BUNCEFIELD MAJOR INCIDENT INVESTIGATION

Initial Report to the Health and Safety Commission and the Environment Agency of the investigation into the explosions and fires at the Buncefield oil storage and transfer depot, Hemel Hempstead, on 11 December 2005

Buncefield Major Incident Investigation Board

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Executive summary

The terms of reference of the Investigation directed by the Health and Safety Commission into the explosions and fires at the Buncefield oil storage and transfer depot, Hemel Hempstead, on 11 December 2005 require an initial report to be produced for the Health and Safety Commission and the Environment Agency when the main facts of the incident have been established.

The independent Board set up to supervise the Investigation has previously published three Progress Reports submitted to the Board by the Investigation Manager. The Initial Report presents the Board's view that enough of the facts have been established, as described in the Progress Reports, to set out with reasonable confidence the sequence of events leading to the incident on 11 December. This also allows the Board to identify several issues of concern for the effective regulation of fuel storage sites such as Buncefield.

Summary of the incident and subsequent investigation

The Initial Report summarises and updates material from the Progress Reports on the nature of operations at Buncefield, the timeline of key events, the emergency response and the progress of the Investigation. Evidence shows that the main explosion probably resulted from the ignition of a vapour cloud emanating from Tank 912 in Bund A in the Hertfordshire Oil Storage Limited West site, most likely resulting from an overfill of unleaded petrol. The probable mechanism for the creation of the vapour cloud is described, though uncertainty remains about why the explosion was so violent.

Main findings since the publication of the Third Progress Report relate to the functioning of the systems used to shut down fuel delivery when a tank is full; the likely composition of the fuel released from Tank 912; and the ongoing monitoring of the environmental impact of the incident, particularly in relation to groundwater contamination. In this last regard, the incident has now been declared a Major Accident to the Environment (MATTE). The Investigation continues.

Issues of concern arising from the Investigation to date

Though knowledge of the Buncefield incident is still incomplete, enough is known for the Board to draw broad conclusions about the need for action in three areas:

- Design and operation of storage sites.
- Emergency response to incidents.
- Advice to planning authorities.

Design and operation of storage sites

The Buncefield incident involved failures of the means provided to contain fuel and water used in fire-fighting (known as 'fire-water') at three levels: primary, secondary and tertiary. The paramount need is to ensure the integrity of the primary means of containment, ie to make sure that fuel does not escape from the vessels in which it is normally contained. Further precautions need to be considered to prevent this happening and, should it still occur, to inhibit the formation of a flammable vapour.

This does not however lessen the need for effective secondary and tertiary containment (bunds and drains, mainly) that prevent pollutants from escaping the site and contaminating the environment should primary containment be lost.

Emergency response to incidents

Overall, the response to the incident was very impressive. The incident has highlighted the need to have effective emergency arrangements, both on and off site, in the event of a major incident of this kind. Lessons from Buncefield provide a very important opportunity to bring about improvements in emergency preparedness of resilience groups throughout Britain, and further afield. There are a number of reviews into the effectiveness of the emergency response to Buncefield being carried out by the agencies concerned, and the Board intends to return to this important area in the future.

Advice to planning authorities

The Buncefield incident poses fundamental questions about residential and commercial developments around sites like Buncefield. Continuing uncertainty in this area creates serious problems for local communities, particularly those directly affected by the Buncefield incident. This is a complex issue requiring a balance to be made between the risks and benefits of development. The Board intends to address these issues in detail once the preliminary conclusions of HSE's current review of its advice to planning authorities are known.

A measured approach is justified since the likelihood of a similar explosion remains low, and should be made lower still by a programme of actions designed to increase the reliability of primary containment. In our view, the importance of reaching conclusions that are considered, costed and sustainable greatly outweighs any benefit that might be derived from coming to summary judgements.

Introduction

1 This report is the 'initial report' required by the terms of reference of the Investigation into the explosions and fires at the Buncefield oil storage and transfer depot, Hemel Hempstead, Hertfordshire on 11 December 2005.[1] The Investigation was directed by the Health and Safety Commission (HSC) using its powers under section 14(2)(a) of the Health and Safety at Work etc Act 1974.

2 The Investigation is being carried out jointly by the Health and Safety Executive (HSE) and the Environment Agency. HSC appointed an independent Investigation Board, chaired by Lord Newton of Braintree, to supervise this investigation.[2] This report has been prepared by the Investigation Board, based on information arising from the continuing HSE/Environment Agency Investigation. Throughout the Investigation, the Board has been supplied with Progress Reports from the Investigation Manager, Taf Powell, which the Board has published.[3]

3 This report does not repeat all the material contained in the Progress Reports, which should be read for a fuller understanding of the Investigation up to May 2006. Part 1 summarises, and updates where necessary, key points of the Investigation for completeness and to aid in understanding the Investigation Board's initial conclusions set out in Part 2. The Board has included significant new findings from the Investigation that have emerged since the publication of the Third Progress Report on 9 May. Other new material is contained in the annexes to this report.

4 The Investigation terms of reference require an initial report to be submitted to HSC and the Environment Agency as soon as the main facts of the incident have been established. The Investigation is still continuing. Nevertheless, the Investigation Board considers that, with publication of the Third Progress Report in May, enough facts have been established to set out with reasonable confidence the sequence of events leading to the incident on 11 December. In particular, enough is known for the Board to be able to identify several issues of concern for the effective regulation of fuel storage sites such as Buncefield. As well as the main facts of the incident, the Board has included in Part 2 of this report its emerging thoughts about future action to address these issues of concern.

5 The Investigation Board plans to give further consideration to these issues.

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1 The full terms of reference are reproduced in Annex 1. Term of reference 6 requires an initial report.

2 The Members of the Investigation Board are listed in Annex 2.

3 Details of the three published Progress Reports are contained in Further information.

Part 1 - Summary of the incident and subsequent investigation

6 This section summarises information contained in the three Progress Reports to the Board published between February and May 2006. Full details can be found in the reports, which are available on the Investigation website.[4] Where necessary, this information has been updated in this report and supplemented by new findings from the Investigation. Other new information is contained in the annexes, referenced as appropriate in the text below.

Overview of Buncefield operations

7 The Buncefield oil storage and transfer depot is a large tank farm occupied by three companies. These are: Hertfordshire Oil Storage Limited, a joint venture between Total UK Limited and Chevron Limited; United Kingdom Oil Pipelines Limited and West London Pipeline and Storage Limited, whose site is operated by British Pipeline Agency Limited; and British Petroleum Oil UK Limited.[5] Each site is classified as a 'top-tier' site under the Control of Major Accident Hazards (COMAH) Regulations 1999.[6]

8 Figure 1 shows the layout of the Buncefield depot and its surroundings. The Buncefield depot forms part of a national petroleum refinery, pipeline and storage system, described in Annex 4. Fuel products were supplied to Buncefield by three pipeline systems:

- 10" pipeline (FinaLine) from Lindsey Oil Refinery on Humberside, terminating in the Hertfordshire Oil Storage Limited West site;
- 10" pipeline from Merseyside to Buncefield (M/B pipeline), terminating in the British Pipeline Agency Limited-operated Cherry Tree Farm site;
- 14" pipeline from Thames (Coryton) to Kingsbury, Warwickshire, with a spur line to Buncefield (T/K pipeline), terminating in the British Pipeline Agency Limited-operated main site.

9 The three pipelines all transported fuel products in discrete batches, separated by an interface or buffer of mixed product. At the terminal, the operators monitored the arrival of the various grades of fuel and separated them out into dedicated tanks by fuel type. The interface of mixed fuel was diverted to special small tanks to be reinjected into the main large storage tanks, if the fuel specification allowed, or transported back to the refinery as 'slops' for re-refining.

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4 Details of the three published Progress Reports are contained in Further information. These reports have not been revised to take account of more recent findings.

5 Texaco Limited became Chevron Limited on 3 July 2006.

6 The regulatory framework for high hazard sites, including the main requirements of COMAH, is summarised in Annex 8.

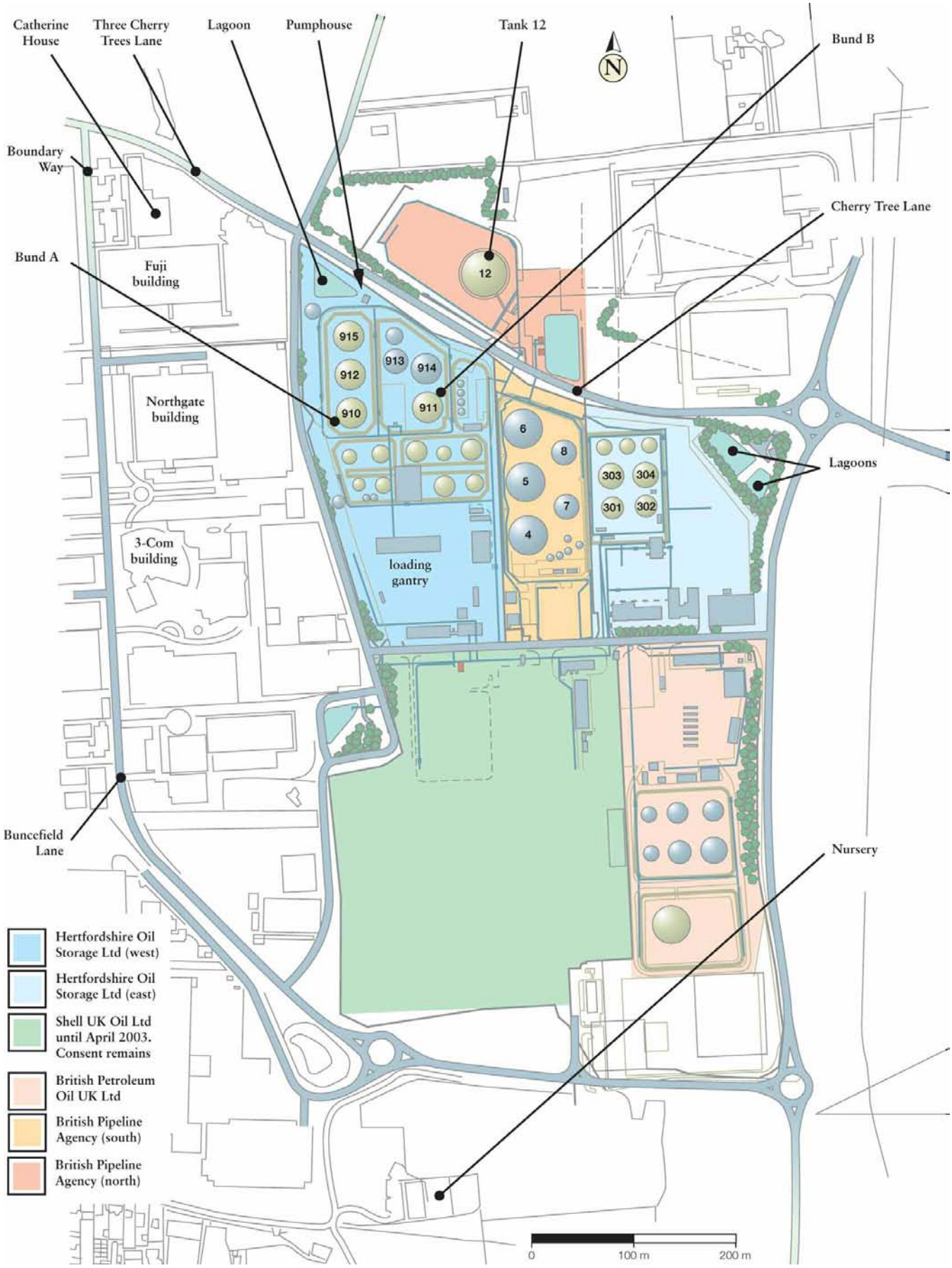

Figure 1 Pre-incident layout of Buncefield depot and immediate surroundings

10 The separated products left the depot either by road tanker or, in the case of the majority of aviation fuel, via two dedicated pipelines from the British Pipeline Agency Limited main site into the West London Pipeline system, which supplies Heathrow and Gatwick Airports. Tankers operating from Buncefield were of 44 or 18 tonnes capacity and were increasingly operated by specialised transport operators.

Timeline of key events

10 December 2005

- Around **19.00**, Tank 912 in Bund A at the Hertfordshire Oil Storage Limited West site started receiving unleaded motor fuel from the T/K pipeline, pumping at about 550 m^3/hour (flow rates are variable within limits).

11 December 2005

- At approximately **midnight** (**00.00**) the terminal was closed to tankers and a stock check of products was carried out. When this was completed at around **01.30**, no abnormalities were reported. From approximately **03.00**, the level gauge for Tank 912 recorded an unchanged reading. However, filling of Tank 912 continued at a rate of around 550 m^3/hour.

- Calculations show that at around **05.20** Tank 912 would have been completely full and starting to overflow. Evidence suggests that the protection system which should have shut off the supply of petrol to the tank to prevent overfilling did not operate. From this time onwards, continued pumping caused fuel to cascade down the side of the tank and through the air, leading to the rapid formation of a rich fuel/air mixture that collected in Bund A.

- At **05.38** vapour from the escaping fuel is first visible in CCTV footage from a camera looking down the western edge of Bund A, flowing out of the north-west corner of Bund A towards the west.[7]

- At **05.46** the vapour cloud had thickened to a depth of about 2 m and was flowing out of Bund A in all directions.

- By **05.50** the vapour cloud had started flowing off site near the junction of Cherry Tree Lane and Buncefield Lane, following the ground topography. It spread west into Northgate House and Fuji car parks and towards Catherine House.

- Between **05.50** and **06.00** the pumping rate down the T/K pipeline to Hertfordshire Oil Storage Limited West, and onwards to Tank 912, gradually rose to around 890 m^3/hour.

- By **06.01** the vapour cloud extended to the west almost as far as Boundary Way in the gaps between the 3-Com, Northgate and Fuji buildings; to the north-west it extended as far as the nearest corner of Catherine House. It probably extended to the north of the Hertfordshire Oil Storage Limited site as far as Tank 12, operated by British Pipelines Agency Limited, and probably extended south across part of the Hertfordshire Oil Storage Limited site, but not as far as the tanker filling gantry. To the east it reached the British Pipeline Agency Limited site.

- At 06.01 the first explosion occurred, followed by further explosions and a large fire that engulfed over 20 large storage tanks. The main explosion event appears to have been centred on the car parks between the Hertfordshire Oil Storage Limited West site and the Fuji and Northgate buildings.

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7 Timings deduced from CCTV footage have been corrected for any inaccurate setting of the CCTV timers.

- At **06.08** an emergency services major incident was declared and operational command and control was set up near the incident site within minutes.

- At **09.00** Strategic Co-ordinating Group ('Gold' command') convened for the first time.

- An extensive plume of smoke from the burning fuel dispersed over southern England and beyond.[8] The plume could be seen from many kilometres away, and was also clearly identified in satellite images.

12 December 2005

- **Noon.** Peak of the fire. 25 Hertfordshire pumps were on site with 20 support vehicles and 180 fire-fighters.

- There was some loss of secondary containment, as the bunds were unable to fully contain the escaped fuel and water used in fire-fighting (known as 'fire-water'), which 'overtopped' (ie spilled over the top of) the bund walls.

14 December 2005

- HSE assumed control of the Investigation from Hertfordshire Constabulary.

- Damage to bunds caused by the intense heat of the fire caused significant loss of secondary containment on the Hertfordshire Oil Storage Limited West and British Pipeline Agency Limited sites. There was also extensive loss of tertiary containment at the site boundaries and large amounts of contaminated liquids escaped off site. The fire service recovered as much of the contaminated run off as possible, but was unable to prevent contamination of groundwater and surface water.

15 December 2005

- 'Fire all out' declared by the Fire Service.

- 786 000 litres of foam concentrate and 68 million litres of water (53 million 'clean' and 15 million recycled) were used overall to contain the incident during the period of fire-fighting operations.

- Strategic Co-ordinating Group ('Gold' command) convened for the last time.

16 December 2005

- The on-site investigation started (the preliminary planning and information gathering had commenced earlier). HSE issued notices to secure the site, to ensure both that evidence was left undisturbed and that clean up operations were conducted safely. Key parts of the site remained too dangerous for investigators to access for weeks or months.

18 December 2005

- Hertfordshire Oil Storage Limited started surveying roads and buildings on the site.

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[8] Monitoring by the Meteorological Office showed that the visible plume was mainly black carbon (soot). Full details of the plume and related air quality monitoring arrangements are given in the Department for the Environment, Food and Rural Affairs' *Initial review of the air quality aspects of the Buncefield oil depot explosion*, available at www.defra.gov.uk/environment/airquality/buncefield/index.htm.

