A.

The modelled 1 in 100 year CC flood extent differs from the 1 in 100 year extent (Flood Zone 3) shown in the current Environment Agency Flood Map as follows:

- the eastern-most of the two principal flow paths shown on the Flood Map, flowing across non-AWE land to the east of the site, is not predicted to occur. This is due to the representation of the Burghfield Brook in the HR Wallingford model, which was not picked up by the coarse low-resolution modelling used to derive the Flood Map.
- flooding on AWE Burghfield is shown to be less extensive in some areas (the north of AWE Burghfield to the north of the application site) and more extensive in others (the southern part of AWE Burghfield to the south of the application site).
- flooding adjacent to the application site is shown to be more or less the same as predicted by the Flood Map, with some isolated areas of increased flooding predominantly due to the increased resolution of the HR Wallingford model in picking up local flow paths along roads and drains.
- increased flooding is shown on the non-AWE land to both the north-east and south of AWE Burghfield, due in part to the inclusion in the modelling of restrictions posed by structures on the Burghfield Brook along the southern boundary of AWE Burghfield and the railway line and road downstream. This is in contrast to the topographic routing approach modelling used to derive the Flood Map, which used a coarse national topographic grid, and did not include river crossings and their impacts.

Overall, flooding predicted with the design flood shown to be more onerous than the current Environment Agency flood map. This is in part due to the 20% increase in flows as part of the inclusion of a climate change allowance (not included in the EA flood map). Also important are the effects of accurately representing the realignment of the Burghfield Brook, the structures affecting conveyance on the Brook and minor flow paths on the site.

The design flood extent shown in Figure 5.1 is the ‘design flood extent’ considered later in this document with regard to the volume of water on the floodplain for the existing situation. The ‘design flood extent’ and associated flood levels account for the site clearance works which have been previously carried out.

Existing Flood Depths

Flooding that occurs for the 1 in 100 year event is predominantly less than 0.5m though there are areas where this depth is exceeded. This flood depth increases by a further 1m for the 10,000 year event. This extreme event has informed the sequential decisions associated with the location and levels for the MPF.

Downstream of AWE, where the railway culvert exerts significant control over conveyance, resulting in ‘backing up’ of floodwaters, the 1 in 10,000 year event is predicted to exceed the flood levels caused by a 1 in 100 year CC event by almost 2m.

5.1.4 Climate change

The Environment Agency Flood Map does not account for the predicted effects of climate change on fluvial flooding. Guidance in PPS25 (Ref. 1) requires that an additional 20% be added to all river flows to account for the predicted increase in frequency and intensity of storm events in 100 years time. The AWE/HR Wallingford Flood Study incorporated this 20% increase in river flows into the modelling of the 1 in 100 year flood. Therefore, the ‘design scenario’ as described above includes an appropriate climate change allowance for the duration of the design life of the proposed development.

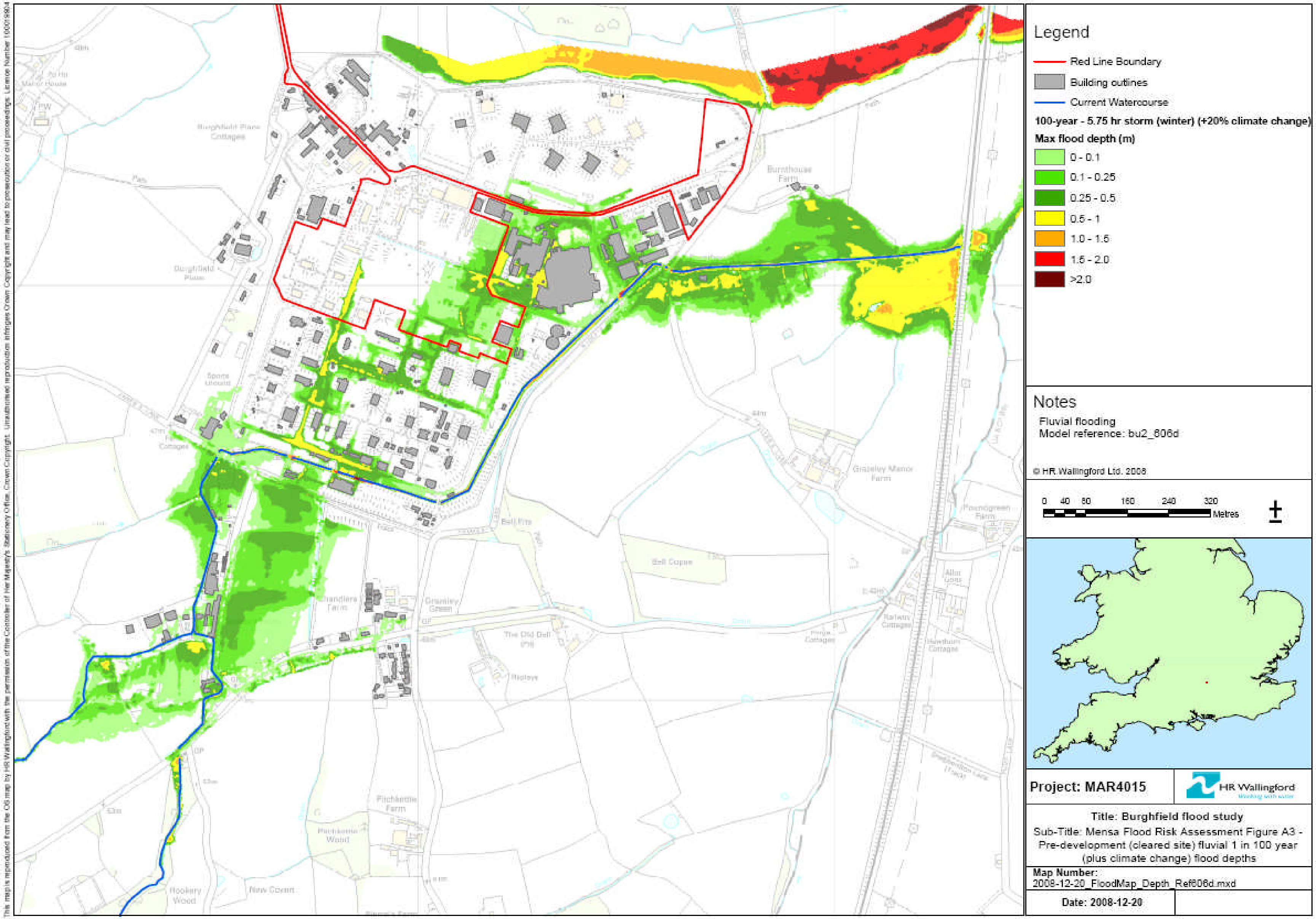

Figure 5.1 – Existing 1 in 100 year (including climate change) flood depths (Ref. 2)

5.1.5 Other Data Sources

West Berkshire Council (WBC) has published a Strategic Flood Risk Assessment (SFRA) on its public website (Ref. 3). This document, however, pre-dates the final publication of PPS25 and by its own admission considers flood risk at the highest level only such that it cannot be used in the production of this FRA. The document refers to a forthcoming, more detailed SFRA in support of the Housing Site Allocations Development Plan Document (DPD), but it is not known when this document is due to be published.

5.2 Surface Water Flooding

The existing surface water drainage for the application site comprises French drains alongside the concrete roads that cross the area. These drains discharge via a relatively shallow network of concrete open channels, which direct the flow to the Burghfield Brook at a number of outfalls. If unmitigated, the proposed development would result in an increase in surface water runoff from the application site into the Burghfield Brook, increasing flood risk both to the site and to receptors downstream. The Environment Agency has stipulated in consultation with AWE that it expects the proposed development to result in no net increase in surface water runoff and provide betterment wherever possible.

Due to the complex nature of the existing development within the application site, estimating the present rate of surface water runoff from the application site is difficult. In order to overcome this, it has been assumed that the existing site is Greenfield in all analysis of surface water runoff. This is a conservative approach which means that proposed mitigation to attenuate post-development surface water runoff to the ‘existing’ runoff rate will actually result in a reduction in surface water runoff rates and is important in terms of flood risk. The Greenfield runoff rate (QBAR) for the application site has been calculated as 4.6 l/s/ha (Ref. 4).

5.3 Summary

The proposed development application site is at risk of flooding from the Burghfield Brook, conveying floodwaters from the catchment upstream and from floodwaters arising from surface water runoff from the site itself. The development site and wider AWE Burghfield site has experienced flooding historically from the Burghfield Brook following prolonged periods of heavy rainfall. Recent flooding was managed on-site by the Burghfield Emergency Control team, involving the evacuation of support buildings and removal of vehicles from car parks.

A detailed modelling study has been carried out by HR Wallingford to refine the existing information on flood risk. This study has been used to define an extreme 1 in 10,000 year flood outline to inform the design of the proposed development in line with Nuclear Safety Case Standards. It has also resulted in a revised 1 in 100 year flood outline, including an allowance from climate change, to satisfy the requirements of PPS25 (Ref. 1).

The resultant revised 1 in 100 year (including climate change) flood outline represents the ‘design scenario’ for the assessment of fluvial flooding under PPS25 and results in a design flood level on the application site of 43.74m AOD (See Appendix B for further details).

The extent of this design scenario differs from the current Flood Zone 3 shown on the Environment Agency Flood Map, due both in part to the inclusion in the modelling of increased flows accounting for climate change and the improved representation of the study area including its topography, the re-aligned nature of the Burghfield Brook and its structures.

The existing surface water runoff regime at AWE Burghfield is a complex network of French drains, culverts and concrete channels, reflecting the sites heritage as a ROF. For the purposes of assessing the existing surface water runoff regime on site, it has been assumed that the site is Greenfield, with a QBAR runoff rate of 4.6 l/s/ha.

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6. Proposed Mitigation

6.1 Overview

This chapter presents information to demonstrate how the proposed development, outlined in Chapter 2, adheres to the principles of PPS25 (Ref. 1) described in Chapter 3, by avoiding where possible and mitigating where necessary the risks described in Chapters 4 and 5. In line with criterion (c) of the PPS25 Exception Test and in order to illustrate that the development will be 'safe' with respect to flooding, the following key points are addressed:

- the safety of the occupants of the proposed development;
- the safety of the proposed development buildings; and
- the safety of sites external to the application site and AWE Burghfield, upstream and downstream on the Burghfield Brook.

These elements are addressed by the following avoidance/mitigation measures, described further below:

- site layout with respect to the predicted 'design flood extent';
- finished floor levels of the proposed development buildings;
- management of construction activities taking account of the risk of flooding on site, including avoidance of flood-prone areas for certain activities;
- management of excess surface water runoff produced as a result of the proposed development and its significant construction processes, by way of design and early construction of a SuDS scheme. The SuDS scheme will be designed both to cope with increased runoff and provide overall betterment to the existing surface water drainage system within the application site; and
- management of residual risks in excess of the 'design scenario', by way of: (i) continual operation of strict and comprehensive emergency procedures on site overseen by the Burghfield Emergency Control team; and (ii) the future investigation of potential river works to increase the capacity of the Burghfield Brook and wider drainage studies to improve current information on the historic drainage systems in place elsewhere at AWE Burghfield.

Over and above the requirements of PPS25 (Ref. 1), and in line with the requirements of the nuclear safety case prepared for the proposed development, a 10,000 year bund will be built along the southern boundary of the development site, to reduce the impacts of a flood wave from the 1 in 10,000 year event as it passes through the site (See Figure A-5). The bund will be designed to allow the relatively small design flood through it. The effects of this flood bund on the design event have been included in the post-development analysis of flood levels presented in this chapter where the impacts of the proposed development on the predicted flood levels has been assessed.

6.1.1 Assessment Scenarios

It should be noted at this stage that there are 3No. development conditions used in the assessments.

The first relates to the previous site condition whereby the application side was occupied by the buildings and bunds as described in section 2.1.1. Herein this is referred to as the **Initial Condition**.

The existing or **Commencement Condition** describes the site in its present state, with demolition and site clearance having taken place. As described above (section 2.3), this FRA and the DEEA consider this scenario as the baseline condition.

The third scenario covers the proposed development in its completed state – herein known as the **Proposed Condition**.

6.2 Proposed Site Layout

The proposed site layout is shown in Figure A5 in Appendix A, overlain by the design flood extent. The ‘Commencement Condition’ design flood extent covers only a tiny part of the Pingewood Gate and is not coincident with the proposed locations of the northern electrical intake substation. The eastern electrical substation is located partially within the ‘Commencement Condition’ design flood extent in an area predicted to flood with a depth up to 0.25m. The MPF is located centrally within the red line boundary such that a very small part of the building footprint overlaps with the ‘Commencement Condition’ design flood extent in an area where flood depths are predicted to be between 0m and 0.5m. All other proposed buildings are located outside the ‘Commencement Condition’ design flood extent.

