The environmental impact of the foot and mouth disease outbreak: an interim assessment

ENVIRONMENT AGENCY

December 2001

This report and other information on foot and mouth and the environment are available on the Environment Agency's web site at **www.environment-agency.gov.uk**

Copies of the report in English, or Welsh bilingual, are available from Agency offices (tel: 0845 933 3111)

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ISBN 1-85-7057856

Printed on Cyclus Print

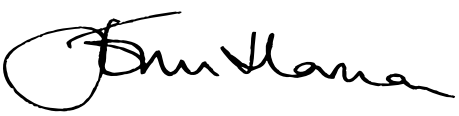
Foreword

The outbreak of foot and mouth disease, which began in February 2001, was a major incident for the nation with widespread economic and social implications. There has been much reporting in the media and elsewhere so why the need for this report? The Environment Agency worked with others from the outset to ensure that the way the crisis was managed protected the environment at the same time. This report looks at the effectiveness of the actions taken.

In general, any environmental impacts have been short-term and localised; much smaller than the day-to-day impacts of current farming practices. The prevention of pollution during an event of such an unprecedented scale in the disposal of animals testifies to the relevance of our actions.

We cannot be sure, however, that there will be no long-term impacts on groundwaters from the burial of carcasses and ash. But we will be monitoring to ensure that any problems are detected and dealt with.

The largest environmental impact of the outbreak is likely to be due to any restructuring of the farming industry as a consequence. We hope that it will be beneficial. This opportunity must be grasped to bring farming onto a more sustainable footing whereby food production, rural well-being, and environmental enhancement are promoted together.



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Executive summary

1. This report provides an assessment of the environmental impact of the foot and mouth outbreak in England and Wales up until October 2001. It is an interim report, which will be updated as more monitoring takes place and more information becomes available. We recognise that environmental impacts are only part of a wider range of impacts, including social and economic impacts. These have been addressed by others such as the Countryside Agency and need to be considered alongside this report.

2. The report:

   - provides an integrated assessment of how the outbreak and the activities associated with its management have affected the environment and puts these into perspective;
   - demonstrates the role played by the Environment Agency in minimising these stresses and impacts;
   - provides an overview to inform the many inquiries that have been announced and the wider debate on future agriculture policy.

3. The main potential pressures on the environment due to the outbreak have been:

   - the disposal of about six million animal carcasses, two-thirds from disease control and one-third from welfare cull, amounting to some 600,000 tonnes. Provisional data show that about 14 per cent went to mass burial, 16 per cent to commercial landfills, 22 per cent to rendering, and the remaining 48 per cent was either burnt or buried on farms;
   - the disposal of pyre ash;
   - the use and disposal of large amounts of disinfectant;
   - the need to find alternative outlets or storage facilities for wastes normally applied to land;
   - a possible increase in illegal activities and pollution as a consequence of reduced access to sites by Agency staff and others responsible for environmental protection;
   - potential increase in flood risk where defence maintenance and construction was disrupted by access restrictions.

4. Two sources of pressures on the environment may have been reduced due to the outbreak:

   - the numbers of tourists and visitors to the countryside;
   - the density of livestock where there has been mass cull.

5. The potential pressures on the environment were identified by risk assessments. Some of the most notable **actual** pressures in the short-term were due to:

   - emissions to air from pyres;
   - the delay in the disposal of carcasses early in the outbreak;
   - the storage of slurry on farms for longer periods than normal;
   - the inappropriate disposal of some carcasses and ash early on in the outbreak;
   - odour from mass burials and landfill sites;
   - the burial of items such as machinery and building materials during the cleansing and disinfection process on farms.

These pressures were limited, demonstrating the effectiveness of the actions taken by the Agency and others. They are also small compared with the overall long-term pressures caused by farming practices in general.

6. The actual impact on the environment from the outbreak, based on the limited information assessed to date, has been as follows.