20 December 2005

- HSC formally directed HSE and the Environment Agency to investigate the incident and to make a special report. HSE appointed Taf Powell, Director of HSE's Offshore Division, to be the Investigation Manager. HSC also announced the appointment of an independent Board to supervise the Investigation.

- The control room on the Hertfordshire Oil Storage Limited West site was sufficiently structurally sound to allow entry for gathering records and other evidence.

23 December 2005

- The Investigation team, with assistance from Hertfordshire Constabulary and Hertfordshire Fire and Rescue Service, recovered computers from damaged offices and placed them in safe storage.

5 January 2006

- Hertfordshire Fire and Rescue Service handed control of the site over to the Investigation team. Hertfordshire Constabulary and Hertfordshire Fire and Rescue Service continued to give invaluable support to the Investigation team that was working to gather and secure evidence.

12 January 2006

- HSC appointed Lord Newton of Braintree to chair the independent Board.

February 2006

- All fire-water had been removed from site and stored, pending safe disposal. The area around the loading gantry had been made safe for access and tankers, which were present at the time of the incident, were removed.

- Investigating personnel gained access to Bund A for the first time.

- Internal roadways were cleared and limited work started on removing debris from Bund A. Sampling of fuel in pipework was carried out prior to safe disposal. As fuel residues still remained in interconnecting pipework and damaged tanks, monitoring for flammable vapour was routinely carried out.

Emergency response to the Buncefield incident

11 The co-ordination and management framework at any incident identifies three levels of interlinked leadership and co-ordination.[9] They are:

- **Strategic** - Gold
- **Tactical** - Silver
- **Operational** - Bronze

12 The emergency services (primarily the Fire and Rescue Service and the police) led the initial response to the incident and its immediate aftermath. Representation of all agencies deployed to resolve the Buncefield incident was established through a meeting process known as the Strategic Co-ordinating Group, also known as Gold command. This included the Environment Agency as a Category 1 responder under the Civil Contingencies Act 2004.[10] The Strategic Co-ordinating Group made decisions to ensure that the implementation of strategic aims was delivered by the tactical (Silver) and operational (Bronze) commands.

13 The Strategic Co-ordinating Group had its first multi-agency meeting at 09.00 on 11 December at Hertfordshire Police Headquarters, chaired by the Police Strategic Co-ordinating Group Commander. A decision was made at this meeting to evacuate those with damaged homes and workplaces, and to tell everyone in the immediate vicinity to shelter – 'go in, stay in, tune in'.

14 The Strategic Co-ordinating Group remained in place until 18:30 on Thursday 15 December.

Disposal of fire-water

15 The contaminated fire-water was removed from the site during the first three weeks following the fire, although an unknown quantity contaminated the surface waters and groundwater. Following the event, further contaminated water resulting from rainfall or cleaning operations was removed from the site by tanker and stored along with the fire-water in a number of locations around the country.

16 The fire-water remains in temporary storage, and it is important for this matter to be resolved. The Board understands that the decontamination of fire-water on such an unprecedented scale may require the use of several processes to render the water suitable for its return to the environment. The oil companies are developing options to achieve this, which will be assessed by the Environment Agency to ensure that they have the minimum impact possible on the environment.

17 On 21 June 2006, the Environment Agency was informed that some 800 000 litres of this contaminated water had been released inadvertently from storage into a sewage treatment plant and thereafter into the River Colne, a tributary of the River Thames. The Environment Agency launched an investigation with the assistance of Thames Water Utilities Limited, who operate the storage facility and associated sewage treatment works. This investigation has yet to be concluded.

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9 *UK Resilience. Management and co-ordination of local operations*, available at www.ukresilience.info/ccact/errpdfs/err_chap_04.pdf.

10 Other Category 1 responders included the Health Protection Agency (HPA) and the Strategic Health Authority. The Environment Agency's role was to minimise the risks of environmental damage. HSE is a Category 2 responder, so during the early phase of the incident stood ready to provide advice and expertise on request.

The Investigation

18 Progress Reports 1-3 detail four key aspects of the Investigation, briefly summarised below:

- Loss of fuel containment.
- Formation of the vapour cloud.
- The explosions.
- Environmental monitoring.

Loss of fuel containment

19 The first Progress Report indicated that the explosion probably resulted from ignition of a vapour cloud emanating from the vicinity of Bund A in the Hertfordshire Oil Storage Limited West site. The Investigation Manager was sufficiently confident in the investigation findings to state in the Third Progress Report that the initial loss of containment which created the vapour cloud occurred from Tank 912 in Bund A, most likely resulting from an overfill of unleaded petrol.

20 To understand how the fuel escaped, the Investigation examined how Tank 912 and its instrumentation and control systems functioned at the time. This examination suggested further lines of inquiry, involving aspects of the automatic tank gauging system, and the high-level alarm system. Investigators wanted to ascertain how the gauging system performed and why automatic shutdown of delivery did not take place as intended when the tank's 'ultimate high level' (ie the specified maximum capacity) was reached.

21 The Third Progress Report detailed findings about instrumentation and control systems on Tank 912. These include the product monitoring systems both for level and temperature, and the 'ultimate high-level switch', which was part of the system to prevent overfilling of the tank. As the Third Progress Report explained, from about three hours before the incident, the level gauge remained static, although the tank continued to fill.

22 The ultimate high-level switch should, if triggered, cause an alarm to sound and shut down the supply of fuel to the tank. Since publication of the Third Progress Report, most of the ultimate high-level switch from Tank 912 has been recovered, along with other parts of the instrumentation systems on this and other tanks, for examination.

23 Further investigation into the design of the ultimate high-level switch indicated that the position of a test lever or plate fitted to the switch is critical to ensure continued effective operation. While the relevance of this feature to the Buncefield incident has still to be determined, one of the issues that has arisen from these enquiries relates to the reliance on this type of switch at many similar installations throughout the UK and worldwide.

24 The Competent Authority has taken action to bring this issue to the urgent attention of operators of similar sites in the UK through a Safety Alert.[11] The Alert applies to a particular kind of switch used in ultimate high-level alarm systems. Improvement Notices have also been issued, requiring the suppliers to contact users or installers of these switches to alert them to this issue and provide revised instructions and labelling on the safe use, setting, cleaning and maintenance of the switches. The Board notes the continuing co-operation of the suppliers in that process.

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11 Sites like Buncefield are regulated by a 'Competent Authority', as detailed in Annex 8. The full text of the Safety Alert can be found on HSE's website at www.hse.gov.uk/comah/alerts/sa0106.htm.

Formation of the vapour cloud

25 The Third Progress Report described extensive tests undertaken to model the behaviour of fuel escaping from Tank 912 during overfilling. Tank 912 was fitted with a deflector plate, installed to direct water from sprinklers on the tank's top to its sides to provide cooling in the event of fire. The tests demonstrated that the deflector plate channelled some of the escaped fuel onto the tank wall, but the rest ran over the top of the plate, fragmenting into droplets that cascaded through the air. Most of the fuel running down the wall hit a wind girder (a structural stiffening ring) and detached from the tank wall, creating a second cascade of droplets.

26 These conditions would promote the evaporation of the lighter components of petrol, eg butanes, pentanes and hexanes. The free-fall of droplets leads to entrainment of air and mixing between the air and fuel vapour, and the formation of a rich fuel/air mixture. Cooling of the surrounding air, already saturated with water vapour by the evaporation, would cause some of the water content to precipitate as an ice mist, which is consistent with the cloud of mist visible on

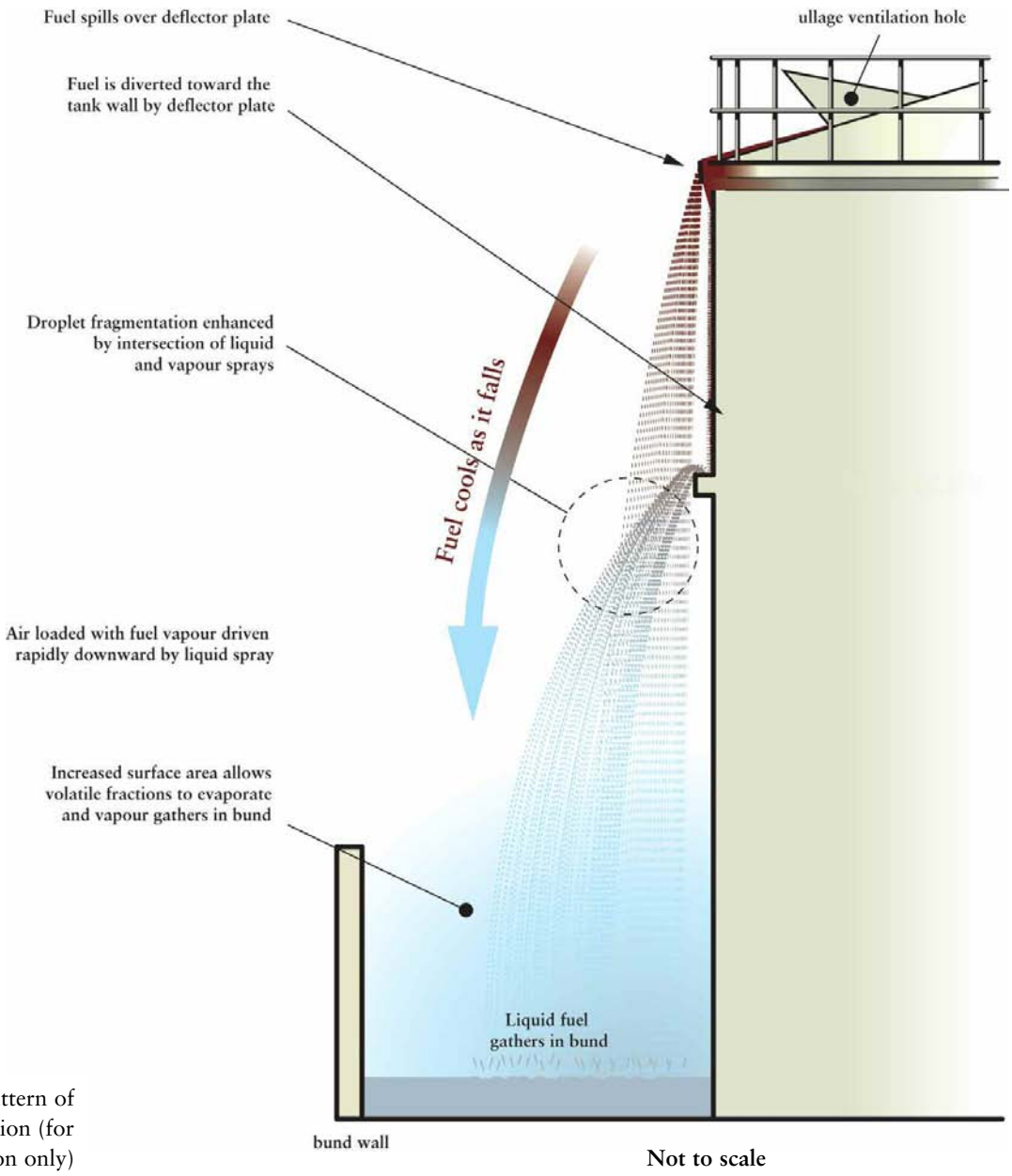

Figure 2 The pattern of fuel dispersion (for illustration only)

CCTV. The fuel/air mixture and its accompanying ice mist were heavier than air and so were initially contained within the bund. As the volume of the mixture grew from the continuing overfilling of the tank, it flowed out of the bund, dispersing and flowing off site. Further mixing with the air would have reduced the vapour concentration to the point where significant volumes of the mixture could support an explosion.[12]

27 Since publication of the Third Progress Report, further work to simulate the overflow of liquid from the full height of Tank 912 has confirmed the pattern of fuel dispersal and vaporisation shown in Figure 2.

The explosions

28 The Third Progress Report described a number of potential ignition sources of the main explosion that occurred at 06.01 on 11 December. The prime candidate appears to be an explosion within the emergency generator cabin on the south side of the Northgate building; this is consistent with the site of the main explosion event. However, further study of the CCTV evidence shows a sudden illumination of the east face of the Fuji building, consistent with an explosion or a flash fire at the location of the pumphouse to the east of the lagoon on the Hertfordshire Oil Storage Limited West site. This illumination was recorded by a camera before it was destroyed by the overpressure, suggesting that this explosion or flash fire occurred before the main explosion at 06.01. The pumphouse is the subject of continuing forensic investigation.

29 Much uncertainty remains about why the explosion was so violent, generating overpressures of a magnitude much greater than current understanding of vapour cloud explosions would predict. For example, a method in current use would predict overpressures of 20-50 millibar (mbar) in the open areas of the Northgate and Fuji car parks. The current best estimates of the overpressures that actually occurred in these areas are of 700-1000 mbar, leading to extensive damage to adjacent buildings. Annex 6 describes the mechanics of fire and explosion hazards from fuels such as petrol, as currently understood.

30 Continuing work relevant to gaining a better understanding of the explosion has included extensive sampling to identify the composition of the released fuels, as well as to verify the product distribution throughout the depot. It shows that the released fuel probably had a butane content of 10% and consequently would have had a high vapour pressure, ie it would be capable of evaporating rapidly to produce a flammable vapour. The total butane content is specified in the standard, and depends on whether the product is winter or summer grade. For winter grade petrol the vapour pressure limits are defined as 70-100 kiloPascals (kPa) and for summer they are reduced to 45-70 kPa. See Annex 7 for further information about standards and fuel composition.

31 Further research is needed to try to discover the actual mechanism for generating the unexpectedly high overpressures seen at Buncefield. The Board refers to this again in paragraph 76, and in relation to terms of reference 1 and 5 in Annex 1.

32 The number and severity of injuries at Buncefield was low compared to some other major incidents involving explosions, and there were no fatalities. Annex 6 provides more information about explosion overpressures, and includes tables which show the levels of damage or injury that would normally be expected to result from different overpressures.

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12 The explosive properties of petrol, including the significance of vapour concentrations, are explained in Annex 6.

Environmental monitoring

Air quality

33 An initial report on the results of the air quality monitoring and the impact of the plume on human health and vegetation was published by the Department for the Environment, Food, and Rural Affairs (DEFRA) in May 2006.[13] Overall, the report concluded 'there are unlikely to have been widespread air quality impacts at ground level due to pollutants emitted from the Buncefield fires.' It went on to say that 'overall it was concluded that the fire at Buncefield Oil Depot did not result in substantial pollution of soil and grasses' and 'that pollutant levels were, in general, unexceptional and typical of UK urban environments.'

34 The prevailing meteorological conditions at the time of the incident and the high buoyancy of the smoke plume from the fire resulted in most of the plume material reaching a high altitude in the atmosphere. It then dispersed over a wide area with minimal mixing down to ground level.

Land investigations

35 Trial pits were excavated starting in February on and surrounding the site to assess the impact on land. The initial findings indicate that the surface layer is contaminated with fuel and fire-fighting products.

36 The extent and degree of the contamination of the land within the Buncefield depot is continuing to be established. Many trial pits have been excavated to investigate the soil beneath the concrete hardstanding and under the bases of the bunds. All of this information will inform the continuing Investigation and allow the Environment Agency to assess the oil companies proposed remediation of the contamination when that is formally submitted to the Competent Authority.

Surface water and groundwater monitoring

37 Extensive surface water monitoring immediately following the incident was carried out at a number of locations, as detailed in the Second Progress Report. Monitoring will continue for the foreseeable future at these locations to determine any long-term effects on the aquatic environment.

38 The Environment Agency started to monitor the groundwater under and around the Buncefield site soon after the incident. This monitoring has shown that there is contamination of the groundwater by fire-fighting products, fuels, and fuel-related products. This has been reported in the previous Progress Reports and on the Environment Agency website.

39 Following the detection of contamination, the Environment Agency reviewed the sampling locations for the existing groundwater monitoring network (details of which were reported in the Second Progress Report) and concluded that further monitoring boreholes were required at specified locations. Some of the new boreholes are already installed.

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[13] This report presents and summarises the air quality measurements made during the Buncefield incident, and includes results obtained from targeted local monitoring, measurements from long-term monitoring networks, the modelling undertaken by the Meteorological Office, and emissions estimates of the pollutants from the fire. See Further information for further details.

40 The new monitoring boreholes will ensure that the extent of pollution is understood. Also, the increased groundwater monitoring network will improve the understanding of flow and contaminant transport within the chalk aquifer.