The layout of the site, whilst designed to minimise the exposure of the proposed buildings and their occupants to the design flood extent, has involved numerous other factors:

- most importantly, the specific nature of the development means that the MPF should be located as far as possible from potential environmental receptors and security risks. Hence its position centrally within the application site boundary puts it at the maximum possible distance within AWE Burghfield away from external receptors such as public roads, private land and watercourses (under normal flow conditions);
- for security reasons, there is a need to locate the MPF, the SB and the electrical sub-stations within the new designated NSPA and associated additional security provisions. Within this area, additional surface water drainage (discussed later) and other connecting infrastructure is required. The EC, not required to be sited within the new NSPA, can and has been located outside of the predicted design flood extent; and
- there are a number of veteran oak trees on the site. The preservation of these trees represents a significant environmental benefit to the proposed development and the surrounding area. It does, however, place further restriction on the placement of buildings within the new designated NSPA and within the application site as a whole.

Given this range of constraints, it is considered that as far as practically possible, the site layout has taken into account the risk of flooding. By avoiding, where possible, the design flood extent, the site layout has reduced the risk of flooding affecting the proposed buildings and their occupants. The following sections describe how further details of the proposed development help to mitigate against the remaining risks not fully eliminated by the site layout.

6.3 Finished Floor Levels

The finished floor level (FFL) of the MPF and SB will be set to a level above the 1 in 10,000 year flood level. Hence the building will not flood during the design event.

The FFL of these buildings will be 45.7m AOD.

In terms of the design event, this FFL will be just under 2.0m higher than the Commencement Condition and Proposed Condition flood levels. Considering the extreme 1 in 10,000 year event, this FFL is around 0.4m higher than the post-development flood level.

This element of design is in direct relation to the AWE Nuclear Site Licence and associated Safety Case. It sets floor levels far in excess of that required to mitigate against the design flood scenario according to PPS25.

The two electrical substations, the gatehouses, the PB and the Pingewood Gate area are not within the proposed condition flood extent. The FFL of the eastern sub-station (which is near the floodplain), will be, at 45.7m AOD, the same as the MPF and SB and it is therefore not predicted to flood in either a 1 in 100 year or 1 in 10,000 year flood event.

6.4 Proposed 10,000 Year Bund

In order to design the proposed development in line with the requirements of the AWE Nuclear Site Licence and Nuclear Safety Case, the HR Wallingford Flood Modelling Study (Ref. 2) has assessed, in detail, the consequences of a 1 in 10,000 year flood event affecting the application site and proposed development.

Due to the large volumes of water involved, a 'flood wave' was predicted to form as the 1 in 10,000 year water levels rise around the proposed development. By sensitivity testing a number of potential options, the study recommended the design of a 'perforated' bund to deflect this 1 in 10,000 year flood wave as it travels along the main north-south road entering the south-western part of the application site.

This flood bund has been incorporated into the construction plans for the proposed development. The bund will be constructed at the start of the construction phase, and will measure 2 to 3m in height, 10m to 15m in length and approximately 2.5m in crest width with sloping sides. The bund reduces the peak 1 in 10,000 year Proposed Condition flood levels by diverting water away from the development.

In the design flood, the numerous small openings and piped culverts through the bund will ensure continuity of the flood extent. This 10,000 year bund provides no protection against the design flood or effects on the design flood extent.

6.5 Existing Flood Mitigation

Investigations are currently ongoing at AWE Burghfield into possible flood protection measures for the site as a result of the flooding on the 20th July 2007. Any proposals that arise from this activity will ensure that flood risk to the application site is not increased.

6.6 Impact of Proposed Development and Mitigation

6.6.1 Impact on Floodplain and Overland Flows

The application site currently conveys floodwater during flood events, such as the design scenario discussed above. PPS25 requires that proposed developments account for any loss of floodplain storage brought about by the specific development proposals, because of the potential this has to affect the flood risk posed to the development itself and neighbouring sites.

It is important to note that this floodplain is associated with overland flows which exceed the capacity of brook in the southern edge of the Burghfield site: its overland flow path is driven by the location of the buildings on the site. Therefore a floodplain has been “created” by former diversion of the brook, with the overland flow paths following the general line of the natural valley. The following analysis puts aside the debate on whether a development 50 years ago which creates a flooding and lies in the original floodplain is pertinent for applying PPS25, but it is a point which needs to be noted with regards to this development.

During site clearance works, all blast embankments within the application site were removed and the site was re-graded. Much of the material removed from this area was used to build up ground levels on the far west of the development site (outside of the floodplain), in the locations to be used for construction welfare buildings and offices. Upon construction, local increases in this planed ground level will be required for vehicle access roads and entrance ramps to the MPF. The overall (net) effect of these works will be to lower ground levels in the floodplain and remove obstructions from the part of the development site which conveys most of the overland floodwater (in the east), whilst building up ground levels in the west.

A 10,000 year bund is proposed for the development. This has been included in the design to mitigate the impact of the 1:10,000 year flood wave and will not protect the development from the design flood.

The clearance of the site of blast bunds and buildings provides two states for pre-development. Thus there are 3 stages for assessing water levels (Initial Condition, Commencement Condition and Proposed Condition), and all 3 have been assessed.

The site has been modified in the demolition activity, so the assumptions made in the model of only removing the bunds and using adjacent ground levels to provide revised ground levels is a simplification. However recent evidence has shown that Commencement Condition (after clearance and demolition) site levels are pretty close to this assumption, though they are not exactly the same. Thus in practice the only true and accurate measures of flood risk are the Initial Condition (site in its former operational state) and the Proposed Condition. Analysis, based on information available at the time of assessment, suggests that, in excess of 20,000m³ of material has been removed from the floodplain, with some 5,000m³ removed below design flood level.

The change in available storage, although a simple concept to apply, does not provide the complete picture of the pre and post construction position on the flooding characteristics of the application site. This is because the modified area generates a combination of changes to the overland flow patterns as well as actual storage. In addition, as flooding takes place adjacent to the application enclave area, changes to water levels in the modified area will influence water volumes stored and conveyed close by.

The best way to provide a complete picture of the changes and to enable a good understanding of the importance of these changes is to provide the following information:

- the change in storage available by the modifications made to ground levels;
- flood depth change information; and
- flow and depth information downstream of the site.

The last bullet point is possibly the most important measure, because the principal requirement of the flood risk assessment is to ensure that the proposed development does not have a negative impact on downstream flooding.

The reason why neither the volume of water on the site, nor the changes in ground level, are sufficient to explain the floodplain storage is because floodwater flows across the site and is not stored or retained.

Whilst the whole site area of AWE Burghfield could be examined, much of the floodwater passing across this area is moving water (conveyance) rather than stored, stationary floodwater. As the flood extents for the 2No pre-development conditions and Proposed Condition do not have exactly the same boundaries, a fixed assessment area has been used. This boundary uses the enclave as the boundary for the north and east sides, extending further to the south to take account of the effects of the deflection bund which modifies the flood extents.

The western edge of the area of assessment has been selected as being the western most extent of flooding from any of the three development conditions. Figure 6.1 shows the template for the area for the analysis.

A number of key points of measurement have been selected and these are shown on Figure 6.2.

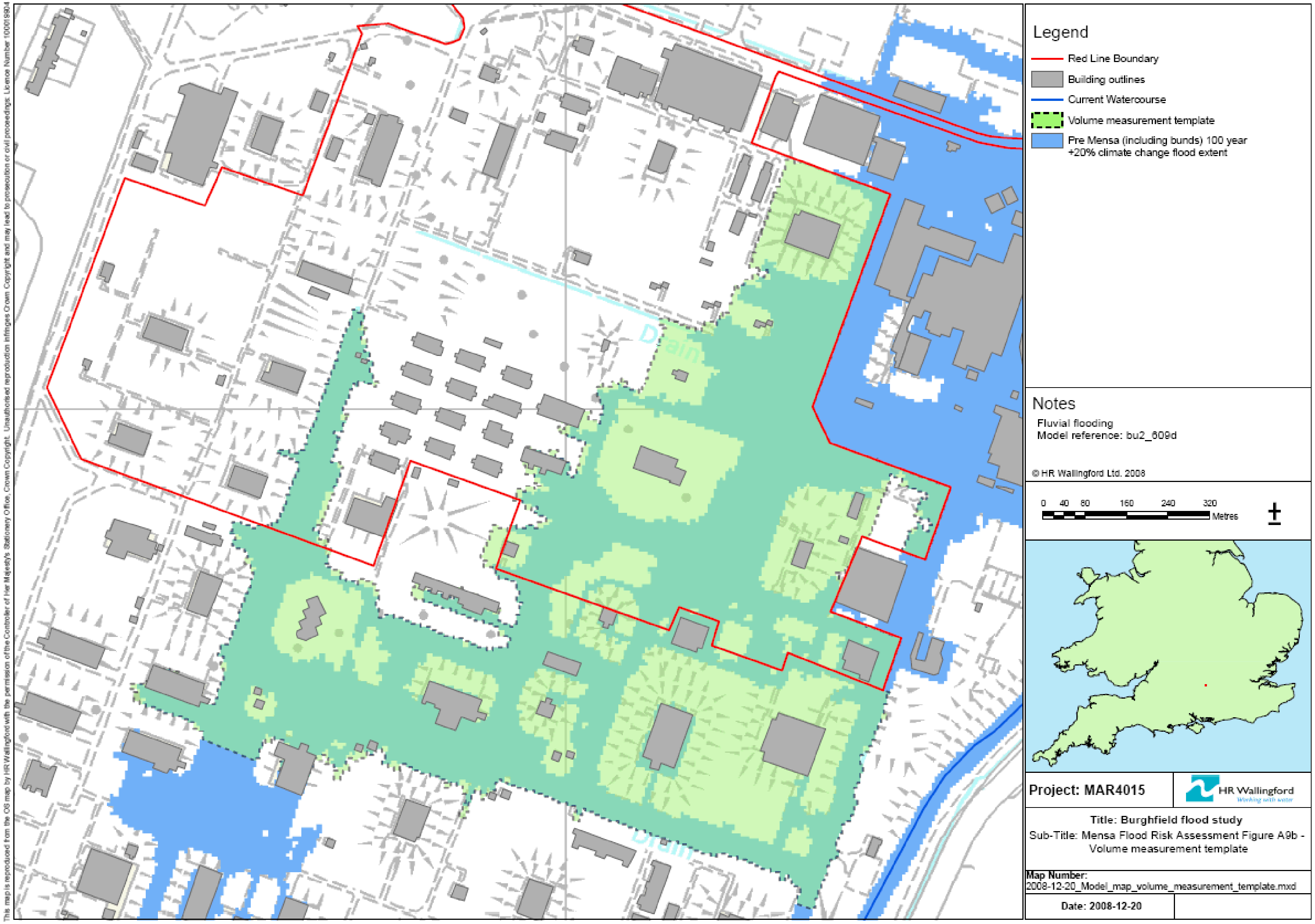

Figure 6.1 - Area template for assessment of flood impact changes due to changes in ground levels.