- No failures of national air quality standards occurred around five pyres and in one town where monitoring took place.
- Over 200 water pollution incidents were reported. Three of these were classified as causing serious damage. There were also some 300 complaints about odour from landfill and mass burial sites.
- Few impacts on surface water or groundwater from the disposal of carcasses or ash have so far been identified. This reflects the appropriateness of Agency pollution, prevention and control activities. There were two cases where water supplies were temporarily interrupted by digging and two private water supplies where microbial contamination was related to burial activity.
- No significant impact on soils has been found.
- No significant human health effects have been reported although there was concern about the location and operation of disposal sites.
- The changes to grazing patterns in the short-term are unlikely to have much impact on biodiversity, although vulnerable species may be affected. Overall the implications for biodiversity are complex.
- The outbreak has caused local changes to landscape quality as a result of changes to livestock densities and grazing intensities. In some areas, less trampling from visitors has probably allowed short-term recovery of damaged areas.

The environmental impacts identified are largely restricted to local areas around disposal sites and have been short-term. Long-term effects on some groundwaters may yet occur; monitoring must continue.

7. The greatest environmental impact is likely to result from any long-term changes in the rural economy and agricultural policy. In particular, improved land management techniques are needed to reduce pollution from all types of agriculture, to enhance biodiversity and maintain landscape quality. This includes the need for sustainable livestock management so that animal densities do not exceed the capacity of the land to support them.

1. Introduction

Over three-quarters of the land in England and Wales is farmed. Livestock farming takes place on over half of this area. The outbreak of foot and mouth disease in 2001, with the need to restrict animal movements and dispose of millions of animal carcasses, has therefore affected a large part of the countryside. The likely impact on rural England, mainly covering economic and social aspects, was reported by the Countryside Agency (Countryside Agency, 2001) and an interim assessment of biodiversity was produced by English Nature in August 2001 (English Nature, 2001). This report provides an interim assessment of the effects on the environment as a whole.

The Environment Agency has a duty to prevent and control pollution (Appendix 1). We have worked with others throughout the outbreak to minimise the risk of pollution and environmental impacts from all potential threats. We also have a duty to report on the state of pollution in the environment. The outbreak may not yet have finished, but three inquiries have been announced by the Government and long-term changes to the livestock industry are being debated. It is therefore timely to assess:

- the actual impacts of the outbreak on the environment;
- the effectiveness of the actions taken.

This interim assessment is based on information drawn from Agency field staff and monitoring programmes, and from other organisations. Quantitative data are limited because general monitoring work has been reduced, as a necessary precaution, by access restrictions. Future monitoring may find impacts not identified in this report. The report will be updated as more information becomes available.

This report concentrates on environmental impacts. The Agency has also made a submission to the National Audit Office which provides more details about the management of the outbreak (Environment Agency, 2001).

This introduction is followed by an overview of the nature and extent of the outbreak up until mid-September 2001. To add perspective some comparisons are made with the 1967 outbreak where relevant.

The **stresses** on the environment from the outbreak are described in Section 3. These include the range of potential ways in which the outbreak could have affected the environment. Such activities include:

- the disposal of carcasses and ash;
- the use and disposal of disinfectants;
- the disposal of materials that could carry the disease;
- difficulties in disposing of slurry and sewage sludge normally applied to land;
- changes in livestock distribution and farming practices;
- fewer tourists and visitors;
- restrictions on Agency operational work.

There is a clear difference between a **potential** stress or risk and what **actually** occurred. The Agency and others carried out risk assessments to ensure that action was taken to minimise risks. In this report we have tried to include information on the **actual** stresses that occurred but, in general, such information is lacking. We have therefore included a brief description of the potential risks and the way in which their reduction was managed.

The **impact** on the environment is described in Section 4 where water, air, soils and biodiversity are examined. For completeness, the impacts on human health have been added, based on the information published by the Department of Health and the Food Standards Agency.

Where possible we have considered short, medium and long-term impacts to put things into perspective. National data are used where available but, in their absence we have referred to specific examples. This will be updated as more information becomes available.

Section 5 contains our interim conclusions. While these may change as more monitoring takes place and after the outbreak has finished, these initial thoughts help to demonstrate that overall agricultural policies play a crucial role in environmental protection. The long-term strategy for agriculture must take account of environmental needs alongside social and economic needs.

This report provides a national overview of the environmental impacts. Local information is available from Agency offices (Tel: 0845 9333111) and will be progressively made available on the Agency website (www.environment-agency.gov.uk).