41 In addition to the extensive sampling that is currently underway, the Environment Agency is developing a groundwater conceptual model to assist in understanding the movement of pollutants within the groundwater and aquifer so that it may assess the likely extent of contamination. This model is a conceptual representation of the environment (in this case an aquifer) and the interactions within it.

42 All of the above will aid the assessment of the impact of the contamination on the environment and to human health. It will also assist in determining the best solutions for the clean up of the groundwater and the aquifer.

Perfluorooctane sulphonates (PFOS)

43 Perfluorooctane sulphonates are a group of chemicals, collectively identified as PFOS, which have been shown to be hazardous (persistent, bioaccumulative and toxic). PFOS chemicals have been used in a diverse range of applications, including as an additive to aid the spreading properties of fire-fighting foam. PFOS does not appear to degrade in the natural environment. Due to this stability, it has now become widespread both in humans and in the environment. Annex 9 describes the environmental hazards presented by PFOS and the current approach to its regulation.

44 PFOS was not routinely monitored and analysed in any surface water or groundwater in the UK prior to the Buncefield incident. Sampling and analysis for PFOS are not straightforward and until very recently there has been no recognised recommended limit for PFOS levels in groundwater or drinking water against which to assess any results.

45 PFOS was present in some of the foam used to combat the Buncefield fire. At the start of the Buncefield incident, PFOS in the fire-water was recognised as an important potential contaminant for land, surface water and groundwater. The Environment Agency and others have sampled groundwater and surface water extensively for PFOS and other contaminants both on and off site from soon after the explosion. The Board notes that it is the responsibility of the local water company to monitor the quality of drinking water (as opposed to groundwater and rivers), and that the Drinking Water Inspectorate (DWI) regulates the activities of water companies in relation to drinking water quality.

Results of monitoring

46 PFOS was detected in the Rivers Ver and Colne in the days immediately following the incident, however, these levels dropped below the lowest threshold detectable by the Environment Agency after a short period. Ongoing testing still shows sporadic detection of PFOS in the rivers. No direct impact has been detected either at the time or in the intervening months on fish or other aquatic species in these waters. Only long-term monitoring will identify if there has been a lasting environmental consequence of the presence of PFOS and its associated fluorinated compounds.

47 Results to date (six months since the incident) of groundwater monitoring have shown the presence of fuels, fuel-related products and residues from the fire-fighting foams in groundwater at a number of locations, but they are most prevalent under and close to the site.

48 Although PFOS above the level of three microgrammes per litre (which is the advisory level set by the DWI for PFOS in drinking water) has been detected in environmental monitoring samples, these levels have not been detected in samples of drinking water.

49 It could be many months before the full extent of the contamination of the groundwater is known. The Environment Agency is working with DWI and the local water supply companies to ensure that they are fully aware of sampling results, and are able to act appropriately to safeguard public water supplies.

Further monitoring

50 In view of the apparent widespread occurrence of trace quantities of PFOS around the Hemel Hempstead area, some apparently unconnected with Buncefield, the Environment Agency is conducting a targeted national groundwater sampling exercise to investigate the wider prevalence of PFOS and related compounds in groundwater.

51 The initial monitoring programme is being carried out in the period April to July 2006. Groundwater is being sampled at selected sites on the Environment Agency's national groundwater monitoring network. A range of sites have been selected in rural, urban and industrial areas. Some sites are where fire-fighting foams may have been used, eg fire stations, airbases etc, while others are where such use is not suspected. Approximately 150 sites will be sampled as a part of this programme.

52 If perfluorosurfactant compounds are detected in groundwater, repeat sampling will be carried out to verify the initial results and to investigate persistence. If widespread detection occurs, the programme will be extended beyond July and, if necessary, selected compounds added to the routine monitoring programme. A similar sampling exercise is planned for surface waters to take place over the period July to December 2006.

Notification to the European Commission

53 The Competent Authority (at Buncefield, jointly HSE and the Environment Agency) is required under regulation 21(1) and (2) of the COMAH Regulations to inform the European Commission of any major occurrence on a COMAH site. HSE, on behalf of the Competent Authority, issued a short report on 10 March 2006 for inclusion on the Major Accident Reporting System. As further information of international significance becomes known, the Competent Authority will also pass this on to the European Commission and hence the international community.

54 DEFRA has established threshold criteria defining a Major Accident To The Environment (MATTE), based on Schedule 7 (part 1) of the COMAH Regulations. The Environment Agency, using these criteria, has determined that the Buncefield incident is a MATTE, and the Competent Authority has recently reported this to the European Commission. This determination is based on the results of Environment Agency monitoring of groundwater beneath and in the vicinity of the Buncefield site, which has been shown to be contaminated with fuels and fire-fighting foam by-products. This area of contamination is deemed to extend over the one hectare threshold described in the Regulations. The reporting of this MATTE to the European Commission has no impact on the continued monitoring and remediation programme that is already taking place.

The continuing Investigation

55 Work continues on the Investigation to ensure that all reasonable lines of enquiry are followed. Evidence continues to be gathered from different sources. The emerging information contributes to a greater understanding of the underlying root causes, and will allow the Investigation team to refine its enquiries further and to bring into focus elements such as wider management systems and organisational factors.

56 Almost all the plant and equipment required for forensic examination has been recovered from the Buncefield site, which will allow the operators to demolish buildings, tanks and bunds. However, further investigation work will be carried out on the integrity of the floors of the bunds together with environmental monitoring of the ground underneath, in particular where tanks were located.

57 The Investigation has also considered previous incidents which may have similarities to the events at Buncefield. These are summarised in Annex 5. Work is in hand to identify other incidents that may be relevant.

Part 2 - Issues of concern arising from the Investigation to date

58 Knowledge of the Buncefield incident is still incomplete, but enough is known to draw some broad conclusions about actions which might be taken to improve health, safety and environmental protection at or near oil storage sites, including areas where further work is needed. The Board does not intend to make any comment at this stage on possible legal proceedings. The initial observations set out here concern broader issues. The Board will continue to ensure that information is made publicly available, either through its own reports or via the Competent Authority, where it is necessary to ensure continued safety, while also attempting to preserve the integrity of any future criminal proceedings that might be brought by the relevant enforcing authorities.

59 The Board's observations and conclusions at this stage fall into three areas, which are considered further below:

- Design and operation of storage sites.
- Emergency response to incidents.
- Advice to planning authorities.

60 We believe these, together with our examination of HSE's and the Environment Agency's roles in regulating the activities on the Buncefield site, will form the broad scope of our further work.

Design and operation of storage sites

61 The Buncefield incident involved failures of primary, secondary and tertiary means to contain fuel and associated fire-waters.

- **Primary** means are the tanks, pipes and vessels that hold liquids, and the devices fitted to them to allow them to be safely operated.

- **Secondary** means are enclosed areas around storage vessels (often called bunds), created usually by concrete or earth walls. Their purpose is to hold any escaping liquids and any water or chemicals used in fire-fighting.

- **Tertiary** means are things such as drains designed to limit the passage of chemicals off site, raised kerbs to prevent liquids that have breached the bunds from escaping into the general area around the site, etc.

62 The Board has already seen sufficient information from the Investigation to be able to express an obvious, but nonetheless important opinion that safety, health and environmental protection are of paramount importance at sites like Buncefield. We would expect this point to be uppermost in the mind of the industry-chaired task group recently convened by HSE to pursue improvements to safety and environmental protection at fuel depots.

63 The occurrence of a massive fuel vapour explosion confirms the overriding need to ensure the integrity of the primary means of containment; in other words, to make sure that liquid does not escape from the vessels in which it is normally meant to be confined.

64 Safety and planning assumptions at fuel depots like Buncefield have until now been based upon fires in pools of escaped liquid, held in check by bunds while the emergency services establish control. The formation of a huge vapour cloud from tank storage was not considered a sufficiently credible scenario for land use planning purposes.[14] One particular lesson from the Buncefield incident is therefore that such a cloud can form while a highly flammable liquid such as unleaded petrol is escaping from primary containment in a storage tank, and where the path of escape involves cascading, fragmenting and dispersing the liquid from height (eg from the vents in the top of a tank that is being overfilled).

65 The Investigation has demonstrated that 'overtopping' a tank with highly flammable fuel is more likely to produce a potentially explosive mixture than pooling from a lower level escape, such as may result from a tank failure. The Investigation has also shown that the design of the tank itself may have contributed to the vapour formation at Buncefield. This suggests that design and construction of tanks and pipework that could be favourable to the formation of flammable vapours should be discouraged.

66 Secondary and tertiary means of containment are vital for environmental protection. However, the secondary containment provided by bunds around tanks is of lesser value where there is rapid formation of vapour that will fairly quickly overflow the bund wall. Tertiary containment also has little effect against a cloud of vapour, as it is intended to intercept and hold liquid flowing along the ground. It is the Board's view that the ineffectiveness of customary means of secondary and tertiary containment against migration of large volumes of vapour re-emphasises that the most urgent focus of attention should be on preventing loss of primary containment and, should that occur, inhibiting rapid large-scale vaporisation and any subsequent dangerous migration of a flammable vapour.

67 The Investigation also revealed that the fire pumphouse that provided the means to distribute cooling water for the whole Buncefield site was immediately adjacent to, and downhill from, Bund A. As described in paragraph 28, recent CCTV analysis has identified this pumphouse as a likely source of one of the early ignitions of the flammable vapour. The loss of the pumphouse, probably from an internal explosion of vapour that had entered from the surrounding cloud, immediately rendered inoperative the fire-fighting provisions for the site. It is foreseeable that flammable vapour in an enclosure could, if ignited, cause damage within that enclosure. The risk of flammable vapour reaching fire pumps increases the closer the pumps are to tanks containing volatile flammable liquids. The industry-chaired task group may want to review whether current guidance related to the siting and/or means of protection of emergency response facilities is suitable at sites such as Buncefield.

68 Following publication of the Investigation Manager's first Progress Report in February 2006, the Competent Authority (HSE with the Environment Agency in England and Wales, and with the Scottish Environment Protection Agency in Scotland) began a programme of site inspections to ensure operators reviewed key design and operational aspects of their sites, a process supported by the findings of subsequent Progress Reports.

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[14] At Buncefield, the formation of a flammable vapour cloud at the tanker loading gantry, as opposed to the tank storage areas, was considered by the Competent Authority and site operators, but the level of off-site hazard this would pose was judged to be lower than a large pool fire originating from the tank storage area.

69 The preliminary findings of the Competent Authority programme were published on 13 June 2006.[15] As a result of the programme, three Improvement Notices have been served. The Board welcomes this initiative and looks forward to the publication of the detailed findings of the Competent Authority programme of inspection this autumn. The Board notes the industry's efforts in working with the Competent Authority to review the findings from both the Investigation and the Safety Alert review, and to make recommendations to the joint industry/regulator task group regarding action needed to improve risk control. In particular, the Board notes that part of this work will be to review and revise published guidance on handling flammable liquids at storage sites by mid-2007, and expects this work to be pursued with vigour.

70 That guidance should be the culmination and record of a substantial effort by the industry, working with the regulators, and begun at once, to develop and implement better methods for handling flammable liquids at storage sites, particularly where volatile fuels are handled, with the principal aim of safely confining them in the vessels intended for that purpose. By 'methods' the Board means the plant, equipment, management systems, operational procedures and working practices provided to achieve safe operation and the ongoing verification by operators, supported by the Competent Authority, that all these control measures are effective.

71 In summary, the Investigation has revealed a number of matters concerning the design and operation of sites such as Buncefield where improvements to maintaining primary containment must be considered by the industry, working closely with the Competent Authority. These matters include:

- the electronic monitoring of tanks and pipework, and associated alarms that warn of abnormal conditions;
- the detection of flammable vapours in the immediate vicinity of tanks and pipework;
- the response to the detection of abnormal conditions, such as automatic closure of tank inlet valves and incoming pipeline valves;
- the extent to which the exterior construction of tanks (eg tank top design) inhibits, or contributes to, flammable vapour formation;
- the siting and/or means of protection of emergency response facilities; and
- the recording of monitoring, detection and alarm systems and their availability (eg off site) for periodic review of the effectiveness of the control measures by the operator and the Competent Authority, as well as in root cause analysis should there be an incident.

72 Where a need for additional systems is identified, HSC and the Competent Authority should satisfy themselves that current legal requirements are robust enough, and supported with sufficient resources, to ensure that these systems are provided and maintained at every fuel storage site where the risks require them, without relying upon voluntary compliance. It has not been established whether changes in the law or in the resources available to the Competent Authority are required to achieve this end. The Board is, however, clear that the severity of the Buncefield incident makes a compelling case for any such changes to be made as a matter of very high legislative priority, should the need be identified.

15 The full report is available on HSE's website at www.hse.gov.uk/comah.

73 As well as ensuring the effectiveness of primary containment, the industry, working with the Competent Authority, should embark on a review of the purpose, specifications, capacity, construction and maintenance of secondary and tertiary containment, and in particular the bunds around tanks. This work should lead to revised guidance, either as part of that referred to in paragraphs 69 and 70, or produced separately – but on at least as rapid a timescale. Again, the necessary standards should be capable of being insisted upon by law.

74 The Board is clear that it will wish to offer further advice when the Investigation is further advanced. This might deal with, for instance, the human and organisational factors that contribute to the safe operation of a major hazard site such as a fuel storage depot. Such factors include, for example, job organisation, management of organisational change, monitoring and supervision, training and control room layout.

75 In the longer term, it may prove necessary to consider additional standards for the overall layout of storage sites.

76 The system for delivering fuel safely around the country depends on good communications between those responsible for delivery and those responsible for receiving the delivered batches, to ensure sites receiving fuel are able to accept deliveries safely. The adequacy of existing safety arrangements, including communications, may also need to be reviewed. The Board expects to return to these and other matters in due course.

77 Further work is needed to research the actual mechanism for generating the unexpectedly high explosion overpressures seen at Buncefield. This is a matter of keen international interest, and participation from a broad range of experts, as well as the industry, is essential to ensure the transparency and credibility of any research programme. The Board will consider further recommendations about the nature and scope of such work.

Emergency response to incidents

78 Improving the arrangements to prevent fires and explosions in no way lessens the need to have effective emergency arrangements in the event of an incident. This covers both planning for emergencies and the effectiveness of the response. Operators of top-tier COMAH sites are required by law to prepare adequate emergency plans to deal with the on-site consequences of possible incidents, and they must also provide local authorities with information to enable them to prepare emergency plans to deal with the off-site consequences. The adequacy of these plans depends, among other things, on a full appreciation of the potential for major accidents. In the light of the emerging findings:

- Operators of oil storage depots should review their on-site emergency plans and the adequacy of information they supply to local authorities to ensure they take full account of the potential for a vapour cloud explosion, as well as fires. From the 'forthwith actions' taken by depot operators and the Competent Authority in response to the Competent Authority's Safety Alert of 21 February 2006, responsible operators should have already undertaken such reviews. The Competent Authority must ensure that this is the case and work with the industry to ensure that all learning is fully shared.

- The public health implications of potential vapour cloud explosions must be considered in both on-site and off-site emergency plans. Though the public health impact of Buncefield appears to have been minimal, this may not necessarily have been the case under different conditions.[16]

- As with on-site protective systems, HSC and the Competent Authority bodies should satisfy themselves that legal requirements are robust enough to ensure any necessary changes to emergency plans are duly made.

79 Several separate reviews are looking at the effectiveness of the emergency response to Buncefield. The emergency services, particularly the fire and police services, responded impressively and on a massive scale that was almost certainly unprecedented in modern times. Inevitably there are lessons to be learned from such an exceptional event. This is particularly important given the newness of the local, regional and national resilience arrangements tested at Buncefield. The Board intends to return to this topic when more information is available from those reviews. Meanwhile the Board has the following observations:

- Given the huge cost of the Buncefield incident, it is essential not to miss any of the lessons it has provided for emergency response. Like the response itself, this is a multi-agency task that requires a clear lead. It will be part of the Board's ongoing work to establish a clear picture of the lead provided by central Government for first responders.

- The public health impacts of Buncefield appear to have been minimal. Nevertheless, the incident has revealed the importance of prompt, useful advice to early responders such as the Fire and Rescue Services, and to the public. There may also be scope to improve the co-ordination of sampling and monitoring activities, particularly in the early stages of major incidents. The Board welcomes the establishment of a Health Protection Agency-led working group aiming to establish frameworks and agreed working practices for any future post-incident environmental sampling, and awaits with interest the results of this work. The Board also welcomes the steps being taken by the Health Protection Agency to draw to the attention of regional resilience fora in Britain the immediate lessons of Buncefield for the provision of health protection advice during a major incident.