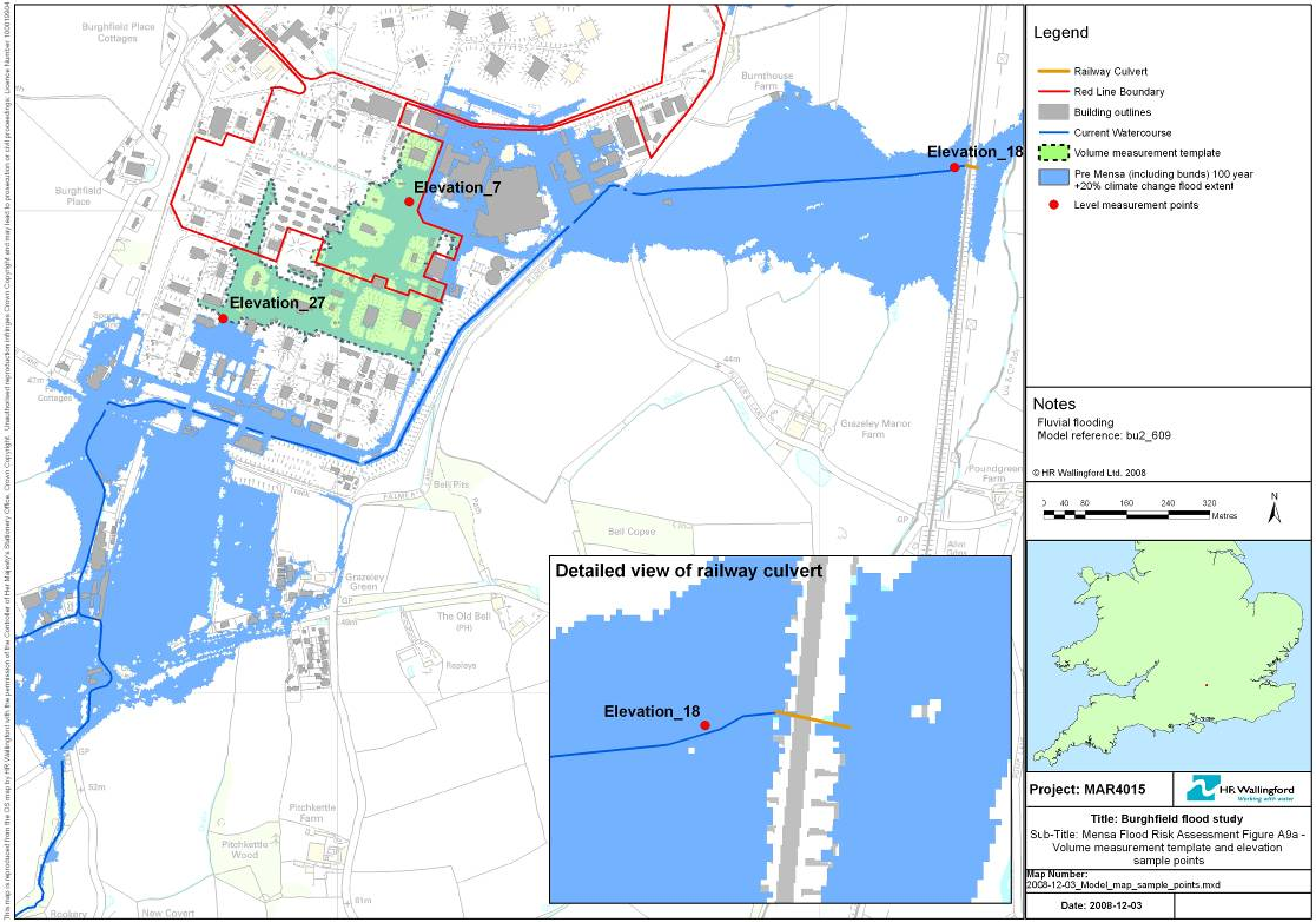

Figure 6.2 - Reference plan for key points of measurement for assessing differences in flood predictions.

6.6.2 Effect of Proposals on Floodplain Volume

The ground level changes that have taken place within the assessment boundary have been assimilated by considering the 'air' volume provided above ground– assuming a glass walled areas. A cumulative approach was undertaken, starting from the lowest point within the area and taking level slices, then calculating the volume of water that could be stored (assuming a flat water level) across the area as the height of water increases. Figure 6.3 shows this information and indicates that as the level increases to 45m AOD, the above-ground-volume available in the 'Proposed Condition' (73,133m^3) is more than the 'Initial Condition' (67,730m^3), but slightly less than the 'Commencement Condition' (78,501m^3).

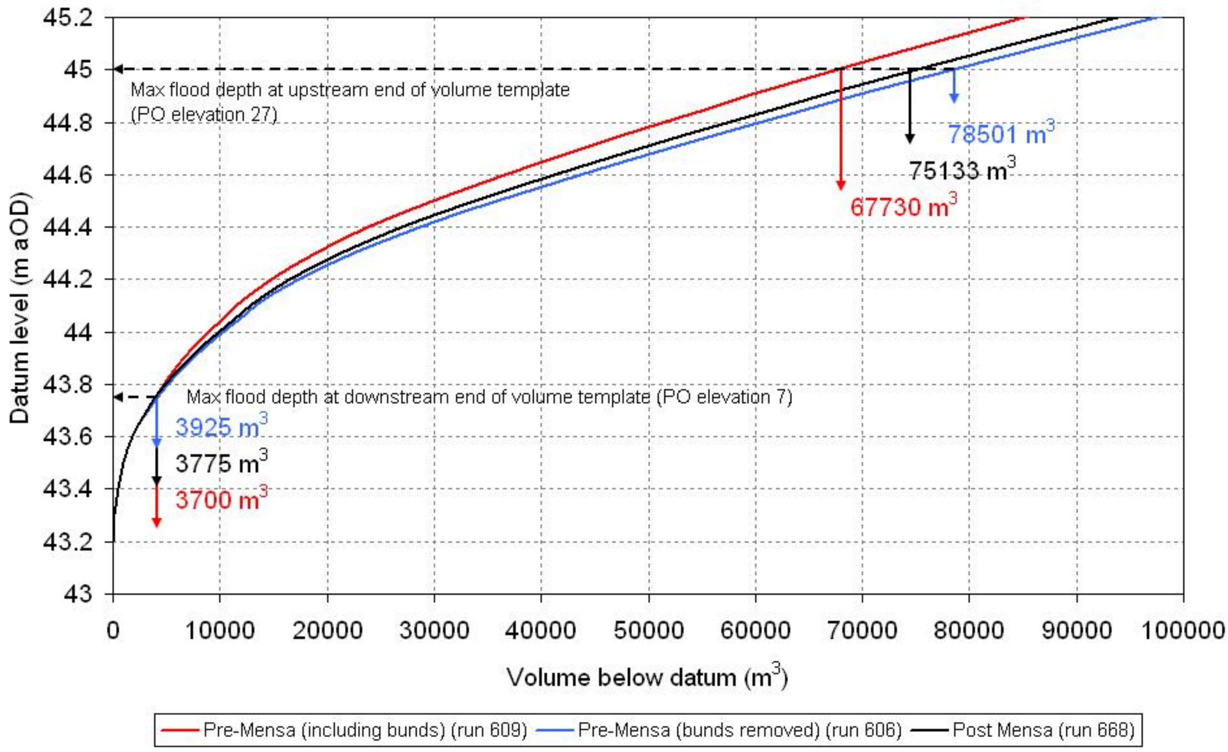

Figure 6.3 - Changes in Storage volume availability for pre and post development states

The proposed changes provide an increase in the volume of water that could be accepted onto the site at a given water level.

Figure 6.4 explains the slight reduction in storage availability between the 'Commencement Condition' and the 'Proposed Condition'. The template area just encroaches on the site area where ground levels are being raised (western side of the site). If this was excluded by taking the post development flood extents outline, this difference would reduce. Figure 6.5 shows that this is the case and demonstrates that most of the land raising is outside the 'Commencement Condition' design flood extents.

It should be noted that the majority of the assessment area in the floodplain is the same ground level except for the existence of the blast bunds. The graph in Figure 6.3 shows two points within the assessment boundary (Points 7 and 27) and with the predicted water levels annotated. Thus if the assessment area was filled to a depth of 45.0m then 75,133m^3 of water would be stored in the 'Proposed Condition'. This volume is more than 7,000m^3 more than in the 'Initial Condition'.

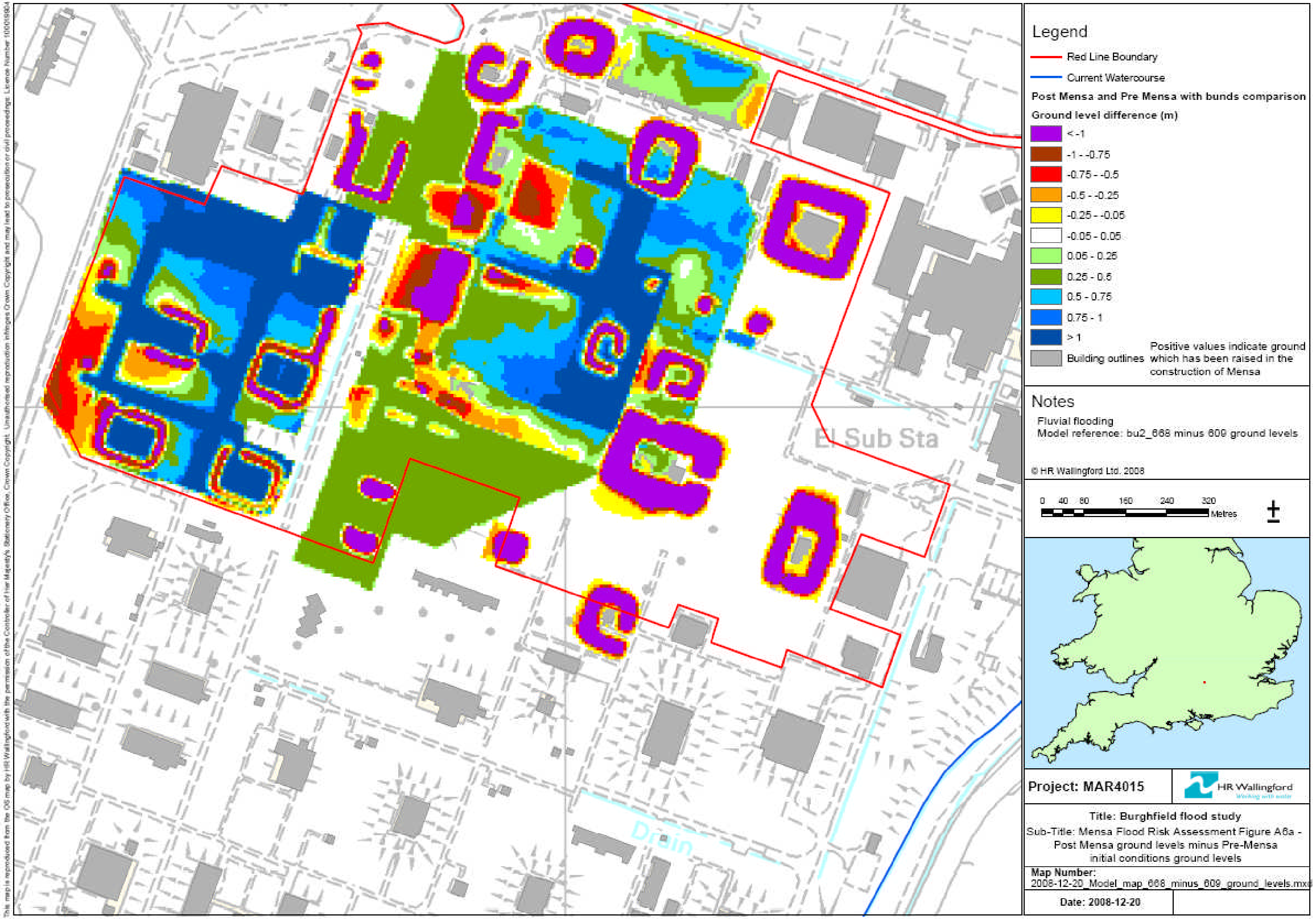

Figure 6.4 - Ground differences plan between pre and post development.

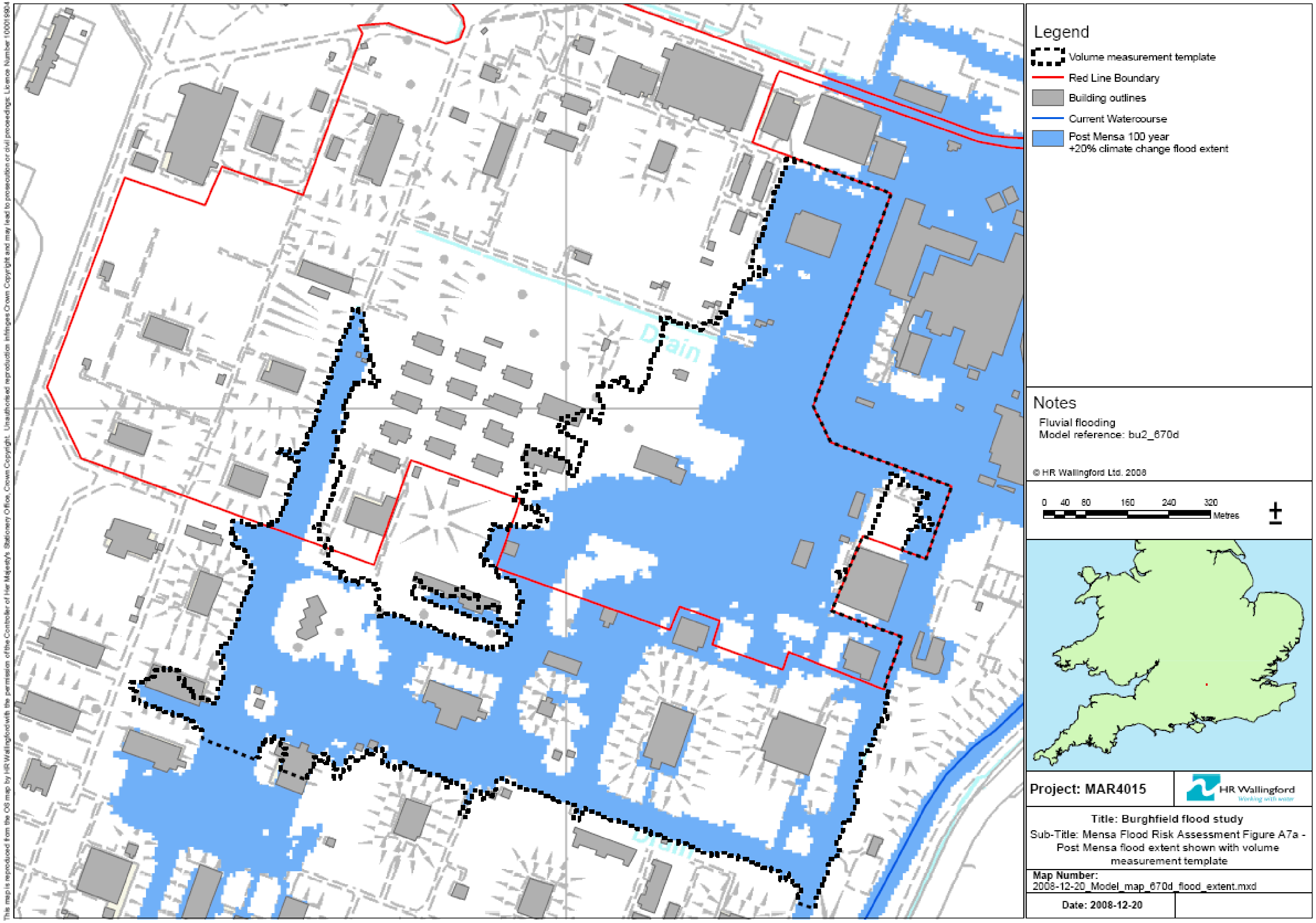

Figure 6.5 - Flood extents for Proposed Condition compared to template area

6.6.3 Effect of Proposals on Overland Flow

A second measure of the impact of the changes in ground level is the effect on the overland flow path and volume of water across the site for the various states of development.