2. Facts and figures for the 2001 outbreak

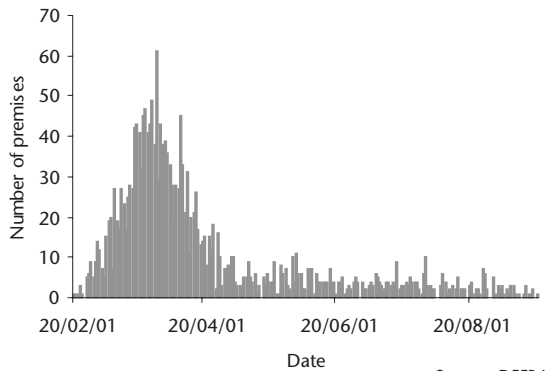
2.1 Extent of the outbreak

The first case of foot and mouth was confirmed on 20 February 2001 at an abattoir in Essex. Investigations are underway to ascertain the cause of the epidemic. The infection can be traced from a farm at Heddon-on-the-Wall, from where it spread to seven other farms in Tyne and Wear. Sheep from one of these farms were taken to Hexham market on 13 February and to markets at Longtown, Cumbria, on 22 February, from where they were dispersed across the country. Movement restrictions were imposed on the 23 February, three days after the first case was confirmed.

In most cases the movement of infected sheep spread the disease into new areas. In 79 per cent of cases further infection occurred by 'local' spread between premises within 3km of each other where the specific carrier was unknown. Other premises were infected by people, vehicles or by airborne virus (DEFRA, September 2001).

About eight per cent of all livestock farms in Great Britain have been directly affected (although not all infected premises were farms). At the height of the epidemic, there were over 40 new cases per day *(Figure 1)*. There have been no new cases since 30 September (as at 28 November, 2001). Some 10 per cent of England and Wales has been designated as Protection Zones around infected places at some time since February 2001 and at the height of the outbreak over one-third of the country was within Infected Areas *(Figures 2 and 3)*. In England and Wales, 25 counties (excluding metropolitan counties) have had no cases of foot and mouth.

Figure 1. Confirmed daily number of Infected Premises



Source: DEFRA

The main areas where restrictions remain in place are in Cumbria, Northumberland, North Yorkshire, Powys and Devon (as at 5 November). Many previously Infected Areas, such as Devon and Somerset, have had restrictions lifted. It is intended that the existing division of the country into Provisionally Free Areas, At Risk Areas and Infected Areas (Appendix 2) will be replaced by classifying counties as FMD (foot and mouth disease) Free, FMD Risk or FMD High Risk. Animal movement controls will be introduced accordingly (DEFRA, September 2001).

Box 1
Summary statistics for the UK (as at 8 November 2001)

Confirmed cases

- 2,030 confirmed cases
- Over half of all cases occurred in Cumbria, Devon and North Yorkshire
- 9,567 affected premises (includes neighbouring farms)