- The local residential and business communities have interests to be considered, eg the maintenance of employment and support in effecting a rapid return to social normality. This appears to be both a regional and, on the scale of Buncefield, a national issue. It is not clear to the Board how far emergency planning arrangements have taken account of this aspect in the past. The Secretary of State for Communities and Local Government, through the Government Office for the East of England, recently established a task force to investigate options for Government support to businesses and local economies in the period following an exceptional disaster. This initiative is very welcome and the Board hopes swift progress will be made in this work.

16 The low impact on public health of the Buncefield incident is an initial conclusion of the Health Protection Agency. Their review of the health effects of the Buncefield fire is available at www.hpa.org.uk/explosions/hemel.htm.

Advice to planning authorities

80 One of the starkest issues raised by the Buncefield explosion is the location of sites with such major hazard potential alongside neighbouring commercial and residential development. The situation poses the fundamental planning question that all parties have to address – quite simply, what to do about such development.

81 The Board is acutely aware of the problems that planning uncertainties cause for local communities, particularly those directly affected by the Buncefield incident. Decisions about rebuilding businesses near the Buncefield depot – crucial to the livelihood of those who work in those businesses and to the local economy in general – hinge on decisions about rebuilding the whole of the area, including the depot itself.

82 A key element of the land use planning process for developments around Buncefield and many similar sites is the advice HSE provides to planning authorities. The Board, in its statement of 9 May on publishing the Third Progress Report, indicated its view that enough information had emerged at that stage to enable HSE to review as a matter of urgency the basis and standard of the advice it provides. The Board notes that HSE has acted on that challenge and expects to produce some preliminary conclusions in the autumn of this year.

83 The Board recognises that this is a complex issue for which there are no simple solutions. There is a need to balance the risks and benefits of development – a judgement made no easier by technical and scientific uncertainties. This is illustrated by the fact that HSE's advice on this site was based on a representative 'worst credible scenario' of a major liquid fuel pool fire. A vapour cloud explosion was initially considered, but arising from tanker loading operations and not tank storage. A pool fire was assessed as presenting the greater off-site hazard. The Buncefield incident brings into question the assessment policy for many oil/fuel depot sites, and the zone setting method which it informs.

84 The Board intends to address these issues in more detail, but not before seeing the preliminary conclusions of HSE's review. A measured approach is justified since the likelihood of a similar explosion remains low, and should be made lower still by a programme of actions designed to increase the reliability of primary containment. In our view, the importance of reaching conclusions that are considered, costed, and sustainable greatly outweighs any benefit that might be derived from coming to summary judgements.

85 We will be interested to know HSE's views on the desirability and feasibility of an approach to advise on developments around sites like Buncefield based more on consideration of risk. Under such an approach, the likelihood of major incidents, taking into account all the measures in place against them, would play a more explicit part than hitherto in determining planning advice.

86 The Board has also noted the incremental development around Buncefield (and presumably other sites).[17] Given that most planning advice currently focuses on specific developments subject to planning approval, this could mean that in the future, more attention should be paid to the total population at risk from a major hazard site. The Board welcomes the Ministerial Statement laid in the House of Commons on 15 May, which referred to cross-Government work on this issue currently being co-ordinated by the Cabinet Office, and to which HSE is making an important contribution, and looks forward to the consultation with stakeholders expected later this year.

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17 The history of development within a 3 km radius of the Buncefield depot site between 1966 and 2005 is shown in Figure 5, Annex 3.

Annex 1

Terms of reference and progress

This annex sets out the eight terms of reference for the Investigation and explains the progress that is being made towards accomplishment of each of them.

1 To ensure the thorough investigation of the incident, the factors leading up to it, its impact both on and off site, and to establish its causation including root causes

The Board has published three Progress Reports from the Investigation Manager. These have revealed the main facts of the incident, but have not speculated on why control of the fuel was lost. The explosion mechanism, ie the means by which unexpectedly high overpressures were generated, is subject to significant further investigation. This may require wider expert consultation and research.

The criminal investigation is pursuing all reasonable lines of inquiry into the facts and causes of the incident to enable the Competent Authority (HSE and the Environment Agency) to take a view on legal proceedings.

2 To identify and transmit without delay to duty holders and other appropriate recipients any information requiring immediate action to further safety and/or environmental protection in relation to storage and distribution of hydrocarbon fuels

The Competent Authority issued a Safety Alert to around 1100 COMAH duty holders on 21 February 2006. Special attention was paid to 108 fuel depot owners storing COMAH quantities of fuel in Great Britain, seeking a review of arrangements for detecting and dealing with conditions affecting containment of fuel. Most duty holders responded to the alert by the Easter deadline. Meanwhile, the Competent Authority visited all 108 depots to follow up the alert. An interim report was published on 13 June and is available at www.hse.gov.uk/comah/alert.htm.

The Environment Agency issued further advice to its inspectors to investigate secondary (bunding) and tertiary (drains and barriers) containment at depots in England and Wales in response to the Second Progress Report. The Environment Agency is expected to publish a report in the summer. The Environment Agency also continues to monitor the effects of Buncefield on the surrounding environment and to issue updates on its website, www.environment-agency.gov.uk. The initiative is being handled separately for Scotland by the Scottish Environment Protection Agency, with joint inspections undertaken with HSE covering primary, secondary and tertiary containment, and management systems. However, it is intended that an overall view of the situation in Britain will be available this summer.

On 16 June investigators served two Improvement Notices on the manufacturers of the high-level alarm switch installed on Tank 912, having identified a potential problem at other sites related to the setting of the switch for normal operations following testing. This was followed up by a Safety Alert from HSE on 4 July alerting operators relying on such switches of the potential problem.

The Chairman of the Buncefield Board wrote to the Chief Executive of the Health Protection Agency on 3 July enquiring into progress with informing regional resilience groups of early lessons learned from Buncefield, focusing on public health issues in the immediate aftermath of a major airborne incident.

3 To examine the Health and Safety Executive's and the Environment Agency's role in regulating the activities on this site under the COMAH Regulations, considering relevant policy guidance and intervention activity

Work is progressing steadily on both parts of the review, concerning respectively HSE's and the Environment Agency's prior regulatory activities at Buncefield. The full findings of the review will be incorporated into the Board's final report (see term of reference 8). Any immediate important lessons from the examination of the Competent Authority's prior role will be incorporated into the lessons learned programme under term of reference 5.

4 To work closely with all relevant stakeholders, both to keep them informed of progress with the Investigation and to contribute relevant expertise to other inquiries that may be established

The ongoing impact on residents and businesses of the Buncefield incident has been reported in all three Progress Reports. The Board has maintained an active interest in releasing as much new information as possible to the community and its representatives, such as the local MP Mike Penning, to assist in understanding the events of 11 December 2005, and to maintain public confidence that progress is being made with the Investigation. Residents and businesses have shown remarkable resilience in great adversity. Dacorum Borough Council in particular, but also St Albans and Hertfordshire Councils, have performed extremely effectively in very difficult circumstances, and have supported the Board in its engagement with residents and businesses, as has Mike Penning MP.

The Board has also kept key Government stakeholders informed of the Investigation's progress, and has maintained its interest in developments that have taken place since Buncefield to help manage the aftermath and support a return to normality for residents and businesses.

The Board has engaged with all the public sector agencies involved in the emergency response to Buncefield and has met with a number of the key agencies, particularly the Category 1 (Gold) responders. This is not an issue in which the Board has primary responsibility but, as reported in this Initial Report, the Board is giving further consideration to emergency response and emergency preparedness issues, and will say more on this later.

The Buncefield Major Incident Investigation made presentations to two multi-agency debriefing sessions on 21 and 28 June to inform regional resilience groups around Britain of the response to the Buncefield incident.

5 To make recommendations for future action to ensure the effective management and regulation of major accident risk at COMAH sites. This should include consideration of offsite as well as onsite risks and consider prevention of incidents, preparations for response to incidents, and mitigation of their effects

HSE, the Environment Agency and the Health Protection Agency are contributing to this work to assist the Board to make sensible, practical and affordable recommendations for improvements in the light of the Buncefield incident. Key workstreams are in environmental protection; land use planning; fire and explosion mechanisms; control and instrumentation; human and organisational factors; health; emergency response and preparedness; and regulatory impact.

HSE has convened an industry-chaired task group that includes the Environment Agency and the Scottish Environment Protection Agency, to consider design and operation issues. The Board is considering how to make suitable arrangements for further research and modelling of explosion mechanisms in flammable vapour clouds. HSE has begun work on changes to land use planning advice and is working closely with a Cabinet Office-led team on applying new knowledge of risks to society in the planning system. The Health Protection Agency is consulting key agencies to improve public health advice and support during significant pollution events.

6 To produce an initial report for the Health and Safety Commission and the Environment Agency as soon as the main facts have been established. Subject to legal considerations, this report will be made public

This element is discharged by the publication of this report.

7 To ensure that the relevant notifications are made to the European Commission

A report from the Environment Agency and HSE was made to the European Commission on 10 March. Subsequently, the Environment Agency declared Buncefield a Major Accident To The Environment (MATTE), and the Competent Authority has recently reported this to the European Commission.

8 To make the final report public

The timing for the publication of the final report remains uncertain and is of course linked to progress on the main terms of reference and to any decision on any criminal proceedings that might be considered. The possibilities include a further interim report or reports; decisions must necessarily depend on the timing of developments and consideration of the public interest.

Annex 2

Members of the independent Board

The Rt. Hon. Lord Newton of Braintree has been a life peer since 1997 after spending 23 years as a Conservative Member of Parliament for Braintree, Essex. From 1982 to 1988 he held ministerial positions at the Department of Health and Social Security. In 1988 he joined the Cabinet as Chancellor of the Duchy of Lancaster and Minister at the DTI. He then held the post of Secretary of State for Social Security from 1989 to 1992 when he was appointed Leader of the House of Commons, which he held until 1997. In 2002 he chaired the Committee that reviewed the operation of the Anti-Terrorism, Crime and Security Act 2001.

Professor Dougal Drysdale is one of the leading international authorities in Fire Safety Engineering. He was the Chairman of the International Association of Fire Safety Science until September 2005 and is currently the editor of the leading scientific journal in the field, Fire Safety Journal. His wide range of research interests includes the ignition characteristics of combustible materials, flame spread and various aspects of fire dynamics. He is a Fellow of the Royal Society of Edinburgh and a Fellow of both the Institution of Fire Engineers and the Society of Fire Protection Engineers.

Dr Peter Baxter is a Consultant Physician in Occupational and Environmental Medicine at Cambridge University and Addenbrooke's Hospital, Cambridge. In the past he has advised the Government on the impacts on public health relating to air quality standards, major chemical incidents, natural disasters and climate change.

Taf Powell is Director of HSE's Offshore Division. He graduated in Geology and Chemistry from Nottingham University. His oil field career has been split between working in the UK and abroad in offshore exploration and development and regulation of the sector in licensing, well operations, policy and safety regulation. In 1991 he joined HSE's Offshore Division from BP and started work to develop the new offshore regulatory framework, one of Lord Cullen's recommendations following his inquiry into the Piper Alpha disaster. As HSE's Operations Manager, based in Aberdeen, he then led inspection teams and well engineering specialists responsible for enforcing the new regulations until 2000 when he took up his current role.

Dr Paul Leinster is Director of Operations at the Environment Agency. Up until March 2004 he was the Director of Environmental Protection, having joined the Agency in 1998. Prior to this he was the Director of Environmental Services with SmithKline Beecham. Previous employers also include BP International, Schering Agrochemicals and the consultancy firm Thomson-MTS where he was Managing Director. Paul has a degree in Chemistry, a PhD in Environmental Engineering from Imperial College and an MBA from the Cranfield School of Management. Paul has worked for 30 years in the health and safety and environmental field.

David Ashton is Director of HSE's Field Operations North-West and Headquarters Division. He joined HSE in 1977 as an inspector in the west of Scotland where he dealt with a wide range of manufacturing and service industries, including construction, engineering and the health services. In 1986 he joined Field Operations HQ to deal with machinery safety. He then held the post of Principal Inspector of manufacturing in Preston for two years, before being appointed as a management systems auditor to examine offshore safety cases in the newly formed Offshore Division. In 1993 he became Head of HSE's Accident Prevention Advisory Unit, looking at the management of health and safety in organisations. Between 1998 and 2003 David was HSE's Director of Personnel, before being appointed to his current position.

Annex 3

Planning history of Buncefield site and neighbouring developments

1 Planning permission was granted in 1966 to Shell Mex and BP Limited, Regent Oil Co Limited, Mobil Oil Co Limited, and Petrofina (GB) Limited to develop 91 acres of land at Buncefield for the construction of a storage and distribution depot for petroleum products. St Albans Rural District Council initially refused the application on the grounds that it was an inappropriate development in the Green Belt and would have a detrimental effect on the amenity of the locality. On appeal, the Minister of Housing and Local Government granted permission subject to a number of conditions relating to design of the site, tree planting and restrictions on the size of office premises.

2 At the time that the terminal was built in 1968, the site was well screened by hedges and trees, but there were about nine dwellings on the periphery of the site to the north whose amenities were affected by the site, and a farm to the south. One of the nine dwellings to the north was converted in 2000 to create five separate properties. Since 1968 there has been general encroachment and development of adjacent land. This can be seen on the map in Figure 5. The majority of this building development took place during the period from the mid 1960s to the early 1980s, comprising the construction or redevelopment of residential properties and a number of schools and industrial premises to the west of the site, all of which fell within a 3 km radius as shown on the map. Between 1990 and 2006, a few additional industrial premises were built around the site.

3 Dacorum Borough Council is the principal planning authority for the site, but a small section to the north of Cherry Tree Lane falls to St Albans District Council.

4 The local planning authority decides whether developments can go ahead. But arrangements have existed since 1972 for local planning authorities to obtain consultee advice from HSE and its predecessors about the safety implications for developments from risks associated with major hazards. Between 1991 and 2005, 28 applications were passed to HSE for advice relating to a variety of commercial or residential developments around the Buncefield site. HSE advised against four of these proposals and advised that seven others could be allowed subject to certain conditions. As far as is known, the local authority followed HSE's advice in these cases.

5 In addition to these specific developments on which HSE was a statutory consultee, HSE is from time to time consulted on other matters. For example, HSE was consulted on four local structure plan revisions.

6 The complex began operations in 1968 after a pipeline was constructed to link two Shell refineries at Stanlow at Ellesmere Port in Cheshire and Shell Haven on the Thames Estuary at Stanford-le-Hope in Thurrock. The depot operated originally under licence given under the Petroleum (Consolidation) Acts 1928 and 1936. The Planning (Hazardous Substances) Act 1990 and subsequent statutory provisions, the Planning (Hazardous Substances) Regulations 1992 (PHS Regulations) and later the Planning (Control of Major Accident Hazards) Regulations 1999 introduced new procedures for consent to be sought from the hazardous substances authority to store hazardous substances.

7 The consent identifies the hazardous substances and their location on site and defines certain conditions of use such as maximum size, temperature and pressure of storage vessels. Figure 6 contains some details of consents obtained for the Buncefield depot. The consents for Shell UK Oil Limited have been included in this table as they have not been revoked, although Shell no longer operates from this site.

HSE's role in land use planning

8 HSE's specific role in land use planning is twofold:

- Under the PHS Regulations, the presence of hazardous chemicals above specified threshold quantities requires consent from the local hazardous substances authority, which is usually also the local planning authority. HSE is a statutory consultee on all hazardous substances consent applications. Its role is to consider the hazards and risks which would be presented by the hazardous substance(s) to people in the vicinity, and on the basis of this to advise the hazardous substances authority whether or not consent should be granted. In advising on consent, HSE may specify conditions that should be imposed by the hazardous substances authority, over and above compliance with statutory health and safety requirements, to limit risks to the public (eg limiting which substances can be stored on site, or requiring tanker delivery rather than on-site storage). Hazardous substances authorities should notify HSE of the outcome of all applications for consent, and where consent has been granted should supply copies of the site plans and conditions.

- HSE uses the information contained in consent applications to establish a consultation distance around the installation. This usually comprises three zones or risk contour areas. The consultation distance is based on the maximum quantity of hazardous substance(s) that the site is entitled to have under its consent. HSE notifies the local planning authorities of all consultation distances in their areas. The General Development Procedure Order 1995 requires the local planning authority to consult HSE about certain proposed developments (essentially those that would result in an increase in population) within any consultation distance. HSE advises the local planning authority on the nature and severity of the risks presented by the installation to people in the surrounding area so that those risks are given due weight by the local planning authority when making its decision. Taking account of the risks, HSE will advise against the proposed development or simply note that it does not advise against it.