The same assessment area was used for assessing the volume of water across the site for the three states of development. As emphasised earlier, this water is a combination of ponded water and overland flow. It is noted that the more water measured upon the site (ponding or flowing), the greater is the likelihood that downstream flow rates will be reduced. Figure 6.6, Figure 6.7 and Figure 6.8 below provide the flood outlines with depth band shadings for the site as a whole.

Figure 6.9 and Figure 6.10 highlight the differences in water levels between the Initial Condition and the Proposed Condition, and the Commencement Condition and the Proposed Condition. It should be noted that where water exists on one plan and not on the other, there is no colour. This means the blank areas within the assessment area on the plans is where water is no longer predicted to extend for the Proposed Condition.

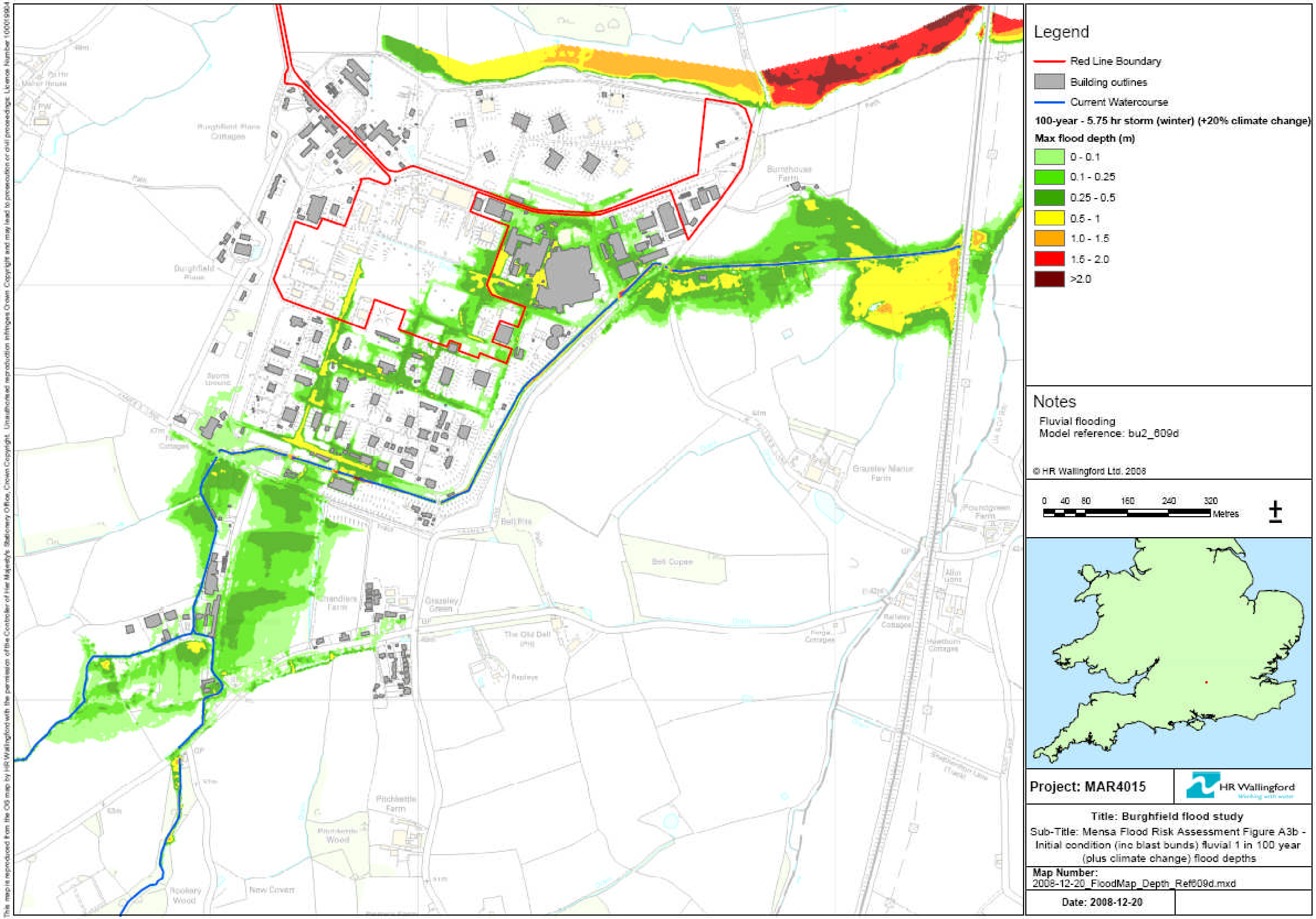

Figure 6.6 - 100 year plan of flood extents across the site and adjacent areas – Initial Condition

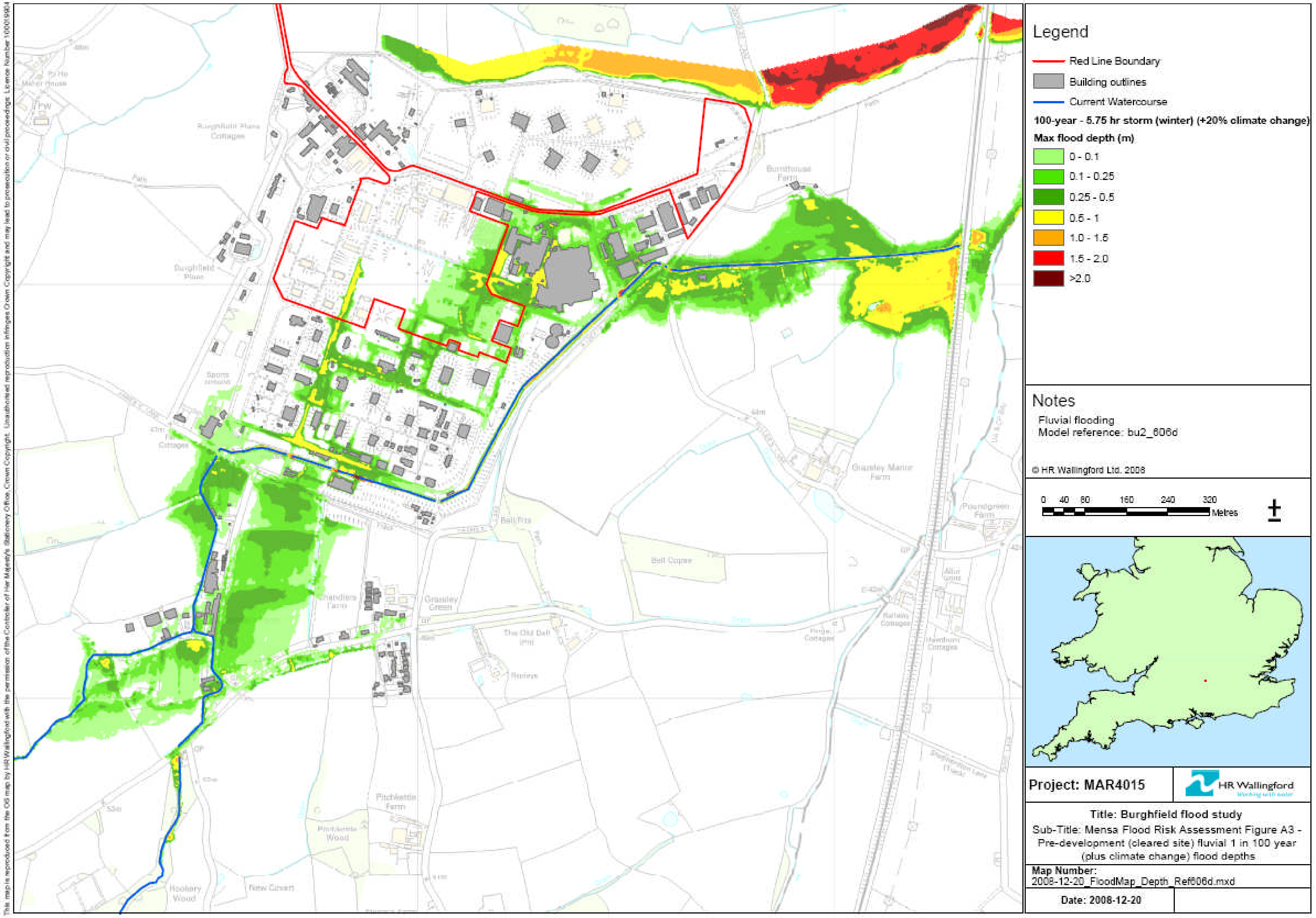

Figure 6.7 - 100 year plan of flood extents across the site and adjacent areas – Commencement Condition

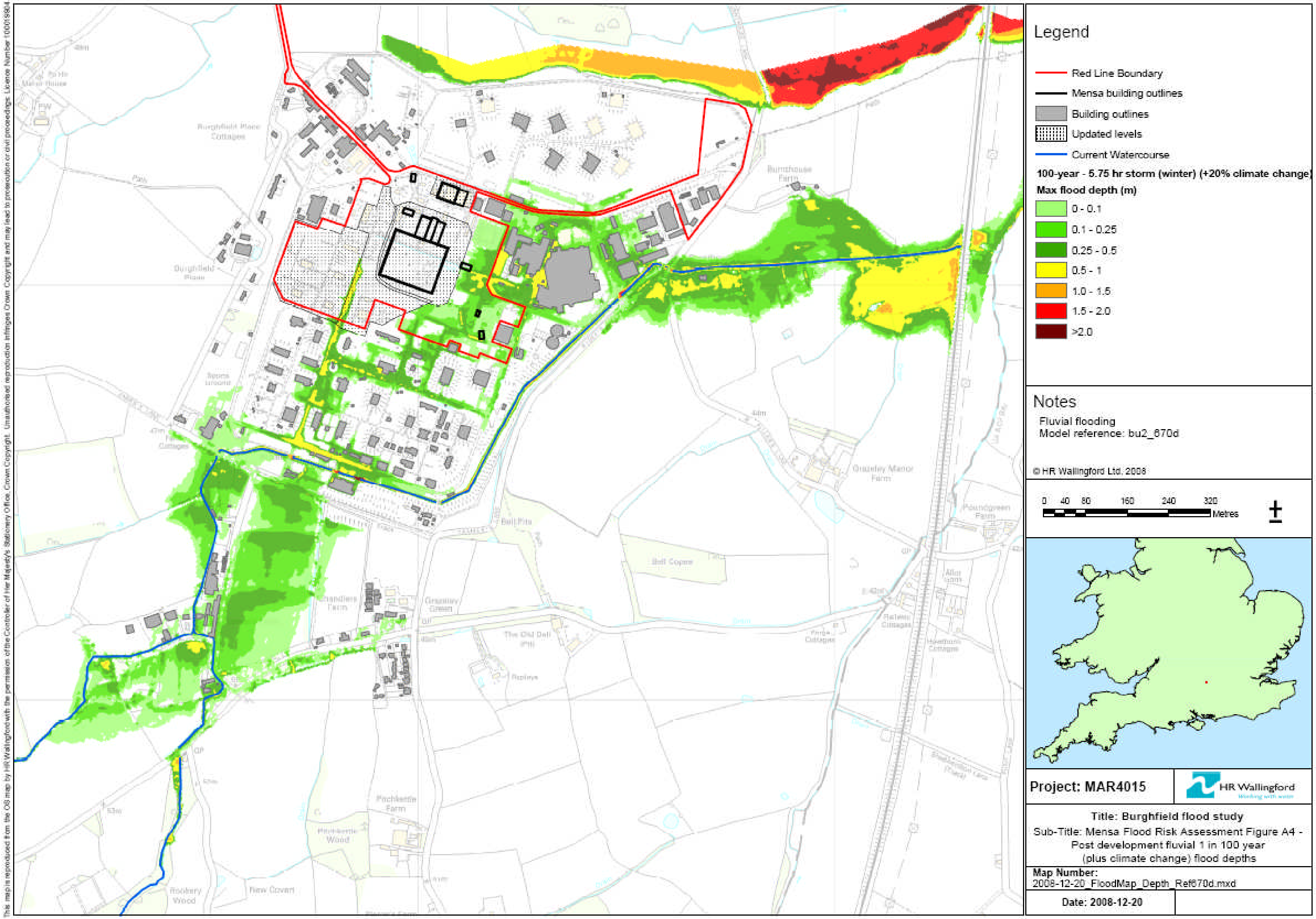

Figure 6.8 - 100 year plan of flood extents across the site and adjacent areas – Proposed Condition