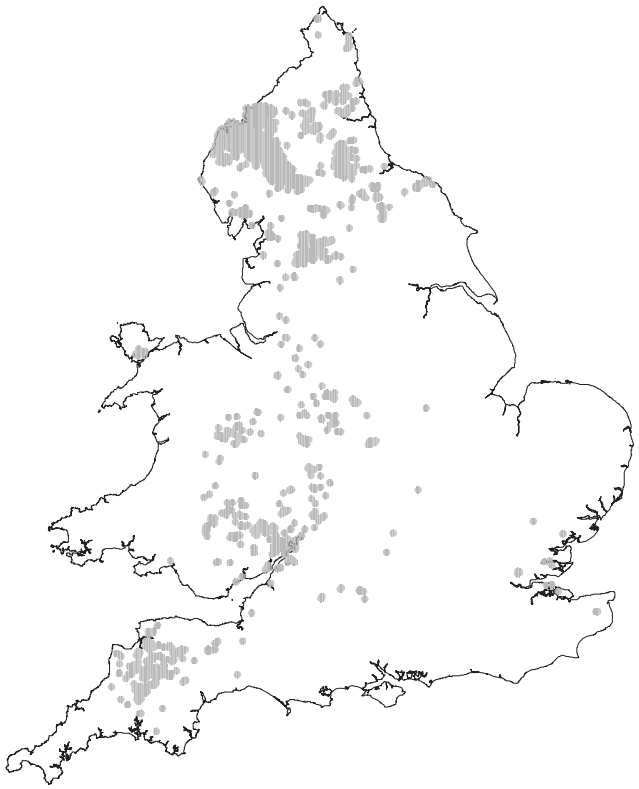
Slaughter and disposal of animals

- 3,939,000 animals slaughtered for disease control (compared with 434,000 in 1967)
- Of these, 601,000 were cattle (seven per cent of stock), 3,188,000 sheep (eight per cent), 147,000 pigs (two per cent), 2,000 goats, 1,000 deer and 300 other animals
- No animals are awaiting slaughter and no carcasses are awaiting disposal for disease control
- A further 2,044,000 animals presented for slaughter under the Livestock Welfare (Disposal) Scheme, including 1,584,000 sheep, 167,000 cattle and 290,000 pigs

Source: DEFRA

Livestock were slaughtered to control the disease on Infected Premises, Contiguous Premises, where they had been exposed to infection (Dangerous Contact) and where they were Slaughtered on Suspicion (Appendix 2). They were also culled for welfare reasons under the

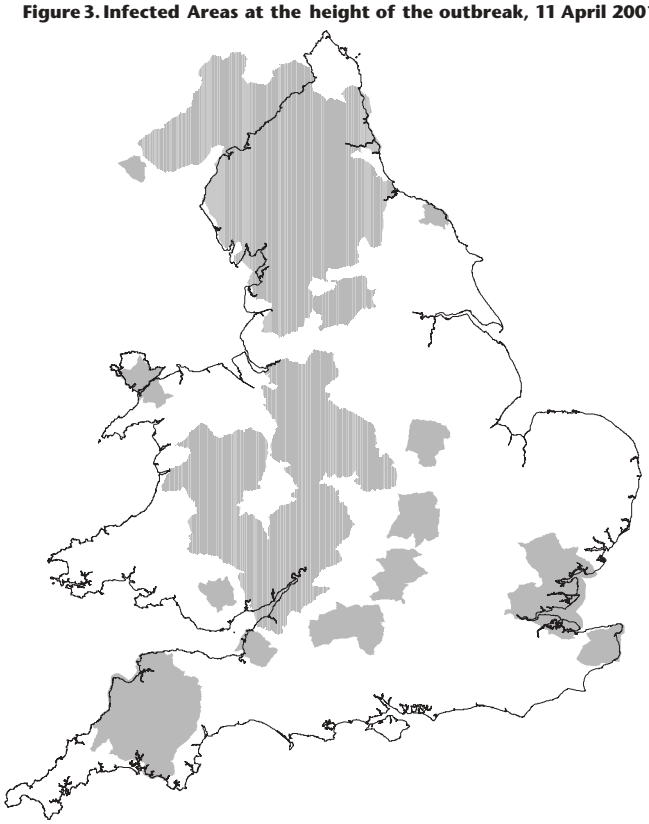
Figure 2. Protected Zones[1] designated up to 22 October 2001



[1]3km around Infected Premises

Source: DEFRA

Figure 3. Infected Areas at the height of the outbreak, 11 April 2001



Source: DEFRA

Livestock Welfare (Disposal) Scheme where livestock were facing welfare problems as a result of the movement restrictions. This includes light lambs, whose usual export has been prevented by the controls. For welfare reasons some 265,000 licences were issued for movement under controlled conditions (DEFRA, September 2001).

2.2 Recent history of foot and mouth disease in the UK

The last foot and mouth epidemic was in 1967. The outbreak started in pigs in a Shropshire farm and was reported by the farmer. Market movements were stopped the same day the disease was diagnosed; two cows had been been sent to market from the same farm that day. During the epidemic the disease spread from multiple primary outbreaks, 24 of which had possible links to legal imports of lamb. In 2001 the disease was not detected until it reached a slaughterhouse, some time after it had started. There were over two million sheep movements in the three weeks before movement was banned.