9 HSE's approach to land use planning is set out in more detail in Annex 2 of the first Progress Report. Some of this process is now being devolved to certain local planning authorities.

10 The consultation distance represents the furthest distance at which HSE wishes to be consulted about developments near hazardous installations/major accident hazard pipelines. This does not mean that there is no risk beyond the consultation distance, just that the predicted risks are sufficiently low that they need not be part of a planning decision.

11 Within the consultation distance, HSE undertakes an assessment of the hazards and risks from the installation and produces a map with three contours representing defined levels of harm or risk which any individual at that contour would be subject to, based on information relating to the hazardous substances consent. The harm or risk to an individual is greater the closer to the installation.

The contours form three zones, with the outer contour defining the consultation distance around major hazard sites. The local authority consults HSE on relevant proposed developments within this consultation distance.

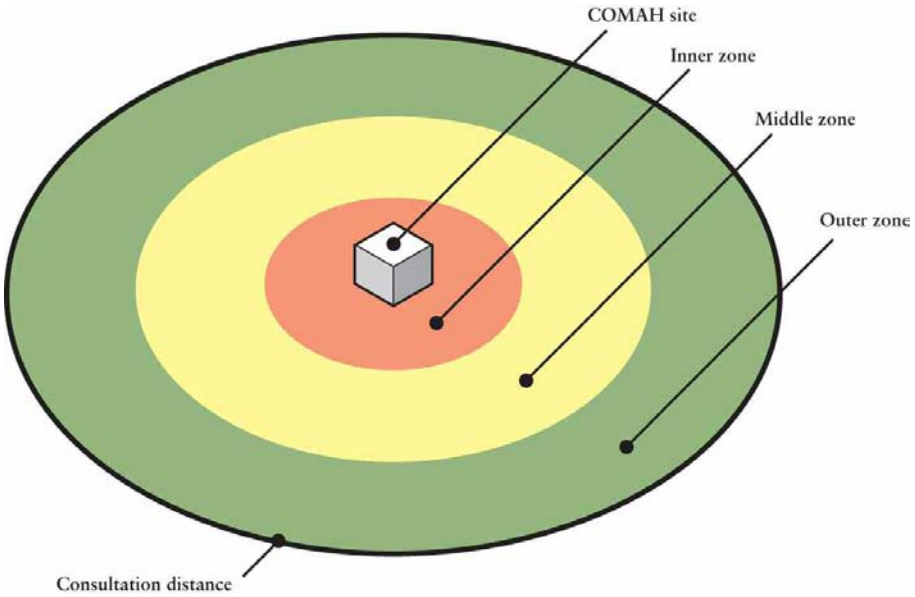

Figure 3 Consultation distance and zones

12 When a planning application is received, HSE or the local planning authority first identifies in which of the three zones the proposed development is located. Secondly, the proposed development is classified into one of four 'sensitivity levels'. The main factors that determine these levels are the number of people at the development, their sensitivity (vulnerable populations such as children, old people) and the intensity of the development. With these two factors known, a simple decision matrix is used to give a clear 'Advise Against' or 'Do not Advise Against' response to the local planning authority, as shown below:

Level of sensitivity	Development in inner zone	Development in middle zone	Development in outer zone
1	DAA	DAA	DAA
2	AA	DAA	DAA
3	AA	AA	DAA
4	AA	AA	AA
Sensitivity level 1	*Example*	Factories	
Sensitivity level 2	*Example*	Houses	
Sensitivity level 3	*Example*	Vulnerable members of society eg primary schools, old people's homes	
Sensitivity level 4	*Example*	Football ground/large hospital	

DAA means Do not Advise Against the development
AA means Advise Against the development

Figure 4 Land use planning 'sensitivity levels' and decision matrix

13 More comprehensive guidance on the allocation of sensitivity levels is given on the Planning Advice for Developments near Hazardous Installations website (www.hse.gov.uk/landuseplanning/padhi.pdf).

History of the consultation distance around the Buncefield site

14 HSE has had arrangements with local planning authorities for consultation around developments in the vicinity of major hazards since the early 1970s, although it was not until the implementation of the Notification of Installations Handling Hazardous Substances Regulations 1982 (NIHHS Regulations) in 1983 that HSE first received notification from Shell Mex and BP of the terminal as a major hazard. A generic non-site specific consultation distance of 250 m from the boundary of the site was set for consultation purposes and the relevant local planning authority was notified. At that time it was customary to issue a generic consultation distance without performing a site-specific assessment. This consultation distance was based upon the assumption that the main hazard was from thermal radiation following a major fire within the bund.

15 In 1992 the site expanded and Mobil and Shell sent another notification and application for consent to store certain amounts of flammable material. The existing consultation distance was maintained at a generic 250 m from the site boundary. There are no records of the technical assessments that were performed when the local planning authority sought advice on developments within the vicinity of the site, but early assessments were based then, as now, upon a pool fire following loss of containment of a substantial quantity of flammable liquid. However, for tanks that were bunded there was a continuing assumption that any subsequent fire would be within the confines of the bund.

16 In 1996 a site-specific reassessment was performed based upon consented amounts of flammable material, and the consultation distance was reduced from 250 m to 190 m. The original 250 m was set in the early days of HSE giving land use planning advice, to ensure that all developments that might be advised against would be subject to consultation. By 1996, technical policy and methodology had been reviewed. In addition, three-zone maps were now being produced so that development control advice could be given more quickly and efficiently. The new policy assumed that the bund would not be able to contain the full contents of a tank following a sudden, catastrophic failure. It was assumed that the bund would be overtopped and the resulting pool fire would extend beyond the confines of the bund.

17 In July 2001 another consultation distance was calculated due to an extensive reassessment of the hazards from the site following the submission of a batch of new consent applications from the oil companies. The regulations requiring consent to store flammable substances were changed in 1999 to include additional flammable materials. The consultation distance was reduced from 190 m to 185 m. This was unchanged following a further consent application on 8 July 2005 from BP. The presence of the additional material did not alter the main basis of the calculation which assumed the worst-case event was the catastrophic failure of the largest tank containing gasoline. The consultation distance was reduced slightly owing to a slight change to the inputs in the model used to perform the calculations. See Figure 7 for a representative plan of the site showing the consultation distance since July 2001.

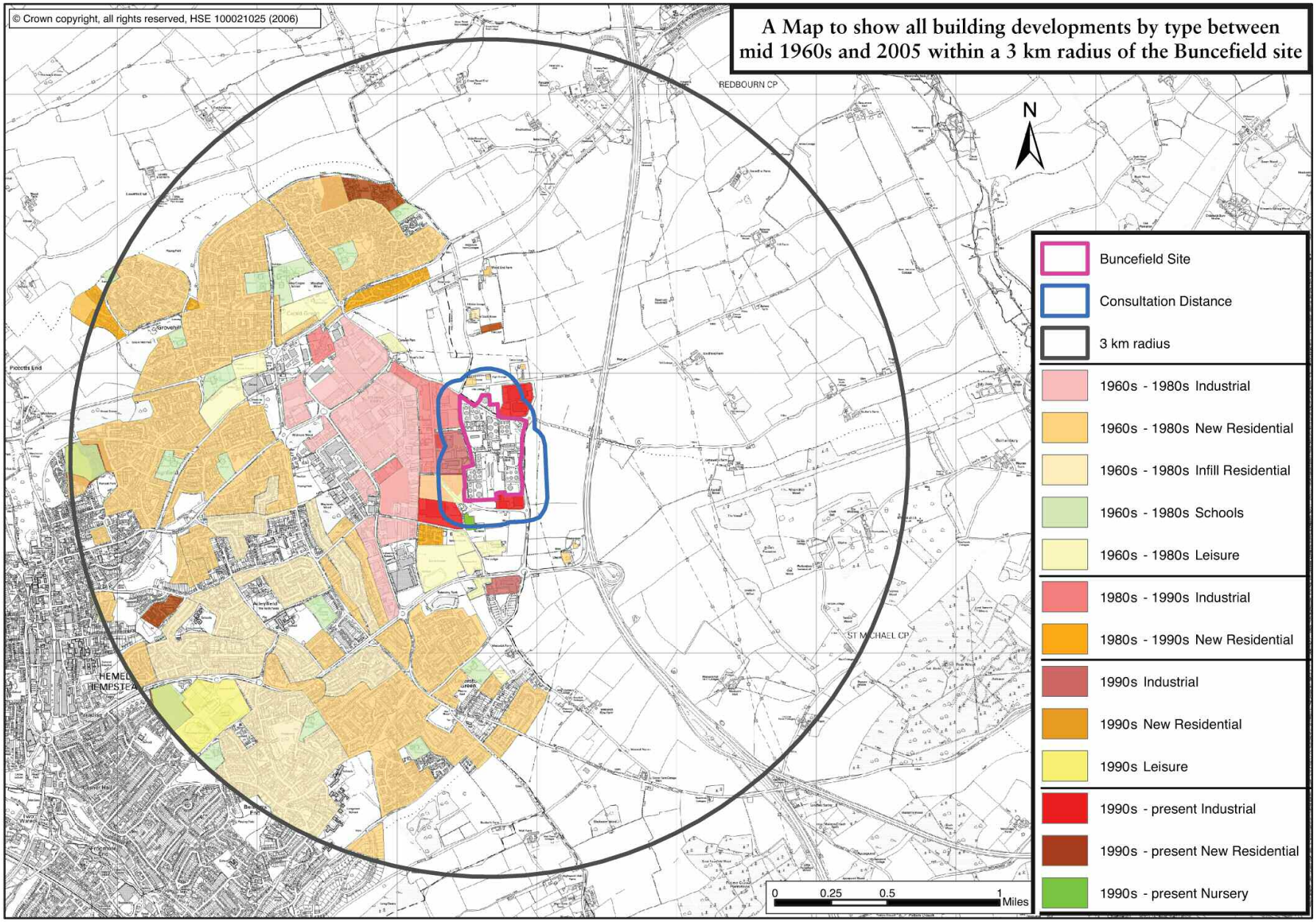

Figure 5 Developments within 3 km of the Buncefield site between 1966 and 2005

Some details of hazardous substances consents issued for the Buncefield oil storage and transfer depot

Operator	Hazardous Substances Consent applications
Texaco Limited	19 September 1983*: 10 571 tonnes motor spirit
Mobil Oil Co Limited	8 November 1983*: 17 650 tonnes petrol
Hertfordshire Oil Storage Limited	30 November 1992: 34 020 tonnes motor spirit 18 October 1999: 15 314 tonnes kerosene
BP Oil UK Limited	18 November 1992: 17 650 tonnes gasoline in name of Mobil Oil Co Limited 26 October 1999: 15 080 tonnes automotive petrol and other petroleum spirits 21 October 2003: 15 200 tonnes automotive petrol and 10 522 tonnes petroleum products classified as dangerous for the environment (most likely to be gasoline or diesel) 3 May 2005: 26 900 tonnes automotive petrol and 10 522 tonnes petroleum products classified as dangerous for the environment (most likely to be gasoline or diesel)
British Pipeline Agency Limited	26 October 1999: 70 000 tonnes automotive petrol and other petroleum spirits
Shell UK Oil Limited	19 September 1983*: 37 397 tonnes HFLs Class 4 and 42 561 tonnes kerosene and white oils 30 November 1992: 34 013 tonnes petroleum spirit and 39 000 tonnes diesel, gas oil and kerosene 1999: 33 000 tonnes motor spirit and 17 000 tonnes kerosene

Figure 6 Hazardous substances consents issued

** **Note:** The first applications for 'consent' were in 1992, before then different arrangements were in place, ie these were notifications under NIHHS and consent was not required.*

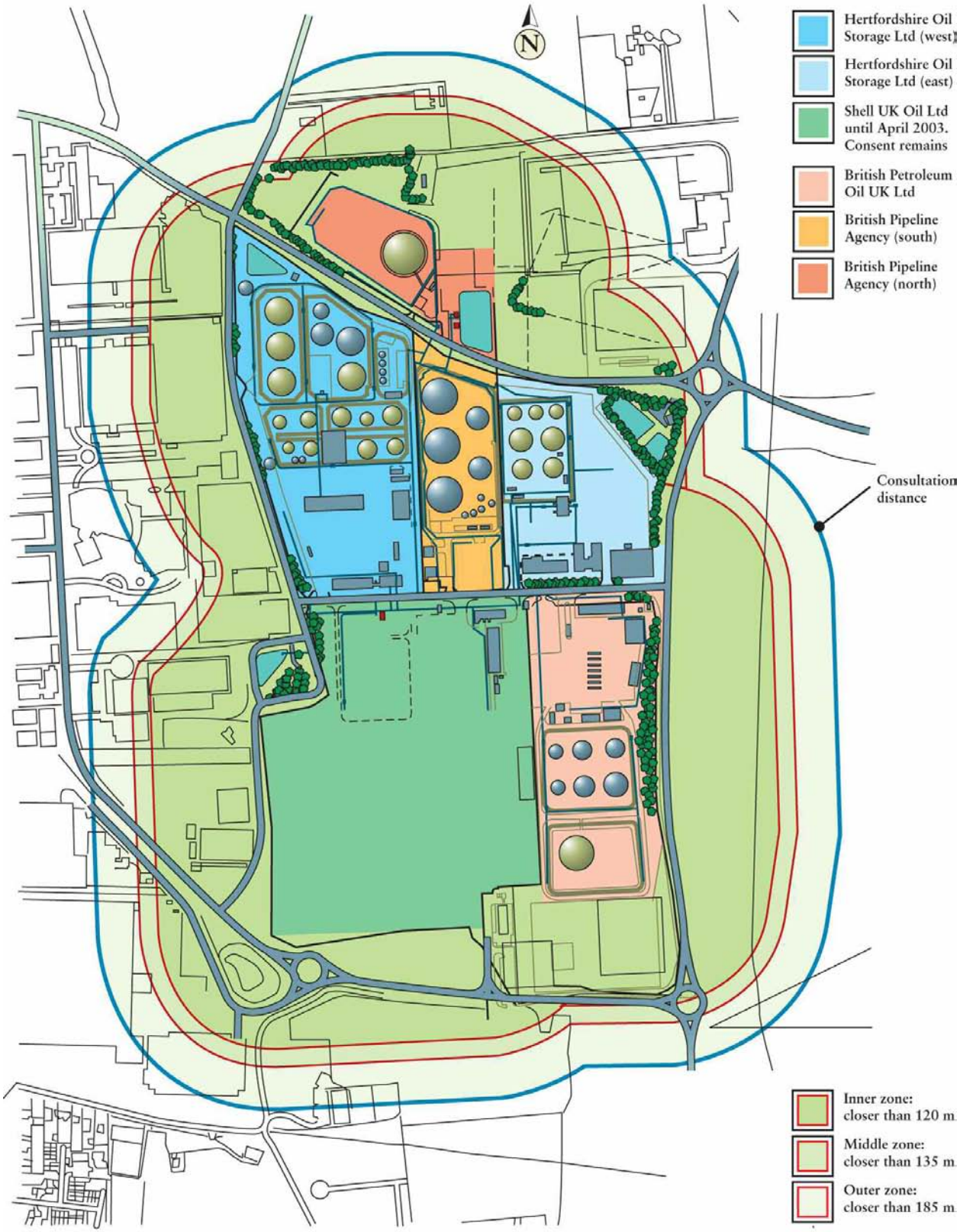

Figure 7 Plan representing the hazardous substances consents and consultation area around the Buncefield depot since July 2001 (for illustration only)

Annex 4

UK petroleum refinery, pipeline and storage system

Refineries

1 Petroleum products in the UK are predominantly supplied from nine refineries where crude oil is refined into liquefied petroleum gas (LPG), petrol, diesel, aviation fuel, gas oil, heating oil and residual bitumen. From a typical barrel of North Sea crude oil, approximately 3% becomes LPG, 37% petrol, 25% diesel, 20% kerosene (aviation fuel/heating oil) and 12% fuel oil (for power generation). Figure 8 shows the location of the refineries. They are sited on the coast or on estuaries so that they can receive crude oil by ship.

Figure 8 UK oil refinery and pipeline network

2 Storing, moving and delivering these fuels to the end user are important elements of the UK economy. Each year approximately 75 million tonnes of petroleum products are moved around the UK.