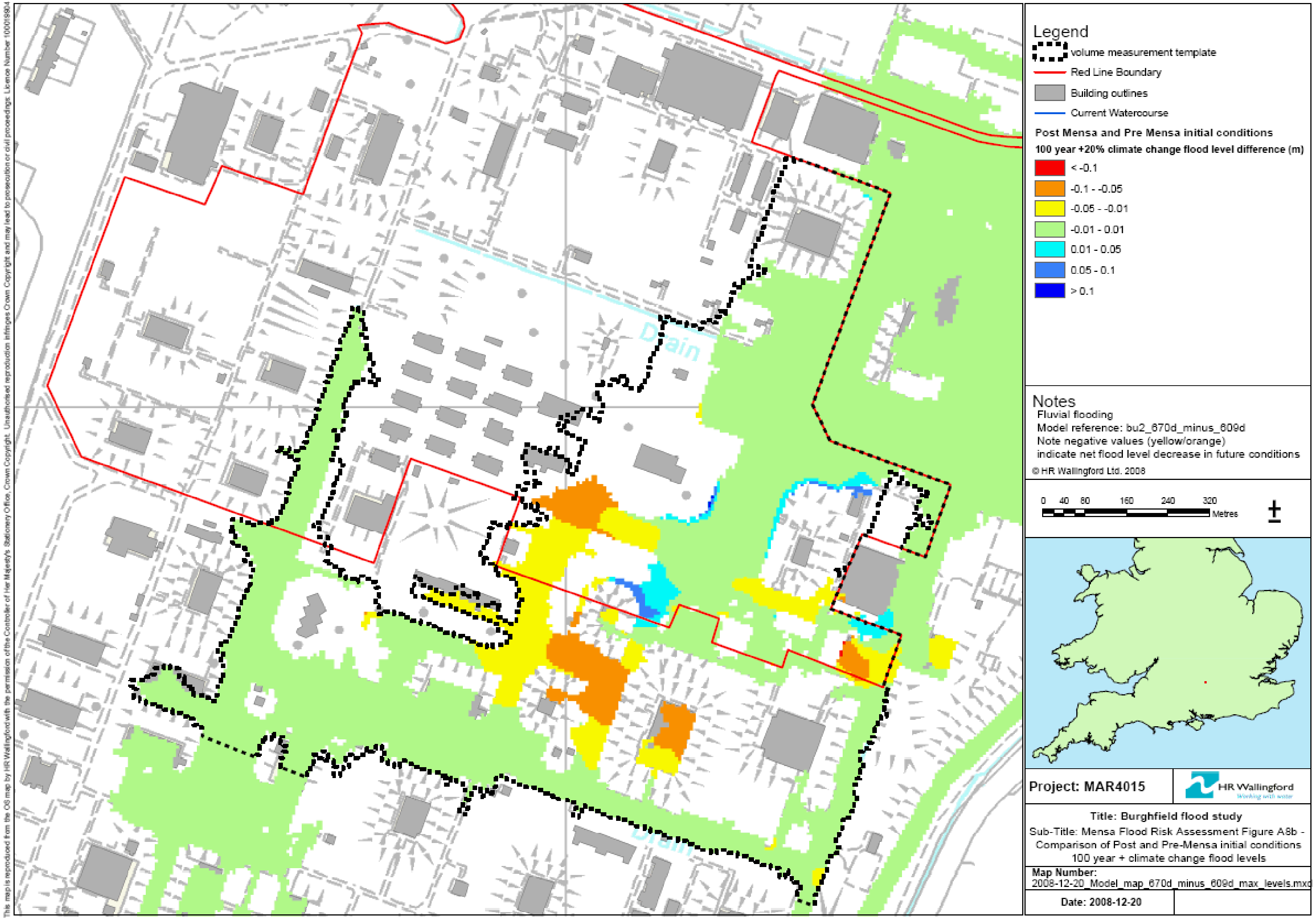

Figure 6.9 - 100 year plan of flood level differences between Initial and Proposed Conditions

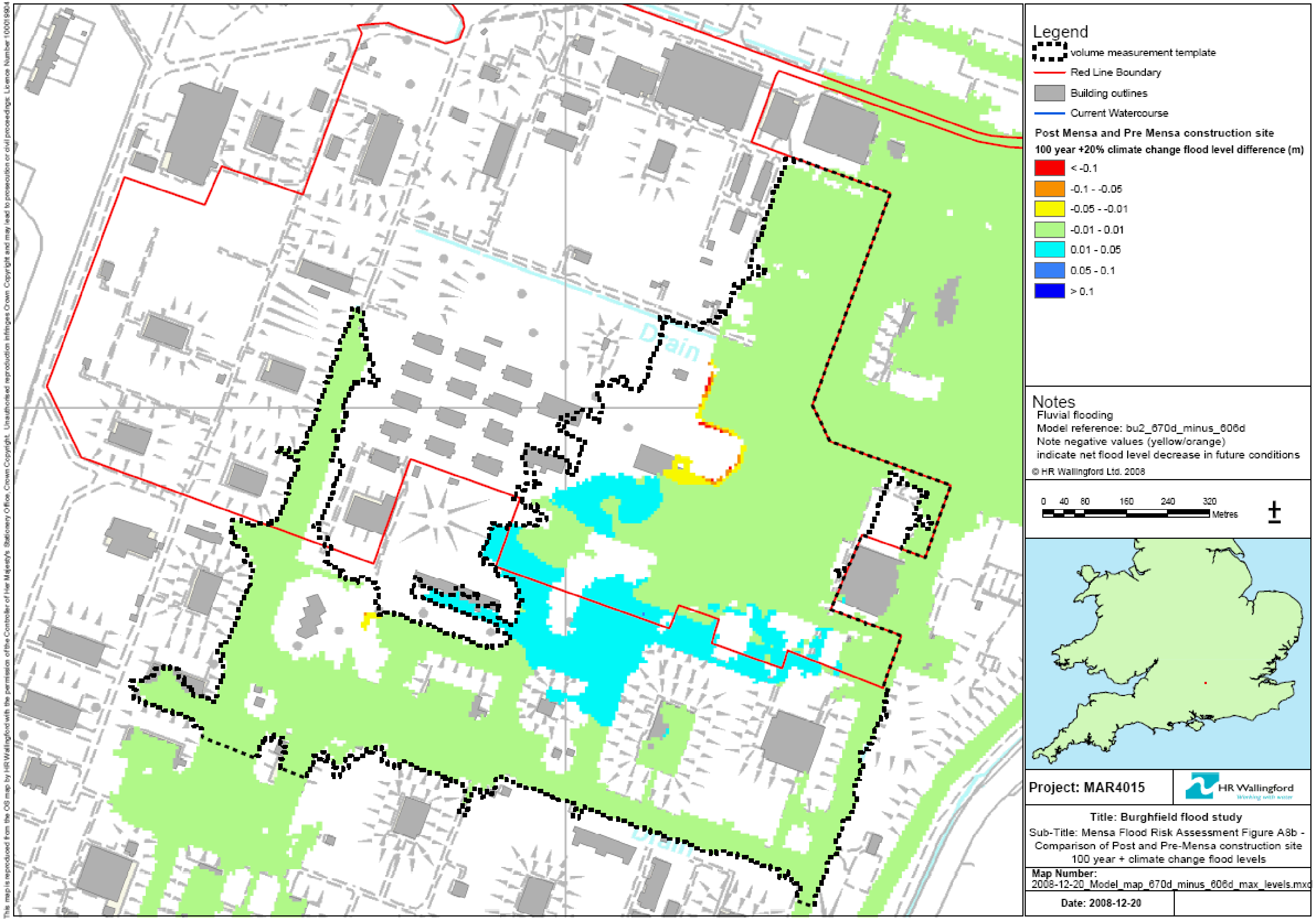

Figure 6.10 - 100 year plan of flood level differences between Commencement and Proposed Conditions

To illustrate the differences as in terms of absolute flood levels, three grid-cell points from the hydraulic model have been selected for analysis (see Figure 6.2). These three points are referenced as points “27”, “7” and “railway / point 18”. The water levels at these three points are given in Table 6.1. Further flood level information for other points in the development area is provided in Appendix B.

Scenario	Design flood level at Pt 27	Design flood level at Pt 7	Design flood level at Pt 18	Design flood flow at railway culvert
Initial Condition	44.977m AOD	43.741m AOD	41.550m AOD	4.008m^3/s
Proposed Condition	44.977m AOD	43.741m AOD	41.550m AOD	4.008m^3/s
Difference	0mm	0mm	0mm	0.00m^3/s
Commencement Condition	44.976m AOD	43.741m AOD	41.550m AOD	4.008m^3/s
Proposed Condition	44.977m AOD	43.741m AOD	41.550m AOD	4.008m^3/s
Difference	+1mm	0mm	0mm	+0.00m^3/s

Table 6.1 - Predicted flood levels and flow for three key locations

Flood point 27 is upstream of the application site but still within AWE Burghfield. At this location, the proposed development has no influence on flood water levels at the design flood with no impact on peak flood level.

Flood point 7 is the middle of the ponded area due to the obstruction of the buildings downstream which impede the flow and thus “create” a floodplain. It can be seen that there is no difference in flood levels at this location. These flood levels are dictated by the conveyance characteristics of the throttled outlets between buildings, so it is unsurprising that water levels are similar.

Flood point “railway” (18) is the water level immediately upstream of the railway (downstream of the site). This was chosen for three reasons: there is a significant control on flows beyond this point; it relates to the impact the flood has on the local farms in the area (which are the only other stakeholders in the immediate vicinity downstream of the site); and the flows through the culvert provides a good representation of the changes in flows created by changes on the site. It can be seen from Table 6.1 that the water level has not increased in either design scenario, with no increase in flow rate in the culvert.

A further point has been examined to check these results The results from Burnthouse Farm are tabulated below in Table 6.2.

	Elevation 29 (Burnthouse Farm)
Initial Condition	41.582m AOD
Proposed Condition	41.582m AOD
Difference	0mm
Commencement Condition	41.582m AOD
Proposed Condition	41.582m AOD
Difference	0mm

Table 6.2 – Predicted flood levels downstream of application site

It can be seen that the proposed development does not raise peak flood levels downstream of the site. Furthermore, downstream of the railway culvert, with no increase in flow, the impacts on communities and populations downstream will be neutral.

6.6.4 Summary of Impacts

- The proposed buildings and the associated changes in ground levels result in minor changes to flood levels for the 1 in 100 year CC event on the application site;
- the floor levels of the MPF and SB will be over 1 m higher than the design flood level. Both of these buildings will be outside the 'Proposed Condition' 1 in 100 year CC flood extent;
- upstream of AWE Burghfield, where James' Farm is potentially at risk of flooding, no changes to peak flood levels are predicted as a result of the proposed development;
- Burnthouse Farm, Downstream of AWE Burghfield, is not predicted to be flooded during a 1 in 100 year CC event either pre- or post-development. The proposed development is not predicted to generate increases in flood level compared to the 'Commencement Condition', or to the 'Initial Condition'. No changes in flow are predicted here either.
- the proposed development does not alter flood depths across the site; and
- the nature of the development and the required local ground level alterations means that shallow floodwaters within the application site are redistributed slightly, although with no change in flood impact on other site buildings and their occupants.