In 1967 some 434,000 animals were culled in 32 weeks, of which about half were cattle, a quarter pigs and a quarter sheep. The north-west Midlands and north Wales were most heavily affected. Carcasses were buried on-site or in some cases burned. No environmental impact assessment of the outbreak was made (MAFF, 1969a,b). In 2001, disposal operations were complicated by the larger scale of the outbreak, a high water-table, better understanding of groundwater protection and the risk of bovine spongiform encephalopathy (BSE) in some cattle.

In the 14 years before 1967 there were only two years without any outbreaks of foot and mouth disease. Most were contained, but there was an epidemic in the early 1950s. Between 1967 and the current epidemic there was only one outbreak in the UK, in the Isle of Wight in 1981. The improvement since then appears largely due to tighter controls on imports from countries with foot and mouth disease, and improved hygiene and animal health standards (DEFRA, March 2001).

3. Activities causing pressures on the environment

3.1 Carcass disposal

Disposal of animal carcasses has been the most publicised aspect of the outbreak, with pictures of pyres and mass disposal sites appearing frequently in the media.

The scale of the outbreak meant that disposal was a major logistics problem. Impacts were minimised through the intensive efforts of the Agency and others, based on environmental protection guidance prepared by the Agency in collaboration with others as appropriate (Appendix 3).

The need to deal quickly with large numbers of carcasses meant that:

- the time to select suitable burning or burial sites was limited;
- authorisations to permit disposal had to be determined rapidly, requiring many groundwater risk assessments to be completed by desk study within around three hours;
- communication difficulties led to environmental advice not being followed in some cases and many disposals not taking place at the exact authorised location;
- communication with the public over their concerns was often contentious.

These factors were likely to have increased the potential environmental risks although most groundwaters, rivers and sensitive conservation sites were protected from immediate harm. Some of the difficulties are exemplified in Box 2.

There were many sites where there was a delay in the disposal of slaughtered animals. Runoff of blood and body fluids from on-farm slaughter and carcasses prior to disposal was worst during the first two months of the crisis, when slaughter rates outstripped disposal rates. This led to many pollution incidents being reported by the public although relatively few cases of significant water pollution. However, exposed carcasses increased the risk of the transmission of pathogens, for example by rats, crows and gulls, and created local odour nuisance (DoH, June 2001).

Box 2.
Conflicting risks of carcass disposal at a farm near Welshpool

Some 1,500 sheep at an infected farm could not be removed and had to be disposed of at a site between a railway line and a main road. Smoke from a pyre was not acceptable in these circumstances so burial was undertaken despite initial Agency advice that the site was unsuitable. After a month, high rainfall resulted in effluent overflowing from the pit. However, the local authority still objected to a pyre because of the risks to human health. After a delay of several days an air curtain incinerator was obtained so that the carcasses could be dug up and burned safely.

The Agency agreed with DEFRA and the Department of Health a hierarchy of carcass disposal options (starting with the best options): rendering, incineration, burial in landfill sites, with burning on-farm, burial on-farm and mass burning or mass burial being jointly bottom (Appendix 4).

During the early stage of the outbreak, restrictions on the movement of animals and carcasses limited the use of existing rendering plants. Suitable landfill sites had also not then been identified. This meant that initially, following 1967 practice, most disposals took place on farms by burial and burning on pyres. Mobile incinerators were trialled but could not achieve the throughput required. Later, suitable landfills were identified and ways found of using rendering plants. No carcasses were sent to incineration plants, although the meat and bone meal from rendering plants were disposed of in this way.

A major factor in managing on-farm disposal and landfill was the risk of BSE infectivity (Appendix 4). Carcasses of cattle over five years old (born before August 1996) were not allowed to be buried or landfilled to prevent BSE transmission through groundwaters or other pathways. Burning on pyres greatly reduced the risk of BSE prions in ash from older cattle, so burial of the ash on-site was

Table 1. Provisional summary of carcass disposal routes

Disposal method	Provisional statistics	Comment
Burning (on farm)	Over 950 sites	Based on available DEFRA/National Assembly for Wales data for England and Wales
Burial (on farm)	900 sites	DEFRA/National Assembly for Wales estimate for UK
Mass burial	61,000 tonnes at four[1] sites	DEFRA/National Assembly for Wales estimate for England and Wales to August
Commercial landfill	95,000 tonnes at 29 sites	Agency estimate for England and Wales to September
Rendering	131,000 tonnes at seven plants	DEFRA/National Assembly for Wales estimate to October

[1]Excluding Sennybridge (abandoned) and Ash Moor (in reserve).
Source: DEFRA, Environment Agency

accepted, subject to assessment and authorisation under the Groundwater Regulations. Where ash had to be removed from the site it was landfilled.