3 All nine main refineries in the UK have substantial storage for finished products coming out of the refinery. However, given the location of refineries, there are also large storage terminals around the country, generally near major conurbations. These terminals are mainly supplied from the refineries by pipeline, rail and sea. Often they are run as joint ventures between a number of oil companies. Commercial arrangements are commonly negotiated between companies to draw products on exchange from another company's terminal. This avoids the need to transport products over long distances from one terminal to another. Figure 9 shows the place of oil storage and transfer depots in the UK oil distribution system.

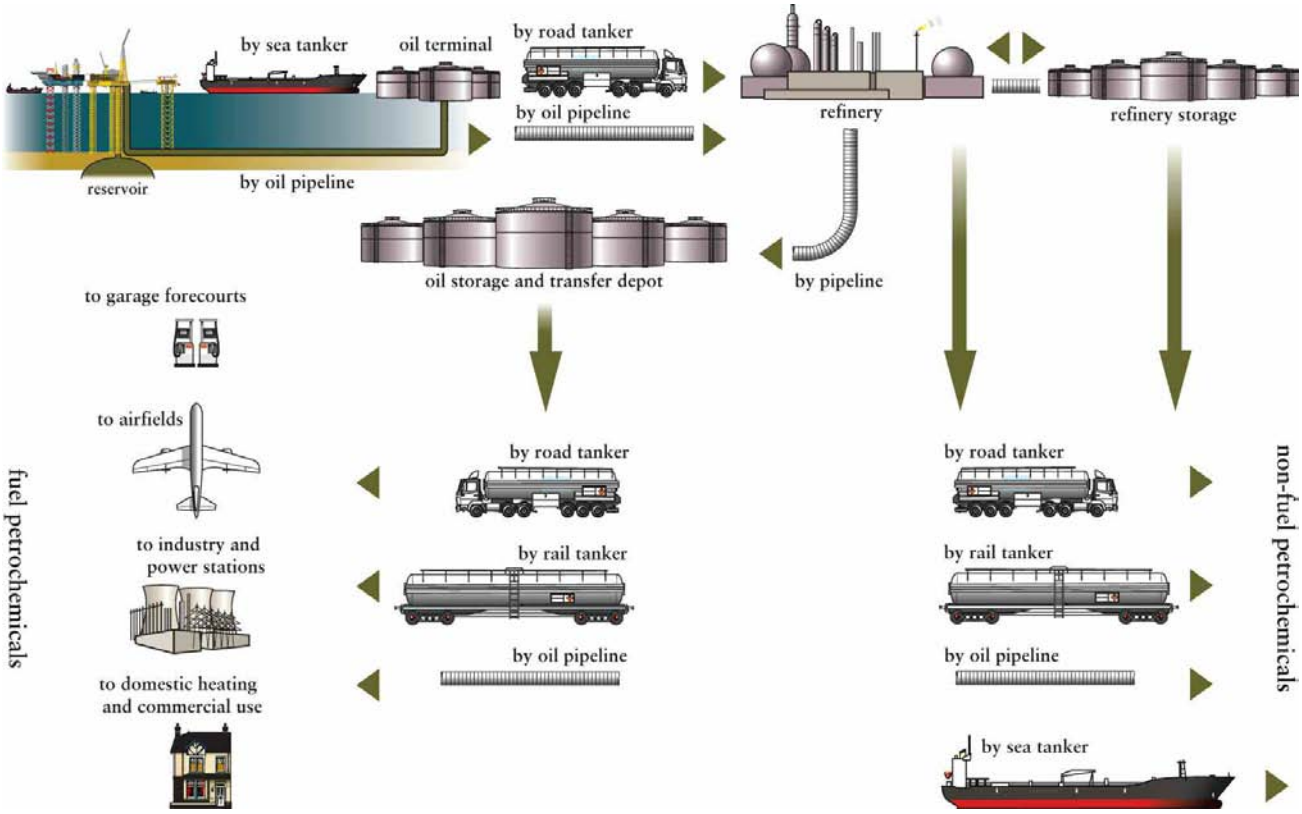

Figure 9 The UK oil distribution system

Petroleum pipelines

4 The UK mainland has a network of approximately 1500 miles of petroleum pipelines. Some of them are owned by individual oil companies dedicated to supplying their own terminals, and some are owned by joint ventures such as United Kingdom Oil Pipelines Limited (UKOP). Others belong to the Government. Once installed, underground pipelines offer substantial environmental and safety benefits, not least from the elimination of road tanker journeys or transportation by rail or sea.

5 These pipelines are used to transport a variety of fuels, including petrol, diesel, heating oil and aviation fuel. After a batch of predetermined volume of one fuel has been delivered through the pipeline, a different fuel may be transported. As the fuels travel along the pipeline, a relatively small degree of mixing will occur at the interface. As this volume of mixed fuels has to be reprocessed, the pipeline operator manages the flow rates continually to minimise these interfaces to reduce wastage. Around 30 million tonnes of fuel are moved around the UK in this way in a year.

Annex 5

Incidents that have similarities with the Buncefield incident

Location	Date and time	Comments – background	Comments – explosion	Ref *see over*
1 Houston, Texas, USA	April 1962	'Severe leak' from a gasoline tank. Almost windless conditions. Ignition near adjacent highway.	Described as a 'blast', but no details are available.	1
2 Baytown, Texas, USA	27 January 1977	Overfilling of a ship with gasoline.	Few details are available, but it is likely that there would have been congestion.	1
3 Texaco, Newark, New Jersey, USA	7 January 1983 After 00.00 hrs	Overfilling of a tank containing unleaded gasoline. 114-379 m^3 (80-265 tonnes) of gasoline released. Slight wind, ignition source 300 m away.	Relatively uncongested area. High overpressures reported, but not quantified. Three minor explosions preceded the main blast.	2
4 Naples Harbour, Italy	21 December 1985	Overfilling of a tank containing unleaded gasoline. 700 tonnes escaped. Low wind speed (2 m/s).	Relatively congested area. The tank overtopped 1.5 hours before ignition. Various overpressures estimated from damage analysis, but they are minimum values (eg >48 kPa).	3
5 St Herblain, France	7 October 1991 04:00 hours	Leak of gasoline from a transfer line into a bund. Wind <1 m/s. 20 minutes delay, ignition in car park c. 50 m away. Volume of flammable cloud est. 23 000 m^3.	Presence of parked petrol tankers may have been sufficient to generate turbulence. High overpressures produced, but not quantified.	4
6 Jacksonville, Florida, USA	2 January 1993 03:15 hours	Overfilling of a tank containing unleaded gasoline. 50 000 gallons (190 m^3, 132 tonnes) released.	High overpressure produced, but not quantified.	5
7 Laem Chabang, Thailand	2 December 1999 23:25 hours	Overfilling of a gasoline tank. Few details.	High overpressure produced, but not quantified. Relatively low congestion in the area.	6

Note: *The root cause of each of the above incidents was the spillage (loss of containment) of a large quantity of gasoline (eg >100 tonnes) due to overfilling of a tank, or failure of pipework inside a bund. In each case, the windspeed was very low, or zero, and a significant vapour cloud was able to form. The feature of the Buncefield explosion that appeared unique was the apparent lack of obstacles which could induce turbulence and thereby lead to rapid flame propagation, sufficient to produce the high overpressures recorded. Accordingly, incidents 2, 4 and 5 may not be relevant. As the 'lack of confinement' cannot be quantified, the relevance of the other incidents might be superficial. More information is required. Work is in hand to identify other incidents that may be relevant.*

References

1 Lenoir EM and Davenport JA 'A survey of Vapor Cloud Explosions: Second Update' *Process Safety Progress* 1993 **12** (1) 12-32

2 Bouchard JK *Gasoline Storage Tank Explosion and Fire: Newark NJ January 7, 1983* National Fire Protection Association (NFPA) Summary Investigation Report (in co-operation with Federal Emergency Management Agency/United States Fire Administration and National Bureau of Standards/Center for Fire Research)

3 Maremonti M, Russo G, Salzano E et al 'Post-accident Analysis of Vapour Cloud Explosions In Fuel Storage Areas' *Trans IChemE* 1999 77 (B) 360-365

4 Lechaudel JF and Mouilleau Y 'Assessment of an accidental vapour cloud explosion. A case study: Saint Herblain, October the 7th 1991, FRANCE' *Loss Prevention and Safety Promotion in the Process Industries* 1995 1 377-388

5 Edited from a report prepared by Lt Lorin L Mock, Training Division, Jacksonville Fire and Rescue Department 'Covered Floater in Jacksonville: Steuart Petroleum Bulk Storage Tank Fire' *Industrial Fire Safety* May/June 1993 17-32

6 *THAIOIL Fire: A whiff of oil, then a thundering explosion* Witness Accounts, Bangkok Post (FBKP) 5 December 1999 Page 1

Annex 6

Fire and explosion hazards from petrol

Introduction

1 This annex sets out a general explanation of the fire and explosion hazards from fuels such as petrol, as currently understood. It is not limited to the circumstances of the Buncefield incident.

Flashpoint

2 The physical properties of highly flammable liquids, such as petrol, are such that if they are mishandled or released they present a significant risk of fire or explosion. In this context, perhaps the most important property of petrol is its high volatility. At normal ambient temperatures, the vapour released by simple evaporation from the fuel surface can readily be ignited as it mixes with air. It is classified legally as a Highly Flammable Liquid, ie it has a flashpoint (measured in a 'closed cup' apparatus) below 32 ^{o}C.

3 'Flashpoint' is used to define the hazard associated with liquid fuels and to help determine safe working conditions. The flashpoint is defined as the minimum temperature at which a liquid fuel produces sufficient vapour to form a flammable or ignitable mixture with air. Petrol has a flashpoint of around minus 40 ^{o}C, well below normal (ambient) temperatures, and can be ignited very easily. It is the vapour that 'burns', releasing heat, some of which is transferred to the surface of the fuel, thus increasing the rate of evaporation that supplies the flame with fuel vapour. Paragraph 7 of this annex provides more information about fuel fires.

4 Not all concentrations of fuel vapour in air are flammable, ie capable of being ignited by a small ignition source such as a spark or a flame. Ignition can only occur if the mixture of flammable vapour in air falls within certain concentrations, known as the lower and upper explosion (or flammability) limits. For petrol vapour, concentrations below 1.4% in air are too lean to burn, while those above 7.6% are too rich.[18] At all concentrations between these two limits, known as the flammable range, the mixtures will burn, in that a flame will propagate away from the ignition source.

5 The flash point and the flammable range are determined by standard test methods.

6 Whether an ignition can give rise to a fire, an explosion or a combination of both depends on a number of factors, including the conditions prevailing at the time and the immediate surroundings of the release, but particularly on the amount of vapour present and how it is able to mix or diffuse with air.

Fires

7 In a fire, the vapour evolved from spilt or released material is ignited and continues to burn above the fuel surface where the vapour mixes with the surrounding air. This type of flame is known as a diffusion flame as the fuel vapour

[18] The concentration of petrol vapour in a partially full petrol tank is above the upper explosive limit and therefore too rich too burn.

and air mix by diffusion, and it is the type of flame associated with fires involving liquid and solid fuels. Heat transferred from the flame to the fuel provides the energy required to maintain the flow of fuel vapours that support the flame. The flames associated with a liquid pool fire will completely cover the surface and will continue to burn as long as there is fuel remaining. The flames of a petrol pool fire will extinguish when all the petrol is consumed, or if air can be excluded from the flames, or if the vapour release can be prevented or inhibited (as happens when the liquid surface is completely covered with a layer of fire-fighting foam).

8 With large hydrocarbon pool fires such as those at Buncefield, the flames are so large that mixing of fuel vapour and air is not efficient. This leads to the formation of species within the flame that cause the release of copious amounts of black smoke. The immediate precursors of the smoke are minute soot particles which radiate, producing the characteristic yellow colour associated with almost all diffusion flames. The hazards arising from such fires are due to heat transfer by radiation to neighbouring surfaces and to the hot fire products (rich in smoke and toxic gases) carried aloft by buoyancy. Pressure effects are negligible and could not cause structural damage, but heat transfer to structures immersed in the flames will cause weakening and eventual collapse.

Explosions

9 For an explosion involving petrol vapour to occur, the vapour/air mixture must be within its flammable range when it encounters a potential source of ignition. A flame will propagate rapidly, spreading spherically from the ignition source throughout the entire flammable mixture. The heat released as the fuel is consumed causes the gases to expand as a result of the associated temperature rise. If confined, eg if the mixture is contained within a building, the gases cannot expand freely and the pressure will rise until parts of the confining structure (such as the windows of a building) fail and relieve the pressure. This is normally a violent event and may produce a shock wave that can cause remote damage.

10 High temperature effects from the explosion are transient, but they will ignite highly flammable liquids and can ignite lightweight combustible solids (eg tissue paper). Some can be left burning after the explosion has passed. The flame created by an explosion of petrol vapour in air is blue or very pale yellow, depending on the fuel/air mixture. It is known as a premixed flame as the fuel vapour and air are mixed before ignition occurs. The amount of smoke produced is negligible compared to that produced in a fire.

11 In general terms, overpressures are not developed if an unconfined petrol vapour/air mixture is ignited because the gases can expand freely. However, the speed at which the flame travels through the flammable mixture can vary considerably, depending on a number of different factors. If the flame speed is very high, some overpressure will be created as the expansion cannot occur rapidly enough, despite the (apparent) lack of confinement. Factors that affect the speed with which a flame will travel through a flammable mixture include:

- composition of the mixture;
- amount of vapour and size of the flammable cloud;
- strength of the ignition source;
- degree of confinement within the flammable cloud ('partial confinement');
- turbulence created within the mixture as the flame front forces the unburnt mixture through a partially confined space.

12 The term 'partial confinement' is used to describe a situation in which obstacles lie in the path of the advancing flame. As the (as yet) unburnt mixture is forced past these obstacles, turbulence is produced. The flame will travel much more rapidly through a turbulent mixture than through a quiescent one.

13 The flame speed may vary from a few metres per second (m/s) to sonic velocities (340 m/s). Under certain conditions, supersonic velocities may be reached. If the velocity is subsonic the propagating flame is termed a deflagration. If the flame speed is greater than the speed of sound the explosion is termed a detonation. The faster a flame travels, the greater the overpressure produced. A cloud of petrol vapour in the open without any turbulence creating obstructions, such as complex pipe racks or congested plant, would on ignition produce a deflagration with a relatively slow flame speed (eg 10 m/s). Such an event would give rise to overpressures of about 0.2 psi (14 mbar). For a flame to accelerate beyond this and create higher overpressures, some or all of the factors mentioned above would have to play a part. A flame would not accelerate to detonation unless it was confined in a long narrow structure such as a pipeline.

14 As indicated above, if a flammable mixture is ignited within an item of enclosed plant or equipment, the pressure will build up until the plant either fails or a purpose-built vent or explosion relief panel opens. Storage tanks, for example, are normally designed with a weak roof joint so that in the event of an internal explosion, the explosive forces are vented upwards without the rest of the tank failing. Without any venting, and provided that the item of plant does not fail, an internal deflagration from hydrocarbon vapours could theoretically give a maximum pressure rise of approximately 130 psi (8.9 bar).

Flash fires

15 A flash fire can occur if a vapour rich cloud spreads from its release point, undergoing some dilution at the interface between the cloud and the surrounding air so that a flammable mixture exists only at the interface. The cloud still has a fuel-rich core. Upon ignition the flame front will rapidly propagate through the flammable regions of the cloud and the fuel-rich region will burn more slowly as it mixes with air. The flames will eventually become established as an ordinary diffusion flame at the point of origin. Flash fires do not usually generate any appreciable overpressure effects.

Overpressure

16 The pressure wave created by an explosion can have an effect on people, plant or property, in addition to the harmful effects from the burning vapour. The greatest effects from the pressure wave will be at the closest point to the explosion. Previous work to categorise the damage from blast overpressure has mainly considered the effects from conventional explosives and nuclear bomb tests, rather than the type of incident that occurred at Buncefield. Explosions are often classified according to their TNT equivalent, with an 'efficiency factor' used to compensate for the lower efficiency of an igniting vapour cloud in converting chemical energy into blast energy.

17 Another difference is that the blast from a conventional explosive has a high peak pressure over a short period of time, when compared to a hydrocarbon cloud which generates a lower peak pressure but of longer duration. The longer duration creates a higher impulse and therefore a different damaging effect than the same energy release from a high explosive. A further problem with using this information to analyse vapour cloud explosion events is the fact that conventional explosives have a point source, whereas a vapour cloud occupies a large volume.