6.7 Management of Construction Activities

6.7.1 Overview

The construction of the proposed development is envisaged to occur over a seven and half year period. Due to the size of the proposed development and the nature of the facility being constructed, construction will involve a number of activities, utilising the majority of the application site. All construction activities will be undertaken in accordance with the AWE Code of Construction Practice and in line with Environment Agency Pollution Prevention Guidelines. Full details of all environmental mitigation measures incorporated into the proposed construction process can be found in the DEEA, which this FRA accompanies. The purpose of this section is to ascertain how construction activities will be managed to take account of the risk of flooding from both identified sources, river flooding from the Burghfield Brook and surface water flooding from the site itself.

6.7.2 Construction Activities

The construction activities, following completion of the currently ongoing site clearance, can be grouped under the following headings:

- enabling works: Preparing the site for construction and creating a central construction enclave in order to isolate the construction activities from the remainder of AWE Burghfield and provide an appropriate level of security for the proposed development;
- substructure installation: Construction of the buildings' reinforced sub-structures / floor slabs;
- concrete and structural steelwork superstructures: Construction of the main reinforced concrete / steel-framed buildings. At times this will require continuous concrete pouring; and
- fit-out and completion: Installation of office and welfare facilities, specialist equipment and mechanical / electrical controls and instrumentation, heating, ventilation and air conditioning.

At its peak in Months 50-51 of the construction programme, the construction phase is projected to require 642 construction staff and 172 managerial staff.

The phased approach to construction activities detailed above means that not all processes will be engaged throughout the entire seven and a half year period. For the purposes of this FRA, however, all construction activities have been assessed as occurring at the same time, representing the greatest impact on the application site and the maximum likely risk from flooding. As such, Figure A6 in Appendix A shows a layout of all construction processes within the construction enclave.

6.7.3 Flood Risk Mitigation During Construction

Fluvial flood risk to construction has been mitigated by assessing the vulnerability of the proposed construction activities and ensuring that those construction activities that are the most vulnerable to flooding are located outside of the predicted design flood extent. This exercise has been carried out as far as practically possible given the size and nature of the proposed development.

Referring to the layout shown in Figure A6, the following is proposed:

- the most vulnerable construction activities (welfare buildings, equipment parking and vehicle refuelling) are proposed to be located away from the south-eastern corner of the application site where the risk of fluvial flooding is greatest.
- the majority of storage, laydown and prefabrication areas are located in areas outside of the predicted design flood extent.
- the hardstanding area shown in the far south eastern corner (within the design flood extent) has been designated for 'restricted' use only, limiting its use. This restriction is related to the type of materials that might cause a negative impact rather than the volumetric reduction in storage, though this will also be taken into account. Thus storage of potentially contaminating products or items that can be easily washed away will be excluded from this area.

- the main vehicle entry point to the construction site and road is via Pingewood Gate, entering the enclave from the north-east. This entrance route is outside the design flood extent.

There are two further points of note with regard to the construction activities. Firstly, the current proposed layout includes an area designated for the batching of concrete. At present, due to other environmental constraints, such as the potential impact of HGV movements on local air quality and transport links, it is not possible to confirm whether concrete batching will be required on site. However if it is required, the concrete batching materials will not be placed in the floodplain.

Any spoil stored on site will also not be placed in the floodplain, unless it is used to form the 10,000 year bund. Appropriate measures will be taken to ensure the material is suitable and any temporary erosion risk (prior to establishment of grass or other similar measure) will be protected against.

6.8 Management of Surface Water Runoff

6.8.1 Overview

As previously stated, mitigation is required to manage surface water runoff arising due to the design of the proposed development. In this regard, a comprehensive SuDS scheme has been designed to serve the various surface water catchments that exist within the site development boundary. The work has been carried out by a SuDS design team comprising the design consultants Atkins and Mott MacDonald and SuDS advisors/coordinators Mayer Brown, HR Wallingford and AWE.

The design team has presented the SuDS design in a single coherent document to inform the DEEA and associated studies. This document is titled <u>SuDS Planning Application Design Submission, Mensa, Burghfield</u> (Ref. 4) and has been included in the planning submission. For the purposes of this FRA, the principles of this SuDS design are re-iterated to illustrate the overall compliance of the proposed scheme with the principles of PPS25. The SuDS design has taken account of the position of the design flood extent and the Flood Study conducted by HR Wallingford. No area outside the design fluvial flood extent drains to a SuDS feature inside the flood extent and vice versa.

The SuDS scheme has been designed in three distinct ‘packages’, reflecting in part the shape of the application site boundary but also the impact that the significant construction process has on the surface water runoff regime of the site. The three packages are:

- Pingewood Gate: The smallest of the SuDS design areas, located in the north-east part of the application site. This SuDS scheme serves the car park and HGV marshalling area and is not connected hydraulically to the other elements of the proposed scheme. The total drainage catchment area is 1.6ha.
- Proposed Development Construction Area: An extended area located in the centre of the application site including the construction enclave and all construction activities as shown on Figure A6. The total drainage catchment area is 15.45ha.
- Proposed Development Permanent Works: This is the constructed proposed development including the proposed NSPA and the PB to the north. Security constraints have had to be taken into consideration in the design of the SuDS features for this area. The total drainage catchment area is 6.4ha.

A summary of each of these SuDS areas is provided from the SuDS Design Submission (Ref. 4) in Appendix C. The following sections describe how the proposed SuDS comply with the AWE SuDS Principles Document which has been produced in consultation with the Environment Agency (Ref. 5). Further information regarding environmental and other benefits of the proposed SuDS can be found in the SuDS Planning Application Design Submission (Ref. 4)

6.8.2 Pingewood Gate

The SuDS Design Submission (Ref. 4) illustrates how the proposed SuDS in the Pingewood Gate area comply with the SuDS Principles Document by way of the following:

- By the use of swales and permeable paving, there will be no excess runoff from 5mm rainfall;
- flows will be attenuated to a total rate of up to 6.5 l/s (4.1 l/s/ha) for a 1 in 100 year event including a 10% increase in rainfall compared to the Greenfield runoff rate (QBAR) of 7.3 l/s (4.6 l/s/ha). The 1 in 1 year peak flow will be 4.6 l/s (2.9 l/s/ha); and
- storage ponds: will provide a total storage volume of 143m³; have been designed on a treatment train basis; will provide opportunities for improvements to local ecology; and will pose no unusual health and safety risks.

6.8.3 Proposed Development Construction Area

The SuDS Design Submission (Ref. 4) illustrates how the proposed SuDS for the Construction area comply with the SuDS Principles Document by way of the following:

- the use of swales, ponds and permeable paving will ensure that there will be no excess runoff from 5mm rainfall.
- flows will be attenuated to a total rate of up to 63.88 l/s (4.1 l/s/ha) for a 1 in 100 year event compared to the Greenfield runoff rate (QBAR) of 68.2 l/s (4.6 l/s/ha).

6.8.4 Proposed Development Permanent Works

The SuDS Design Submission (Ref. 4) illustrates how the proposed SuDS for the Proposed Development Permanent Works area comply with the SuDS Principles Document by way of the following:

- the use of filter strips, bio-retention areas, under-drained swales and attenuation ponds will ensure that there will be no excess runoff from 5mm rainfall.
- flows will be attenuated to a total rate of up to 15.5 l/s (3.7 l/s/ha) for a 1 in 100 year event including a 10% increase in rainfall compared to the Greenfield runoff rate (QBAR) of 22.1 l/s (3.5 l/s/ha). The 1 in 1 year peak flow will be 13.6 l/s (3.2 l/s/ha).

6.9 Summary

This chapter has described the details of a number of proposed measures which, in line with PPS25 (Ref. 1), serve to avoid, substitute, control and mitigate the flood risk both to and from the proposed development:

- the layout of the proposed development has taken into account the position of the 1 in 100 year (including climate change) ‘design flood extent’ as far as practicable given numerous environmental and security constraints;
- the floor levels of the most significant proposed buildings, containing the majority of the 160 future staff, will be set to 45.7m AOD, approximately 0.4m above the 1 in 10,000 year flood levels and over 1 m higher than the design flood.
- although not included in analysis of the pre- and post-development flood levels, site clearance work has resulted in an increase in floodplain storage on the application site. This has not translated into an increased storage of water due to the complex issues of ponding and changes to the overland flow paths, but the implications of proposals are shown to be negligible in terms of flood depths affecting the site and downstream land, and flow rates in the Burghfield Brook;

- the vulnerability of construction activities has been carefully considered in relation to the design flood extent. As far as practicable, given the magnitude, complexity and duration of the construction process required as part of the proposed development, areas at risk of flooding have been avoided when planning the location of sensitive processes; and
- a comprehensive SuDS scheme has been designed to service the drainage from all areas within the application site. As well as being tailored to the final proposed development, the SuDS scheme has been designed to cope with both the construction processes and the increased risk of flooding throughout the development's design life due to climate change. The SuDS scheme has been designed in line with best practice and industry guidance, by the design teams of Atkins and Mott MacDonald, co-ordinated by Mayer Brown and AWE with expert advice provided by SuDS guidance authors HR Wallingford.

7. Residual Risk

Chapter 6 assessed proposed mitigation to ensure that the risks from flooding both to and from the proposed development are managed up to and including the design scenarios considered (1 in 100 year fluvial and rainfall events with appropriate climate change allowances where required). PPS25 (Ref. 1) requires that FRAs address how developments will manage the residual risk of flooding remaining after the implementation of all mitigation measures.

Table 7.1 lists the mitigation measures described in Chapter 6 and indicates whether a residual risk remains. It should be noted that mitigation measures that provide benefit to the wider site (e.g. the proposed SuDS scheme) are not listed. The presence of residual risk has been assessed against the 1 in 100 year CC flood event.

Phase	Proposed Development Component	Proposed Flood Mitigation	Residual Risk Remains (Yes/No)
Construction	all	Management of construction activities by layout.	**Y**
Operation	Main Process Facility (MPF)	Raised finished floor level in excess of 1 in 10,000 year flood level.	N
	Support Building (SB)		N
	Energy Centre (EC)	Proposed outside the fluvial floodplain.	N
	Electrical sub-station (northern)	Proposed outside the fluvial floodplain.	N
	Electrical sub-station (eastern)	Proposed outside the fluvial floodplain.	N
	Gatehouses and Vehicle Inspection Bays (VIBs)	West gatehouse not in fluvial floodplain.	N
		East gatehouse floor level set at 44.6mAOD, above 1 in 100 year CC flood levels for South-Eastern Corner and Eastern Boundary of application site (see Appendix B).	**Y**
	Pingewood Gate area (incl. electrical intake substation)	Proposed outside the fluvial floodplain.	N

Table 7.1 – Proposed flood risk mitigation and residual risks for PPS25 Flood Zones 2 and 3 flood events

Table 7.1 illustrates that the two components of the proposed development which will be subject to a residual risk are the construction activities and the eastern gatehouse. The risk to construction activities will be addressed throughout the construction phase by: briefing workers about the risk of flooding; safeguarding equipment and materials in advance of forecast heavy rainfall; and development of a flood warning system for the construction site.

Additionally, throughout the design life of the proposed development, there will remain a residual risk from flooding to the entire site from flood events with return periods in excess of the design event. It is considered that these risks can be managed by on-site engineering and emergency management staff at AWE Burghfield because:

- the main development buildings are designed to be safe from flooding from a ‘catastrophic’ 1 in 10,000 year flood event. The design and construction of the proposed MPF and SB is such that the majority of staff on site, who will be based in these two buildings, will be very safe from all types of flooding inside the reinforced concrete structures raised above the 1 in 10,000 year level.
- suitable evacuation routes will be available from the MPF during the design flood event, on the northern and western sides of the building, linking with the principal thoroughfare and main entrance to and from AWE Burghfield. These routes will be available for higher return period events up to extreme flooding.
- existing emergency procedures within AWE Burghfield carried out by the Burghfield Emergency Control team have in-built resilience to flooding due to the consideration of security-related incidents with consequences far in excess of those arising from flooding of parts of the application site. This will ensure that during both construction and operation of the proposed development, safe access and evacuation will be possible for all site staff along these routes should a flood event occur.