Statistics on the disposal methods used are still being collated and verified by DEFRA and the National Assembly for Wales, but estimates are given in Table 1. Some 600,000 tonnes of carcasses have been disposed of, equivalent to about two per cent of annual household waste or 30 per cent of annual commercial and industrial food waste.

Each disposal option is now considered in more detail.

Table 2. Disposal of carcasses to rendering plant (to 10 October 2001)

Location of rendering plant	Still in use?	Approximate weight of carcasses (tonnes)
Waltham	No	200
Torrington	No	7,700
Motherwell	No	9,400
Exeter	No	13,200
Lancaster	Yes	23,600
Bradford	Yes	24,000
Widnes	No	53,300
Total	-	**131,400**

Source: DEFRA

Rendering

Rendering should result in minimal environmental impact provided all control measures and best practice are fully implemented. The residue from rendering cattle over 30 months must be incinerated to destroy any BSE infectivity. By October 2001 about 130,000 tonnes of carcasses resulting from the outbreak had been disposed of by rendering at seven plants, with the plant at Widnes receiving 40 per cent (Table 2).

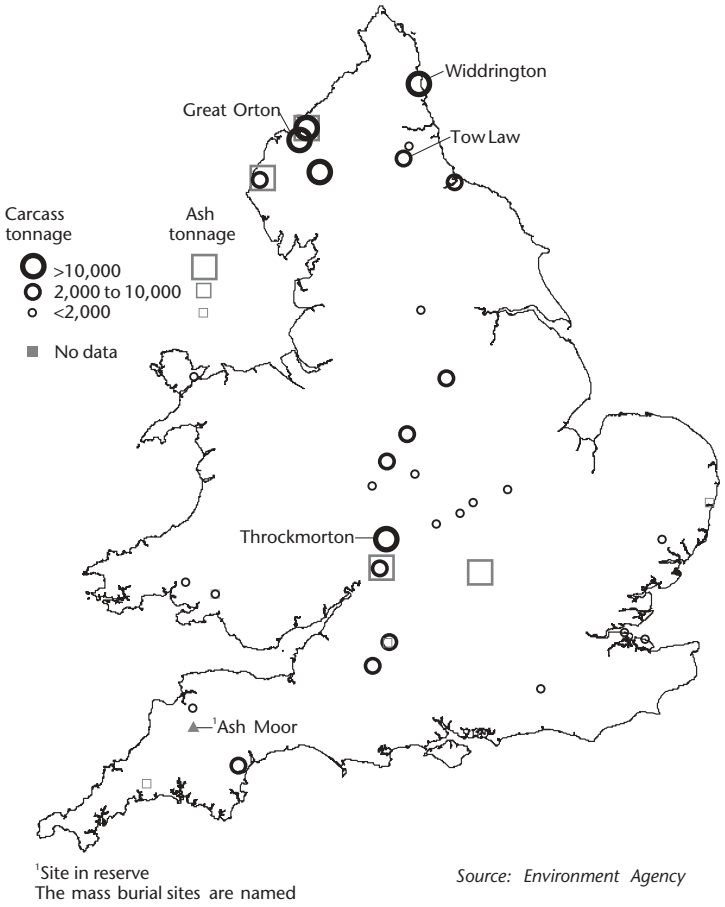
Landfill

Landfilling of carcasses will generate very high organic loads and other pollutants for up to 20 years or more. In the short-term, constructing trenches in existing landfilled waste to deposit carcasses created odour. This affected many local people despite efforts to minimise the problem (Section 4.7).

Only landfills authorised to receive carcasses were used, operating to an agreed protocol (Appendix 3). Requirements included a well-engineered site with good collection, treatment and disposal of leachate, adequate monitoring and contingency plans. Gas collection and combustion, and odour and vermin control were also important. In England and Wales, out of 111 landfill sites identified as suitable for disposal of carcasses, 29 landfills were used for some 95,000 tonnes of carcasses *(Figure 4)*.