18 The following table lists commonly accepted damage figures from blast overpressure and can be used for comparative purposes. However, care has to be taken in using this data as it does not take into account the duration of the pressure wave.

Commonly accepted damage figures from blast overpressure

Pressure (psi)	**Pressure (millibar)**	**Damage**
0.02	1.4	Annoying noise, if of low frequency
0.10	7	Breakage of small windows under strain
0.15	10	Typical pressure for glass failure
0.30	21	Damage to some ceilings
0.40	28	Minor structural damage
0.5-1.0	34-70	Large and small windows shattered, damage to window frames
0.75	52	Minor damage to houses, 20-50% of tiles displaced
0.9	63	Roof damage to oil storage tanks
1.0	70	Houses made uninhabitable
1.0-2.0	70-140	Asbestos cladding shattered, fastenings of corrugated steel panels fail, tiled roof lifted and displaced
2.0	140	Partial collapse of walls and roofs of houses, 30% of trees blown down
3.0	210	90% of trees blown down, steel framed buildings distorted and pulled away from foundations
3.0-4.0	210-280	Rupture of oil tanks
4.0-5.0	280-350	Severe displacement of motor vehicles
5.0	350	Wooden utility poles snapped
7.0-9.0	490-630	Collapse of steel girder framed buildings
8.0-10	560-700	Brick walls completely demolished
>10	>700	Complete destruction of all unreinforced buildings
70	4900	Collapse of heavy masonry or concrete bridges

Source: HSE Specialist Inspector Report Number 37 – Simplified calculations of blast induced injuries and damage

Commonly accepted figures for direct harm to people from blast overpressure

Pressure (psi)	**Pressure (millibar)**	**Direct harm to people**
2	138	Threshold for eardrum rupture
1.5-2.9	103-200	People knocked down or thrown to the ground
10-15	690-1035	90% probability of eardrum rupture
12-15	830-1035	Threshold of lung haemorrhage
30-34	2068-2400	Near 100% fatality from lung haemorrhage

19 HSE uses the following levels of overpressure for providing land use planning advice around hazardous installations. These are based on estimates of fatalities within occupied buildings.

Pressure (psi)	**Pressure (millibar)**	**Direct harm to people**
8.6	600	50% fatalities for a normal population
2	140	Threshold of fatality (1-5%) for a normal population
1	70	Threshold of fatality (1-5%) for a vulnerable population

Annex 7

Product composition at Buncefield

1 Extensive sampling of the various petroleum products at the Buncefield depot has been carried out to verify the product distribution through the site from the different supply pipelines, and also to identify the composition of the released materials. The majority of the samples were taken from the Hertfordshire Oil Storage Limited site but samples were also taken from the two pipelines feeding unleaded petrol to the site, the United Kingdom Oil Pipelines Limited T/K pipeline and the FinaLine pipeline from the Lindsey refinery.

2 As a release of unleaded petrol is considered to be the initiating event for the explosion and subsequent fire, all petrol samples have been tested against the standard BS EN 228 for automotive fuels, together with a full chemical analysis by an independent accredited test house.[19] Samples of other products handled on site including diesel, aviation fuel and gas oil have been subject to simple laboratory tests to confirm their identity.

Product identification

3 The test results from the samples taken on site are consistent with the product type identified from the site plans or by the company as being contained or held within any particular plant or section of pipework. Many of the samples showed degradation or contamination caused by heat-damaged plant or open pipework as a result of the incident. This degradation is particularly noticeable by the loss of the more volatile components, including butane, from many of the samples.

4 The loss of volatile components from the samples has made a direct comparison of their analytical results and subsequent tracking of the different product sources through the site extremely difficult. In addition representative samples from Tank 912 after the incident are not available as this tank completely burnt out, and only fire-damaged residues consisting mainly of water could be extracted from the tank bottom. The samples of the material feeding Tank 912, taken by the operator prior to the incident and retained on site, were destroyed during the incident.

Product composition

5 The evidence to date is consistent with the release of petrol from Tank 912 while it was being fed from the British Pipeline Agency Limited manifold. Petrol is a blend of many different hydrocarbons, each of which will have an impact on the vapour pressure. The British Pipeline Agency Limited manifold feeding Tank 912 was being supplied by a parcel of unleaded petrol from the British Petroleum PLC oil refinery at Coryton, Essex. That in turn was made up from the feed from four separate tanks. No sample of the parcel is available as the part-batches from the feeder tanks are not blended and tested as a composite batch before being pumped from site. British Petroleum PLC has provided the Conformity Certificates for the individual feeder tanks showing their analysis against the British Standard. The British Standard is a performance specification and only details specific limits for

[19] BS EN 228: 2004 *Automotive fuels. Unleaded petrol. Requirements and test methods.* Available online at www.bsonline.bsi-global.com.

the chemicals lead and benzene. By way of example, the standard does not specifically limit the content of butane, which comprises a mixture of butanes and butenes, and therefore the presence and levels of these individual components are not routinely determined. The total butane content, however, will affect the vapour pressure and this is specified in the standard depending on whether the product is marketed as winter or summer grade. For winter grade petrol the vapour pressure limits are defined as 70-100 kPa and for summer they are reduced to 45-70 kPa.

6 The Conformity Certificates show that the vapour pressure for the four part-batches were all at or very close to 100 kPa. This was corroborated by evidence obtained from the British Pipeline Agency Limited site after the incident. This corresponded to a total butane content of 10.0%. By contrast, other samples of petrol taken from the site after the incident and which had been degraded by exposure to the fire were found to have lower vapour pressures and correspondingly lower butane levels. Therefore the product released on site was at the top end of the winter grade limit for vapour pressure. A reasonable estimate of the butane content of the released material is 10% by weight.

Annex 8

Regulatory framework for high hazard sites

1 The regulatory framework for sites such as Buncefield, which present potential major accident hazards, comprises requirements imposed on the site operators under both health and safety and environmental legislation, complemented by the requirements of planning law. In particular, the Control of Major Accident Hazards Regulations 1999 (COMAH) apply.

Health and safety law

2 Operators in the process industries are subject to the requirements of the Health and Safety at Work etc Act 1974 (the HSW Act) and the Management of Health and Safety at Work Regulations 1999 which require, respectively, safety policies and risk assessments covering the whole range of health and safety risks.

Control of Major Accident Hazards Regulations 1999 (COMAH)

3 COMAH's main aim is to prevent and mitigate the effects of those major accidents involving dangerous substances, such as chlorine, liquefied petroleum gas and explosives which can cause serious damage/harm to people and/or the environment. The COMAH Regulations treat risks to the environment as seriously as those to people. They apply where threshold quantities of dangerous substances identified in the Regulations are kept or used. There are two thresholds, known as 'lower-tier' and 'top-tier'. The requirements of COMAH are fully explained in The requirements of COMAH are fully explained in *A guide to the Control of Major Accident Hazards Regulations 1999 (COMAH). Guidance on Regulations* L111 HSE Books 1999 ISBN 0 7176 1604 5.

4 The COMAH Regulations are enforced by a joint Competent Authority comprising HSE and the Environment Agency in England and Wales, and HSE and the Scottish Environment Protection Agency (SEPA) in Scotland. Operators will generally receive a single response from the Competent Authority on all matters to do with COMAH. The Competent Authority operates to a Memorandum of Understanding, which sets out arrangements for joint working.

5 The COMAH Regulations require operators of top-tier sites to submit written safety reports to the Competent Authority with the purpose, among others, of demonstrating that major accident hazards have been identified and that the necessary measures have been taken both to prevent such accidents and to limit any consequences. Operators of top-tier sites must also prepare adequate emergency plans to deal with the on-site consequences of possible major accidents, and to assist with off-site mitigation. Local authorities for areas containing top-tier sites must prepare adequate emergency plans to deal with the off-site consequences of possible major accidents, based on information supplied by site operators.

6 The COMAH Regulations place duties on the Competent Authority to have in place a system of inspections for establishments subject to the Regulations, and to prohibit the operation of an establishment if there is evidence that measures taken for prevention and mitigation of major accidents are seriously deficient. The Competent Authority also has to examine safety reports and inform operators about the conclusions of its examinations within a reasonable time period.

7 The inspection plan for a particular establishment is drawn up by inspectors from the Competent Authority based on previous interventions at the site and on information gained from the assessment of the safety report. The inspection programme requires input from a range of inspectors with specialist knowledge and identifies and prioritises issues. The focus of the programme is to ensure that the key risk control measures for preventing and mitigating major hazards are maintained.

8 The adequacy of this process and its application at Buncefield by HSE and Environment Agency inspectors is subject to a review under term of reference 3.

Environmental legislation

9 Some of the establishments regulated under the COMAH Regulations are also regulated by the Environment Agency and SEPA (the Agencies) under the Pollution Prevention and Control Act 1999 (PPC) or Part I of the Environmental Protection Act 1990 (EPA 90). The regime under EPA 90 is gradually being replaced by the PPC regime and will be fully replaced by 2007.

10 While the purpose of the COMAH Regulations (the prevention of major accidents) differs from that of PPC, the means to achieve them are almost identical. They require industry to have good management systems to control risk. PPC includes a specific duty to prevent and mitigate accidents to the environment which is complementary to the main COMAH duty. The Agencies manage this overlap between their different regimes following the principle that accident prevention work on COMAH sites is generally more significant because of the greater risks.

Supporting guidance and standards

11 The legal requirements are supported by a large body of guidance and standards that set out recognised good practice in the control of major accident hazards. This includes national and international standards, industry guidance and guidance published by the Competent Authority. Examples of the latter are *Reducing error and influencing behaviour* HSG48 (Second edition) HSE Books 1999 ISBN 0 7176 2452 8 and *Successful health and safety management* HSG65 (Second edition) HSE Books 1997 ISBN 0 7176 1276 7.

Land use planning

12 The land use planning aspects of the Seveso II Directive are given effect in the UK by the Planning (Hazardous Substances) Regulations 1992, as amended in 1999. Under these Regulations the presence of hazardous chemicals above specified thresholds requires consent from the hazardous substances authority, usually the local planning authority. HSE is a statutory consultee on such occasions. The role of HSE is to consider the hazards and risks which would be presented by the hazardous substances to people in the vicinity, and on the basis of this advise the hazardous substances authority whether or not consent should be granted. HSE will also supply a consultation distance around the site. Any future developments in these zones require HSE to be consulted.

13 The aim of health and safety advice relating to land use planning is to mitigate the effects of a major accident on the population in the vicinity of hazardous installations, by following a consistent and systematic approach in providing advice on applications for planning permission around such sites.

14 Historically, HSE has based its land use planning advice on the presumption that site operators are in full compliance with the HSW Act. Section 2 of the Act places a duty on an employer to ensure, so far as is reasonably practicable, the

health and safety of his employees. There is a corresponding duty in section 3 to ensure, so far as is reasonably practicable, that others (including the public) are not exposed to risks to their health and safety. These duties are goal-setting and operators are expected to determine the most appropriate means to comply with them, without the need for detailed approval from HSE.

15 Under the General Development Procedure Order 1995, both HSE and the Environment Agency are statutory consultees for:

- the development of a new major accident hazard site; or
- developments on an existing site which could have significant repercussions on major accident hazards; or
- other developments in the vicinity of existing establishments, where the siting or development is such as to increase the risk or consequences of a major accident.

Annex 9

Regulation of perfluorooctane sulphonates (PFOS)

1 Perfluorochemicals are a family of chemicals used in products designed to repel dirt, grease and water, including kitchenware, carpet treatments, food wrappers, sprays for leather and other clothing, paints and cleaning products.

2 A group of these substances, perfluorooctane sulphonates (collectively identified as PFOS), has been shown to be hazardous (persistent, bioaccumulative and toxic). PFOS has been used in a diverse range of applications, from fire-fighting foam additives to use as a mist suppressant in chromium plating. PFOS was also used in common household anti-soil treatments often referred to by the trade name 'Scotchgard' (a trademark of 3M PLC).

3 The UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT), an independent scientific committee that provides advice to the Food Standards Agency, the Department of Health and other Government Departments and Agencies on matters concerning the toxicity of chemicals - is currently evaluating PFOS, most recently in May 2006.[20]

4 On the basis of the preliminary COT discussions, the Health Protection Agency advised the Drinking Water Inspectorate in March 2006 that, 'It appears unlikely that a lifetime's consumption of drinking water containing concentrations up to three microgrammes (of PFOS) per litre would harm human health' and that 'drinking-water concentrations of PFOS should not exceed three microgrammes per litre.' The Health Protection Agency will review its advice when COT has finalised its assessment of PFOS.

5 In the light of current Health Protection Agency advice, the Drinking Water Inspectorate's view (29 March 2006) is that to safeguard human health, PFOS should not be present in drinking water supplies above three microgrammes/litre (µg/l).

6 PFOS does not appear to undergo any degradation in the natural environment. Due to this extreme stability it has now become widespread both in man and the environment. The biological persistence of PFOS in living organisms is high, with an estimated elimination half-life for humans of the order of four to eight years.

7 These concerns resulted in the principal manufacturer of PFOS (3M) announcing a voluntary phase-out of PFOS manufacture from 2001 onwards. PFOS, however, continues to be produced by some companies and is used in some industrial processes, for example semiconductor production and chromium plating. PFOS was used as an ingredient in some AFFF Class B fire-fighting foam concentrates until a few years ago. These concentrates have a shelf life of at least ten years and remaining stocks will therefore continue to be available for use on oil fires.

8 DEFRA consulted on a national action to restrict the use of PFOS and substances that may degrade to PFOS in October 2004. This included proposals to phase out the use of PFOS in fire-fighting foams. In December 2005, the European Commission issued a proposal for a Directive restricting the marketing and use of PFOS. In this draft Directive PFOS used in fire-fighting foams as well as

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20 The COT minutes and background working paper are available from www.food.gov.uk/science/ouradvisors/toxicity/cotmeets/cot2006/334454.

photolithography, photographic coats, chromium plating and hydraulic fluids for aviation would be allowed to continue.

9 The Environment Agency has conducted a national environmental risk assessment of PFOS.[21] This concluded that there was an environmental risk for all PFOS uses. For now, the drive to minimise PFOS in the environment and drinking water has to be reconciled with its continued use in some industrial sectors.

10 The risk reduction strategy proposed by DEFRA would have phased out PFOS use in chrome plating two years after the legislation came into force, and in fire-fighting foam and most other applications five years after the legislation came into force. The draft EU Directive (December 2005) on PFOS does not phase out the use of PFOS in these applications. The EU has now prohibited the UK from imposing unilateral restrictions on the use of PFOS and any action to restrict the use of PFOS will now proceed at an EU level.

The Environment Agency's approach

11 The Environment Agency's policy aim is to progressively reduce and ultimately phase out the discharge of PFOS to controlled waters. However, the Environment Agency does not regulate all users and, due to its widespread presence, it is not feasible to prevent all discharges of PFOS into controlled waters. When calculating acceptable concentrations of PFOS in consented effluent discharges to surface water the Environment Agency will aim to prevent detectable emissions where possible. As PFOS is a List I substance under the Groundwater Directive, the Environment Agency cannot authorise its disposal to groundwater.

[21] Brooke D, Footitt A and Nwaogu TA *Environmental risk evaluation report: perfluorooctane sulphonate (PFOS)* Research Contractor: Building Research Establishment Ltd. Risk and Policy Analysts Ltd.

Annex 10

Legal considerations

Prosecution decision making

1 The Board is aware that the process of making enforcement decisions is complex. Every duty holder and situation is unique. The prosecution decision can only be considered once the criminal investigation is fully complete, ie all reasonable lines of enquiry have been followed (in line with the Code of Practice issued pursuant to the Criminal Procedure and Investigations Act 1996). In the case of HSE, the HSC Enforcement Policy Statement sets out the approach to be followed, in accordance with the aims of the Government's 'Principles of Good Enforcement' and requires HSE to apply the Code for Crown Prosecutors (The Code).

2 The Environment Agency has its own Enforcement and Prosecution Policy, which also relies on those principles and commits the Agency to take account of the Code. Each case is unique and will be considered on its own merits. Any prosecution decision requires a careful balancing of individual factors present in that particular case and will be taken by a lawyer who is independent of the Investigation.

3 The Code states that the decision-maker (prosecutor) must be fair, independent and objective. It is their duty to review cases and to ensure that the law is properly applied, that all relevant evidence is put before the court and that obligations of disclosure are complied with. The prosecutor will also ensure that the investigators have identified any material that might undermine the prosecution case or assist the defence, and that they have acted in compliance with the Human Rights Act 1998. The more complex the circumstances of a case and/or the technical evidence, the longer this process may take.