8. Conclusions

8.1 Conclusions

To summarise, this FRA has found the following in respect of the proposed development:

- the proposed development is crucial to the ongoing work of AWE at AWE Burghfield and has been designed and planned balancing the requirements of all relevant planning policy, health and safety legislation, environmental best practice and nuclear-related legal requirements. Furthermore, the function of the proposed development and the existing site has meant that all design and planning for the proposed development has taken place under strict security controls.
- part of the application site is within Flood Zone 3 and is designated by the Environment Agency as having a 'high probability' of flooding in PPS25 (Ref. 1). The location of AWE at the historic ROF site at Burghfield pre-dates flood risk planning policy and the proposed development is required to continue the current operations on site into the future in line with modern safety standards. Given the size of the proposed development, the importance attached to its operation by the Government and the magnitude of the impact of developing it elsewhere, it is considered that there are no alternative sites upon which the development could be located. Furthermore, the proposed development will ultimately result in the repositioning of the existing maintenance and assembly/disassembly process within AWE Burghfield to a location at less risk of flooding. The development of a replacement facility allows for flooding to be considered appropriately from the outset, as detailed in this FRA.
- part of the proposed development is at risk from fluvial flooding from the Burghfield Brook. Part of the application site is within the 'design flood extent' designated as the 1 in 100 year flood extent (including an allowance for climate change), based on detailed 2D modelling of the site and surrounding area carried out by HR Wallingford. Flood depths on site are predicted to reach up to 0.5m with some isolated areas of the application site experiencing flood depths of up to 1.0m. The development is also at risk of surface water flooding due to its size and amount of impermeable surfaces.
- wherever possible, given the many other constraints and requirements placed on the development, the proposed buildings and construction activities have been set out on site to avoid the design flood extent as described in this FRA.
- the floor levels of the MPF and SB will be raised to a level of 45.7m AOD, set approximately 0.4m above a flood level derived for an extreme 1 in 10,000 event and over 1m higher than the design flood level detailed in this FRA. Furthermore, the design of the MPF and SB will be such that they will automatically be very resistant to flooding. The majority of the 160 staff to be employed within the application site will be located within these two buildings. As required by PPS25 (Ref. 1), suitable evacuation routes will be available from the MPF for the design flood event, on the northern and western sides of the building, linking with the principal thoroughfare and main entrance to and from AWE Burghfield. During both construction and operation of the proposed development, safe access and evacuation will be possible for all site staff along these routes should a flood event occur.
- 'Permitted development' works to clear the existing site have resulted in the removal of most buildings, embankments and bunds within the application site. This has increased significantly the amount of floodplain available in the application site with the improvement retained in the Proposed Condition.
- the proposed development will not have adverse flood risk impacts on other developments upstream of AWE Burghfield.

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- peak flood levels and flows downstream of the site are not predicted to increase;
- the seven and a half year construction process will be carefully managed to take into account the risks of flooding on site. Construction activities have been assessed with regard to their vulnerability to flooding and, where possible, have been located away from the floodplain. Examples of vulnerable activities that have been successfully located outside the area of flood risk from the Burghfield Brook include Staff Welfare Facilities, Equipment Parking and Vehicle Refuelling. Given the need to also locate substantial SuDS drainage solutions within the construction enclave, some construction activities such as secondary storage, laydown and prefabrication areas will still be located in the area at risk of flooding. It is not considered possible to construct the proposed development in this location without accepting a small, but manageable, risk to construction activities.
- similarly the location of materials which might provide pollution risks if a flood occurs will be located outside of the flooding areas.
- the proposed development and its construction processes will result in a decrease in surface water runoff rates from the application site. This is because of the design and construction of a number of SuDS schemes bringing about a reduction in downstream flows on the Burghfield Brook as well as other environmental benefits. The SuDS schemes have been set out in a planning submission document (Ref. 4) to ensure that full details are available for the DEEA, FRA and other studies. The SuDS schemes have been designed by a combined design team which has included supervision from the authors of national SuDS best practice guidance, HR Wallingford. Typical SuDS features of the proposed scheme include pervious paving and detention ponds.
- it is for the reasons summarised above that the proposed development complies with Government planning policy and flood risk PPS25. It is also considered that, subject to the recommendations below being implemented, the proposed development will be safe with respect to flood risk.

Further to the conclusions above, the following actions will be taken with respect to the proposed development and flood risk:

- during construction all site workers will be briefed on the flood risk to the site and appropriate flood response measures will be incorporated into site health and safety information. These measures will include removal of construction equipment from the south-eastern corner of the construction enclave following periods of intense rainfall and/or upon receipt of flood warning information (see below) notification of all construction staff that flood conditions are imminent.
- flood warnings are already provided to AWE Burghfield by the Met Office of the risk of extreme rainfall occurring and site procedures are in place to act on this information. The construction management will need to incorporate these site flood warning procedures into the site management process.

9. References

1. Planning Policy Statement 25: Development and Flood Risk (PPS25), 2006, Department for Communities and Local Government
2. Burghfield Flood Modelling – Initial Outline Report (Draft – unpublished), 2008, HR Wallingford.
3. West Berkshire Strategic Flood Risk Assessment, undated, West Berkshire Council.
4. SuDS Planning Application Design Submission, Mensa, Burghfield, 2008, Mayer Brown / Atkins / Mott MacDonald.
5. SuDS Principles Document, AWE Aldermaston and Burghfield, AWE, 2008.
6. Design Manual for Roads and Bridges, Volume II: Environmental Assessment, Section 3 Environmental Assessment Techniques, 2006.
7. AWE Drainage Studies, Burghfield TUFLOW modelling report, August 2008, HR Wallingford, EX5756

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Appendix A – Figures

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Appendix B – Modelling Summary

Note – modelling carried out by HR Wallingford as part of the wider Burghfield Flood Study (Ref. 2)

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B.1 Detailed Hydraulic Modelling

B.1.1 Modelling Requirements

In order to comply with the specific nuclear-related requirements of the design and operation of facilities at AWE Burghfield as described in Chapter 3, AWE commissioned a detailed flood modelling study of the Burghfield Brook and surrounding area. HR Wallingford have undertaken this work for AWE and the latest version (2008, Ref 2) of the flood modelling study report has been used to develop this FRA.

The principal aims of the AWE/HR Wallingford flood study were to:

- construct a hydraulic computer model capable of representing the complex flow paths across the AWE Burghfield site and the re-aligned channel of the Burghfield Brook; and
- use this model to define the extent of the 1 in 10,000 year flood event.

AWE requires the definition of the 1 in 10,000 year flood extent in order to appropriately design the proposed development in line with the nuclear-related requirements described in Chapter 3. In addition, the 1 in 100 year flood event has been assessed (including an allowance for climate change) to provide a 'design scenario' for the purposes of assessing the proposed development against the principles in PPS25 (Ref. 1) in this document.

B.1.2 Modelling Approach

A two-dimensional hydraulic model of the Burghfield Brook, the AWE site and surrounding area was constructed by HR Wallingford using the TUFLOW software, as follows (see Ref. 2 for full details):

- an initial 'coarse' model of an area of 40km², stretching from 5km south of AWE Burghfield to the crossing of the Foudry Brook by the M4 motorway, was constructed to define appropriate boundary conditions (river flows and levels) for the flood scenarios considered. This coarse model has a grid cell size of 20m x 20m;
- a 'detailed' model covering a smaller area of just 3km² was constructed from just upstream of AWE Burghfield to the crossing of the Burghfield Brook by the railway line to the north east of the site. This finer model has a grid cell size of 4m x 4m and is therefore more suitable for representing both the re-aligned Burghfield Brook and the many changes in elevation which can be observed across the AWE Burghfield site.
- the coarse model was constructed using topographic levels derived from Light Detection and Ranging (LiDAR) data at 2m resolution. The 'detailed' model used a LiDAR resolution of 0.25m
- pluvial inflows to the model for extreme event analysis (1 in 10,000 year) were generated from Flood Estimation Handbook (FEH) rainfall, with water allocated to each grid cell, based on the cell size, the rainfall intensity and the time step duration. Runoff percentages were estimated using various methods resulting in a range of values which were dependent on the magnitude and duration of event considered.
- for the design event, ReFH was used to generate a series of inflow hydrographs close to the southern boundary of the site and an analysis to determine the critical duration for peak levels was carried out. This was found to be 6 hours. The ReFH calculated percentage runoff was 33% and with the baseflow included this rose to an effective runoff of 38%.
- the Burghfield Brook around AWE Burghfield and downstream to the railway culvert was modelled in detailed using a 1d ESTRY model to maximise the accuracy of the flood flow predictions. For the more extreme events, due to stability issues, this approach was not taken and manual alteration of the 4m x 4m grid was used. However all culverts along the stream were explicitly modelled in 1d.
- 1-dimensional openings were also used in the coarse model for stream culverts, bridges and larger in-line embankments such as the railway line and motorway where appropriate.

A detailed breakdown of Manning's n values was used to adequately represent the range of frictional roughness on the floodplains modelled. Typical values ranged from 0.050 to 0.070 for cropped fields, 0.060 for the maintained grass on site and 0.025 for roads and other hardstanding areas.

In applying calculated inflows to the TUFLOW model, two approaches were adopted; fluvial and pluvial. Initially, flows from the coarse model were extracted to provide inflows to the detailed site model, with no consideration of rainfall falling on the site. This 'fluvial' approach allowed the definition of a fluvial flood extent through the site. The rainfall which would have fallen on the site and therefore contribute to the runoff, was added in as flow-time hydrographs at suitable points upstream and downstream. This has the advantage of providing an edge to the predicted flood extents, rather than modelling rain falling onto the land and the resulting overland flow directing it towards the watercourse. All figures and values in this report use the fluvial results.

In order to more accurately predict flood levels on the site and check the fluvial results, the TUFLOW model was also run with pluvial inputs (rainfall) applied across the site. This has the disadvantage of showing all areas as being wet, making the demarcation of flood extents difficult to see.

Modelling Approach	Description	Use in FRA modelling
Fluvial (river) flooding	• inflows provided by upstream catchment pluvial modelling only; • local runoff provided as convoluted hydrographs; • shows fluvial flood extents through the site.	Defines existing fluvial 1 in 100 year (plus climate change) outline for the purposes of assessing the proposed development against fluvial flood risk and evaluating the need for flood storage.
Pluvial (rain) flooding	• pluvial inflows provided for entire modelled area; • includes rainfall on site itself; • shows widespread flooding on site, due to localised shallow water ponding and overland flow; • flood extents take no account of existing surface water systems or infiltration.	Not used in FRA modelling but considered separately for 1 in 10,000 year flood event.

Table B.9.1, repeated from the main report, explains how model results from these two modelling approaches were used in this FRA.

Modelling Approach	Description	Use in FRA modelling
Fluvial (river) flooding	• inflows provided by upstream catchment pluvial modelling only; • local runoff provided as convoluted hydrographs; • shows fluvial flood extents through the site.	Defines existing fluvial 1 in 100 year (plus climate change) outline for the purposes of assessing the proposed development against fluvial flood risk and evaluating the need for flood storage.

Modelling Approach	Description	Use in FRA modelling
Pluvial (rain) flooding	• pluvial inflows provided for entire modelled area; • includes rainfall on site itself; • shows widespread flooding on site, due to localised shallow water ponding and overland flow; • flood extents take no account of existing surface water systems or infiltration.	Not used in FRA modelling but considered separately for 1 in 10,000 year flood event.

Table B.9.1 – Modelled scenarios for use in this Flood Risk Assessment (Table 5.1 in main report)

Numerous scenarios were simulated as part of the AWE wider flood study. For the purposes of this FRA, however, three scenarios have been reported on, as summarised in Table B.9.2 below

Scenario	Description
Initial Condition Pre-development	existing buildings and blast embankments represented using LiDAR data.
Commencement Condition Pre-development	Demolition of existing buildings and blast embankments represented by lowering ground levels using LiDAR data.
Proposed Condition Post-development	Proposed development incorporated in the flood model as follows: • Demolition of existing buildings and blast embankments represented by lowering ground levels using LiDAR data. • Impact of MPF, SB and PB included by preventing flow in these areas • Local land raising to the west of the MPF incorporated. • Minor changes in elevation incorporated in flood model where required around MPF to facilitate vehicle entry etc. • 10,000 year bund.

Table B.9.2 – Modelled scenarios for use in this Flood Risk Assessment

B.1.3 Consultation with the Environment Agency

On 24th April 2008, HR Wallingford and AWE presented the results of the flood modelling study to the Environment Agency, at Red Kite House, Howberry Park, Wallingford. HR Wallingford stated that further detail or demonstration could be provided to the Environment Agency if required at HR Wallingford's own Howberry Park offices.

The final flood model was sent to the Environment Agency with accompanying documentation on 28th September 2008. This model has been reviewed and audited by the Environment Agency and their consultants the Halcrow Group.

B.1.4 Model Results

The following table lists the modelled peak flood levels for the 1 in 100 year (plus climate change) event using the fluvial modelling approach detailed above. The model locations presented in the table are based on model results provided by HR Wallingford for over 40 locations through AWE Burghfield. A location plan of these points is provided. The locations have been selected to provide a feel for the changes in flood levels in and around the development. By convention, flood levels are presented to two decimal places, reflecting the accuracy of the modelling techniques used.