Evidential stage

4 There is a strict order in which the prosecutor must apply the two stages which form the Full Code Test under the Code. The prosecutor must first consider the evidential stage. If there is not the required level of evidence then no prosecution can go ahead, no matter how important the case or how strong the public interest is in favour of prosecution. The prosecutor must be satisfied that the evidence is admissible to meet the evidential test.

5 To pass the evidential stage the Approval Officer must be satisfied that there is enough evidence to form 'a realistic prospect of conviction' against each defendant on each charge. This is a different test to the one that magistrates or juries have to apply. This is not simply a case of percentages. The evidential stage is met if there is 'sufficient evidence to ensure that a jury or bench of magistrates, with a correct understanding of the law, is more likely than not to convict the defendant of the alleged charge.'

6 The prosecutor's considerations will include:

- Is there any evidence which might support or detract from the reliability of an admission?
- What explanation has the suspect given?
- Is the character of any of the witnesses likely to weaken their evidence?
- Does the witness have a motive that might influence his or her evidence?
- Is there any concern over the accuracy or credibility of a witness? If so, what is the basis for that concern?

Public interest stage

7 If the case meets the standard required by the evidential stage, only then can the prosecutor consider whether a prosecution is required in the public interest. The prosecutor has to balance the factors for and against prosecution very carefully. The decision must not be affected by improper or undue pressure from any source.

8 For HSE, the HSC Enforcement Policy Statement sets out the common health and safety public interest factors, which, if one or more is present, HSC expects should lead to a prosecution, eg where:

- death was a result of the breach of legislation;
- the gravity of an alleged offence, taken together with the seriousness of any actual or potential harm, or the general record and approach of the offender, warrants it;
- there has been a reckless disregard for health and safety requirements, repeated breaches which give rise to significant risk, or persistent and significant poor compliance;
- work has been carried out in serious non-compliance with an appropriate licence or safety case;
- a duty holder's standard of managing health and safety is found to be far below what is required by health and safety law and to be giving rise to significant risk;
- there has been a failure to comply with an improvement or prohibition notice, or there has been a repetition of a breach that was subject to a formal caution;
- false information has been supplied wilfully, or there has been an intent to deceive, in relation to a matter which gives rise to significant risk;
- inspectors have been intentionally obstructed in the lawful course of their duties.

9 The list is not exhaustive. The Enforcement Policy Statement acknowledges that there may be occasions where these factors may be present but that the public interest does not require a prosecution.

10 The Environment Agency will consider the environmental effect of the alleged offence, the foreseeability of the offence or the circumstances leading to it, the intent of the offender, any history of offending, the attitude of the offender, whether a prosecution is required in order to ensure deterrence, and the personal circumstances of the offender. Again the list is not exhaustive.

11 There is a presumption that the Environment Agency will prosecute where one or more of the following are present:

- Incidents or breaches that have significant consequences for the environment, or which have the potential for such consequences.
- Operations have been carried out without a licence.
- There have been excessive or persistent breaches of regulatory requirements.
- There has been a failure to comply or to comply adequately with formal remedial requirements.
- There has been reckless disregard for management or quality standards.
- There has been a failure to supply information without reasonable excuse, or knowingly or recklessly supplying false or misleading information.
- Agency staff have been obstructed.
- There has been an attempt to impersonate Agency staff.

12 The Code for Crown Prosecutors also lists other relevant factors for and against prosecution, which again are not exhaustive. The prosecutor balances the factors for and against prosecution.

Views of the victim(s) (part of the public interest stage)

13 The prosecutor will also take into account the consequences for the victim of the decision to prosecute or not to prosecute, and any views expressed by the victim or the bereaved. While the prosecutor will 'take into account' their views, neither enforcement authority is bound to follow those views when reaching the final decision on enforcement.

Glossary

ambient temperature The temperature of the surrounding air

aquifer A water-bearing stratum of porous rock, gravel or sand

bar and millibar Although a bar is not a measure in the International System of Units (SI), it is one of the units used in meteorology when describing atmospheric pressure. The SI unit for measuring pressure is the pascal (Pa). A millibar is equal to 1/1000 of a bar, or 100 pascals (a hectopascal)

bioaccumulative Literally, to accumulate in a biological system. It is commonly taken to measure the uptake over time of toxic substances that can stay in a biological system

borehole A cylindrical shaft drilled into the ground, often for geological exploration or extraction of resources

Bronze command The working name for the operational command level during a Major Incident

bund An enclosure designed to contain fluids should they escape from the tank or vessel inside the bund, as well as any additional materials added to the container area such as fire-fighting water and foam, etc

COMAH See Control of Major Accident Hazards Regulations 1999

COMAH sites A site to which the Control of Major Accident Hazards Regulations 1999 apply

Competent Authority The Control of Major Accident Hazards Regulations (COMAH) are enforced by a joint Competent Authority comprising the Health and Safety Executive (HSE) and the Environment Agency in England and Wales, and HSE and the Scottish Environment Protection Agency in Scotland

Control of Major Accident Hazards Regulations 1999 The main aim of these Regulations is to prevent and mitigate the effects of those major accidents involving dangerous substances, such as chlorine, liquefied petroleum gas, and explosives which can cause serious damage/harm to people and/or the environment. The Regulations treat risks to the environment as seriously as those to people. They apply where threshold quantities of dangerous substances identified in the Regulations are kept or used. See also Seveso II

duty holder In the context of this report, any person or organisation holding a legal duty – in particular those placed by the HSW Act, the Management Regulations, and the COMAH Regulations

Environment Agency The Environment Agency is the lead regulator in England and Wales with responsibility for protecting and enhancing the environment. It was set up by the Environment Act 1995 and is a non-departmental public body, largely sponsored by the Department for Environment, Food and Rural Affairs and the National Assembly for Wales

fire-water Water stored for use during, and used during, fire-fighting operations

foam In the context of this report, a foam used during operations to extinguish hydrocarbon fires

forthwith action The Investigation terms of reference require the Investigation team and Board to 'identify and transmit without delay to duty holders and other appropriate recipients any information requiring immediate action to further safety and/or environmental protection in relation to storage and distribution of hydrocarbon fuels.' This is referred to as 'forthwith' action for both the Investigation, the Competent Authority, and duty holders

Gold command The working name for the strategic command centre during a Major Incident - also known as the Strategic Co-ordinating Group

groundwater All water below the water-table, as opposed to 'ground waters', which include groundwater but also sub-surface water above the water-table. The term 'ground water', where used in the previous progress reports, should normally have read 'groundwater'

hazard Anything with the potential to cause harm

Health and Safety Commission The Health and Safety Commission is a statutory body, established under the Health and Safety at Work etc Act 1974, responsible for health and safety regulation in Great Britain

Health and Safety Executive The Health and Safety Executive is a statutory body, established under the Health and Safety at Work etc Act 1974. It is an enforcing authority working in support of HSC. Local authorities are also enforcing authorities under the Health and Safety at Work etc Act 1974

HSC See Health and Safety Commission

HSE See Health and Safety Executive

hydrocarbon An organic chemical compound of hydrogen and carbon. There are a wide variety of hydrocarbons such as crude oil (basically a complex mixture of hydrocarbons), methane, propane, butane etc. They are often used as fuels

Improvement Notice Improvement Notices are one of a range of means which enforcing authorities use to achieve the broad aim of dealing with serious risks, securing compliance with health and safety law and preventing harm. An Improvement Notice allows time for the recipient to comply

kiloPascal Pascals (Pa) are the unit of pressure in the International System of Units (SI). A kiloPascal (kPa) is equal to 1000 Pa. Although bar are not units within SI, they are sometimes used as units to measure atmospheric pressure. 1 kPa = 10 bar. See also bar and millibar

kPa See kiloPascal

lower-tier See tier

Major Accident To The Environment DEFRA has established threshold criteria defining a 'Major Accident To The Environment' (MATTE), based on Schedule 7 (part 1) of the Control of Major Accident Hazards Regulations 1999. The Environment Agency, using these criteria, has determined that the Buncefield incident is a MATTE, and the Competent Authority has recently reported this to the European Commission

MATTE See Major Accident To The Environment

millibar See bar and millibar

overpressure For a pressure pulse (or blast wave), the pressure developed above atmospheric pressure

perfluorooctane sulphonates A group of chemicals, collectively identified as PFOS, which have been shown to be hazardous (persistent, bioaccumulative and toxic). PFOS chemicals have been used in a diverse range of applications, including as an additive to aid the spreading properties of fire-fighting foam

perfluorosurfactant In the context of the Buncefield incident, a surfactant is a chemical added to fire-fighting foam which allows the foam to form a thin sealing film over the burning fuel. Perfluorosurfactants are a type of surfactant

PFOS See perfluorooctane sulphonates

pool fire A fire over a pool of fuel and/or water or other liquids

primary containment The tanks, pipes and vessels that normally hold liquids, and the devices fitted to them to allow them to be safely operated

pumphouse In the context of this report, the structure enclosing the pumping equipment used to move water around the Buncefield site prior to the incident. It principally stored water intended for fire-fighting operations

risk The likelihood that a hazard will cause a specified harm to someone or something

run off Uncontained liquid, either deposited on site as rain, or in the context of the Buncefield incident, fuel and/or fire-water not contained as part of the operation to control the incident

Safety Alert Where the Competent Authority considers that an issue poses significant risk, it can choose to issue a Safety Alert to operators of COMAH sites informing them of the issue and possibly requiring them to undertake certain activity

SCG See Strategic Co-ordinating Group

Scottish Environment Protection Agency The public body which is responsible for the protection of the environment in Scotland

secondary containment Enclosed areas around storage vessels (often called bunds), created usually by concrete or earth walls. Their purpose is to hold any escaping liquids and any water or chemicals used in fire-fighting

SEPA See Scottish Environment Protection Agency

Seveso II In 1976, a major accident occurred in Seveso, Italy, where the accidental production and release of a dioxin as an unwanted by-product from a runaway chemical reaction led to widespread contamination. A number of such incidents, and the recognition of the differing standards of controls over industrial activities within the European Community, led the European Commission to propose a Directive on the control of major industrial accident hazards. The Directive on the Major Accident Hazards of Certain Industrial Activities (82/501/EEC) was adopted on 24 June 1982, and is generally known as the Seveso Directive. Following a complete review of the Directive by the European Commission a new one, now known as Seveso II, came into force on 3 February 1997 and was implemented in Great Britain on 1 April 1999 by the Control of Major Accident Hazards Regulations 1999, except for land use planning requirements, which were implemented by changes to planning legislation

Silver command The working name for the tactical command centre during a Major Incident

Strategic Co-ordinating Group Representation of all agencies deployed to resolve the Buncefield incident was established through a meeting process known as the Strategic Co-ordinating Group, also known as Gold Command

surface water Water that sits or flows above land, including lakes, seas, rivers and streams

tank farm A facility where hazardous substances, very often petroleum products, are stored in tanks

tertiary containment The site surface and associated drainage, boundary walls, roads, containment kerbs and any features such as road humps that can provide some retention of liquids. Proper design of drainage systems will limit loss of product out of the site and prevent lost product permeating into the ground with the potential risk that it can migrate to groundwater, or contaminate surface waters and land

tier The Control of Major Accident Hazards Regulations 1999 apply where threshold quantities of dangerous substances identified in the Regulations are kept or used. There are two thresholds, known as 'lower-tier' and 'top-tier', and COMAH sites fall into one or other of these

topography The physical configuration of the surface of the land, including its elevation, slope, and orientation

top-tier See tier

ultimate high-level switch Part of the system to prevent overfilling of the tank, the ultimate high-level switch is an independent mechanism which should be triggered when the 'ultimate high level' (ie the specified maximum capacity) is reached in a tank to which it is fitted, both causing an alarm to sound and shutting down the supply of fuel to the tank

vapour pressure A measure of the tendency of a material to form a vapour. The higher the vapour pressure, the higher the potential vapour concentration

volatility The readiness of a substance to evaporate

wind girder Structural stiffening ring attached to the tank side wall

Further information

Useful links

Buncefield Major Incident Investigation
Marlowe Room, Rose Court
2 Southwark Bridge
London, SE1 9HS
Tel: 020 7717 6909
Fax: 020 7717 6082
E-mail: buncefield.inforequest@hse.gsi.gov.uk
Web: www.buncefieldinvestigation.gov.uk

Community/Business support
Dacorum Business Contact Centre
Tel: 01442 867 805

Business Link Helpline
Tel: 01727 813 813

Hertfordshire Chamber of Commerce
Tel: 01727 813 680

Dacorum Community Trust Mayor's Fund
To apply, call the freephone helpline on 0800 131 3351.
Lines are open 9.30 am-4.30 pm, Monday to Friday

Dacorum Borough Council
Tel: 01442 228 000
Web: www.dacorum.gov.uk

Hemel Hempstead Citizens Advice Bureau
19 Hillfield Road, Hemel Hempstead HP2 4AA
Tel: 01442 213368

Local authorities and emergency services
Dacorum Borough Council
Tel: 01442 228 000
Web: www.dacorum.gov.uk
(Dacorum Borough Council Digest newsletter, available monthly
Dacorum Borough Council Buncefield Update Newsletter)

St Albans District Council
Tel: 01727 866 100
Web: www.stalbans.gov.uk

Hertfordshire County Council
Tel: 01483 737 555
Web: www.hertsdirect.org

Hertfordshire Fire and Rescue Service
Web: www.hertsdirect.org/yrccouncil/hcc/fire/buncefield

Hertfordshire Constabulary
Web: www.herts.police.uk/news/buncefield/main.htm

Hertfordshire Chamber of Commerce
Tel: 01727 813 680
Web: www.hertschamber.com

Government links
Department for Communities and Local Government
Fire and Resilience Directorate
Web: www.communities.gov.uk

Government Office for the East of England
Web: www.go-east.gov.uk

Environment Agency
Web: www.environment-agency.gov.uk

Department of Trade and Industry
Oil and Gas Directorate
Web: www.og.dti.gov.uk

Health and Safety Executive
Hazardous Installations Directorate
Web: www.hse.gov.uk/hid
Control of Major Accident Hazards
Web: www.hse.gov.uk/comah

Department for the Environment, Food and Rural Affairs
Web: www.defra.gov.uk

Health Protection Agency
Web: www.hpa.org.uk

Food Standards Agency
Web: www.food.gov.uk

Drinking Water Inspectorate
Web: www.dwi.gov.uk

Industry links
United Kingdom Petroleum Industry Association (UKPIA)
Tel: 020 7240 0289
Web: www.ukpia.com

Chemical Industries Association
Tel: 020 7834 3399
Web: www.cia.org.uk

Three Valleys Water
Tel: 0845 782 3333
Web: www.3valleys.co.uk

Investigation reports
Buncefield Major Incident Investigation:

- Progress Report, published 21 February 2006
- Second Progress Report, published 11 April 2006
- Third Progress Report, published 9 May 2006

Available from www.buncefieldinvestigation.gov.uk

DEFRA: Initial review of Air Quality aspects of the Buncefield Oil Depot Explosion
www.defra.gov.uk/environment/airquality/buncefield/buncefield-report.pdf

Hertfordshire Fire and Rescue Service's Report into the 'Fire Response' – to be published in November 2006

Angus Fire, Buncefield Oil Terminal Incident December 2005: Review of part played by Angus Fire and lessons learned
www.angusfire.co.uk

Other related reports/information
East of England Development Agency – report by SQW, Economic Developments Consultants on: *The Buncefield Oil Depot Incident: Economic and Business Confidence Impact Study*, June 2006
www.eeda.org.uk

Swiss Fire Service: *Quick Look Report – Buncefield Fire 11 December 2005*

Contract research reports for HSE

- W.S. Atkins Science and Technology: Derivation of fatality probability functions for occupants of buildings subject to blast loads Phases 1, 2, & 3 - 147/1997 and Phase 4 - 151/1997

- Biomedical Sciences Chemical and Biological Defence Sector Defence Evaluation and Research Agency: Review of blast injury data and models 192/1998

Available from: www.hsebooks.com

Government Advisory Bodies

- Committee on mutagenicity of chemicals in food, consumer products and the environment (COM)

- Committee on carcinogenicity of chemicals in food, consumer products and the environment (COC)

- Committee on toxicity of chemicals in food, consumer products and the environment (COT)

www.advisorybodies.doh.gov.uk/coc/

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