Location **(HR Wallingford reference in brackets)**	**Proposed Condition** **Flood Level (m AOD)**	**Pre-Development**	
		Initial Condition **Flood Level (m AOD)**	**Commencement Condition** **Flood level (m AOD)**
Main Process Facility (A15)*	44.330	44.388	44.320
Southern boundary of application site (5)	44.923	44.923	44.923
Eastern boundary of application site (2)	43.738	43.737	43.738
South-eastern corner of application site (A13)	44.010	44.017	44.007
North-eastern corner of application site (A21)	43.625	43.625	43.625
Upstream of AWE Burghfield (15)	48.312	48.312	48.312
Downstream of AWE Burghfield (18)	41.550	41.550	41.550

Table B.9.3 – Model results 1 in 100 year CC event

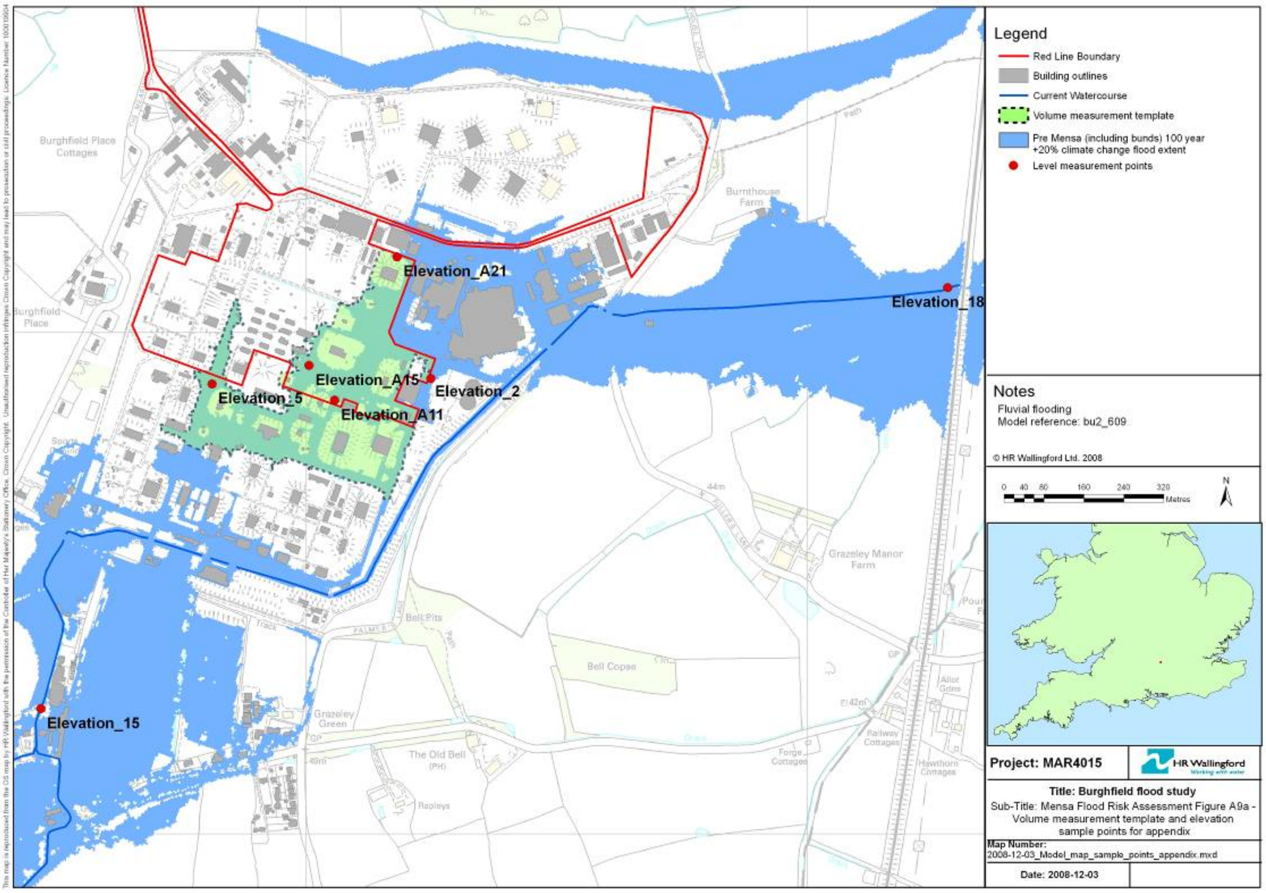

Figure B.1 - Location plan for flood level values

Appendix C – Summary of SuDS Design

Note – SuDS Design detailed in separate planning submission document (Ref. 4)

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C.1 Overview

This Appendix provides a summary description of the design and features of each of the SuDS schemes detailed in the SuDS Design Submission (Ref. 4). Figures A7 – A12 in Appendix A include detailed maps of the proposed SuDS catchments where available.

C.2 Pingewood Gate

The surface water drainage design for the Pingewood Gate area has been split into two catchments either side of Trident Way and consists of the HGV Marshalling Area to the north and the proposed Car Park to the south.

The HGV Marshalling area will be impermeable bituminous paving, with surface water collected from this area using linear drains (or similar) discharging into a filter drain or dry swale. This will connect to a storage pond, itself equipped with a flow control device to throttle the outflow to the Greenfield runoff rate. The outflow from the system will connect to Outfall 7, which will discharge to the drainage ditch to the north of AWE Burghfield. At present, it is intended that pollution control shut-off valves will be incorporated into the design.

The Car Park will be covered with pervious paving, underlain by a layer of open textured granular material which will provide some storage of surface water during storm events. This water will be discharged to a filter drain or dry swale along the edges of the Car Park fitted with a flow control device to throttle the discharge from the Car Park to a rate 20% lower than the existing runoff rate. An oil separating device will be incorporated into the design.

C.3 Proposed Development Construction Area

C.3.1 Construction Area Drainage Principles

The SuDS scheme proposed for the construction site and enclave is very complex and reference should be made to the SuDS design submission and associated appendices for specific information. The site has been split into three discrete catchments due to site constraints such as available discharge points, ground levels, site features such as roads, the predicted design fluvial flood extent referred to in this document and the precise construction land use requirements. A total of seven sub-catchments have been delineated within the proposed three catchments.

The drainage design for these sub-catchments is briefly summarised below but has been based on the following principles:

- off-site discharge has been limited to the Greenfield runoff rate (QBAR) of 4.6 l/s/ha. No long term storage is currently proposed but will be investigated as the design progresses following planning submission.
- treatment and storage will be provided at the downstream ends of the catchments, by ponds where possible. As the number and location of pond sites and the available space is restricted, where they are acceptable the areas and depths of ponds have been maximised in the design.
- pervious paving will provide additional storage in sub-catchments where the total required storage cannot be provided by ponds, but in areas designated for only light and infrequent use by construction transport, and restricted to avoid superfluous construction costs associated with pervious paving.
- the possibility of ‘blinding’ (blockage) of pervious paving due to construction activities will be considered by incorporating linear drains which will collect runoff in the event of blinding.
- in order to meet the required design levels of service whilst minimising construction costs of SuDS, managed surface water flooding up to a maximum depth of 150mm is proposed to make up the balance of storage requirements up to the 1 in 100 year rainfall event. Where surface water flooding is utilised, shallow bunds or kerbs will be used to manage (or contain) flooding where necessary.

- runoff will be collected from large open paved areas (such as storage and laydown) via linear drains and from roads by roadside filter drains or swales for onward conveyance to the pond system via a piped network where necessary. These drainage systems will employ catch basins and silt traps to remove suspended solids, while a vortex separator may be used immediately upstream of the outfalls to ponds, to remove finer particles.
- outflows from ponds will connect to the existing site drainage system and will be controlled by means of orifices or vortex flow controls. Overflow weirs may be used to allow discharge in excess of design events considered. Oil separators and shut-off valves will be used downstream of ponds if required.

C.3.2 Construction Catchment 1

This catchment will include the proposed construction welfare buildings (1a), which due to site constraints will drain off-site to the west to existing drainage systems. It is envisaged that attenuation of the flows from this small area will be incorporated into drainage improvements carried out outside the application site as part of a future scheme at AWE, hence the area of catchment 1a (approximately 0.6 ha) has been excluded from the assessment of runoff rates.

The other sub-catchment (1b) in catchment 1 will contain the restricted access spoil storage and lay down areas (light use), plus equipment parking, re-fuelling, storage areas and site distribution roads (all heavy use). The sub-catchment will drain to pervious paving in the light-use areas designed to provide storage of a 1 in 10 year rainfall event. Managed surface water flooding will be utilised to store run-off in excess of this to a maximum depth of 150mm for a 1 in 100 year rainfall event. Attenuated flows will discharge directly to the existing open channel culvert running south-north along the edge of the sub-catchment.

C.3.3 Construction Catchment 2

This catchment will include the whole of the secure zone of the permanent works and is split into two sub-catchments. Sub-catchment 2 will contain a likely area of future laydown and fabrication, storage/laydown areas (both light use) plus heavy use site roads, prefabrication, storage and laydown areas and a proposed SuDS pond (pond 2a) that will form part of the permanent works SuDS design (see section 6.8.4).

Sub-catchment 2a will drain to pond 2a, which will coincide with the proposed permanent works pond and will discharge to the existing open culvert running west to east to the north of the application site. Pond 2a will be designed to provide attenuation storage up to a 1 in 30 year rainfall event, with pervious paving storing run-off in excess of this for up to a 1 in 100 year rainfall event with no surface flooding.

Sub-catchment 2b contains the MPF, SB and PB, plus various site roads and several other construction site uses (both light and heavy). This sub-catchment will drain to pond 2b, which will also coincide with the proposed permanent works pond, and will discharge into the existing open culvert running west to east inside the eastern site boundary. Pond 2b will provide attenuation storage of a 1 in 100 year rainfall event with no surface flooding. Thus no additional storage is proposed.

C.3.4 Construction Catchment 3

According to the SuDS Design Submission (Ref. 4) catchment 3 from earlier design iterations has been absorbed into Catchment 2, thus the third and final construction area catchment in the Design Submission is labelled Catchment 4.

C.3.5 Construction Catchment 4

Catchment 4 is broadly defined by the extent of the 1 in 100 year floodplain. Note this floodplain extent is different to that referred to in this FRA as the ‘design flood extent’ (for fluvial flooding) as it does not account for climate change because of the temporary nature of the construction works. Consideration of the fluvial floodplain is required in order to separate those drainage systems outside the 1 in 100 year floodplain from those within to ensure flows from outside the floodplain are still suitably attenuated during a flood of this magnitude from the Burghfield Brook. Catchment

4 will comprise areas of hardstanding, prefabrication, storage and laydown, some site roads and some areas not designated a construction use. The catchment has been split up into 3 sub-catchments for the SuDS design.

Sub-catchment 4a is a narrow strip of land in the north of the application site, with no designated use, which will drain via a swale which will provide attenuation storage up to a 1 in 100 year rainfall event. This will drain to the existing open culvert running west to east inside the eastern boundary of the site.

Sub-catchment 4b drains to pond 4b which will also drain to the existing open culvert running west to east inside the eastern boundary of the site. Pond 4b will be designed to provide attenuation storage for a 1 in 30 year rainfall event, with managed surface water flooding utilised to store up to a 1 in 100 year rainfall event with a maximum depth of 150mm.

Sub-catchment 4c will not be able to accommodate a pond, but will drain to pervious paving located in the light-use areas and designed to provide storage up to a 1 in 10 year rainfall event. Managed surface flooding with a maximum depth of 150mm will be used to store excess flows up to a 1 in 100 year rainfall event. The sub-catchment will discharge via the existing culvert flowing south to north outside the eastern boundary of the catchment.

C.4 Proposed Development Permanent Works

The Permanent Works SuDS scheme will serve the final built solution and include the entire area within the proposed NSPA and an additional area to the north where the PB will be located.

For the purposes of a SuDS design, the site has been separated into three different areas. A SuDS pond to the north (North Pond) will collect water from the roads outside of the NSPA security fence and from the Energy Centre. A SuDS pond to the east (East Pond) will collect water from the roads in the northern part of the site, runoff from the SB and part of the runoff from the MPF. Swales are not able to be used adjacent to all roads due to space restrictions. An additional drainage run will be located from the western side of the MPF, along its southern boundary and into the East Pond. This will transfer runoff to the pond from swales running between the catenary towers along the length of the roads within the NSPA. Both SuDS ponds outflow to the adjacent existing culverts flowing west to east. Petrol interceptors may be used if required.

The Lorry Park Area will be within the 1 in 100 year floodplain from the Burghfield Brook, so will have a separate drainage system consisting of under-drained swales flowing through a petrol interceptor and directly into the existing culvert to the east of the site.

The SuDS scheme will also comprise filter strips and bio-retention areas.

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Appendix D – AWE Burghfield Flood Plans

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