Pyre ash was taken to authorised landfills unless it was buried on site. By the end of October, of an estimated 120,000 tonnes of ash and associated material needing to be removed, some 100,000 tonnes had been landfilled,

Figure 4. Landfills and mass burial sites used for carcass and ash disposal, as at September 2001



[1]Site in reserve
The mass burial sites are named

Source: Environment Agency

mostly in four sites *(Figure 4)*. The use of landfills for carcasses may affect the long-term local availability of landfill void space, although the effect has probably been small. To add some perspective, 280,000 tonnes of waste are sent to landfill daily from other sources.

Commercial landfills routinely monitor leachate, surface water discharges and groundwater, and report the results regularly to the Agency. Apart from some increase in leachate strength and volumes, this monitoring had shown no effects by mid-October, with the exception of one site. Chapmans Well landfill in County Durham is being investigated for possible damage to the liner caused by excavation to bury carcasses. Leachate is being pumped out to reduce the level and groundwaters are being monitored to locate any leaks requiring remedial action.

Burning

There were over 950 pyres in England and Wales. The largest numbers of pyres were in south west England, the Upper Severn, Wales and Cumbria.

A typical pyre for 300 cows included some 175 tonnes of coal, 380 railway sleepers, 250 pallets, 4 tonnes of straw and 2,250 litres of diesel. Such a pyre could:

- release body fluids, disinfectants and excess liquid fuel into the ground immediately before burning (some pyre pits were lined to contain these);
- emit particles (including PM_{10}), sulphur dioxide, nitrogen dioxide and other products of combustion such as polycyclic aromatic hydrocarbons (PAHs), dioxins and polychlorinated biphenyls (PCBs);
- leave 15 tonnes of carcass ash and 45 tonnes of other ash for disposal;
- contaminate air and water from other waste burnt on the pyres.

There was also concern that pyres may spread the disease through the dispersal of the virus in the plume.

Air emissions

Estimates for pollutant emissions were made for a range of typical pyre sizes and for the total of all animals burned up to 6 April 2001 (Table 3)(DoH *et al.*, April 2001). These estimates will be updated when the final disposal data are available. Emissions of sulphur dioxide and nitrogen oxides are likely to be less than one per cent of UK annual emissions, while particles (PM_{10}) may reach a few per cent. The dioxin estimates are very uncertain so conclusions cannot be drawn from them; comparison with the air concentration measurements near pyres (Section 4.1) suggests the estimates may be much higher than actual emissions. To add some perspective, dioxin emissions on bonfire night are about 30g and those from waste incineration in 1999 were 37g. As far as the spread of pathogens from pyres is concerned, it is considered that most are destroyed by well-managed burning.

Table 3. Estimated air pollutant emissions from all pyres to April 2001[1]

Pollutant	Estimated emissions	Percentage of UK annual emissions
PM_{10}	1,171 tonnes	0.45
Sulphur dioxide	424 tonnes	0.04
Nitrogen oxides	184 tonnes	0.01
PAHs	15 tonnes	1.04
Dioxins	25 - 252g[2]	7 - 73

[1]Based on estimates of 75,435 cattle, 266,878 sheep and 14,234 pigs burned.
[2]Estimate very uncertain and may be too high.

Source: DoH et al., April 2001

To reduce potential risks to human health, including annoyance and stress, pyres had to be sited and designed to take into account the proximity to residential areas. Guidance on siting was supported by modelling of the potential impacts (DoH *et al.*, April 2001).

In a few cases, the burning of other waste on pyres occurred against Agency and DEFRA advice, increasing pollutant emissions. The waste included tyres (2,000 at one site), waste oils, plastic sheeting and animal feed. These are likely to have increased emissions of dark smoke and persistent organic pollutants.

Ash

After burning, the ash was sprayed with disinfectant. Ash from pyres and the associated contaminated soil had to be buried on site, buried at another location, landfilled or taken for re-incineration. Most ash was buried on farms in unlined pits to minimise the risks from transport, but some ash had to be removed for safe disposal, for example if it was in a floodplain or the risks to groundwater were unacceptable. Out of 134 pyres in Cumbria, ash was buried on-site in 60 per cent of cases and the rest was landfilled.

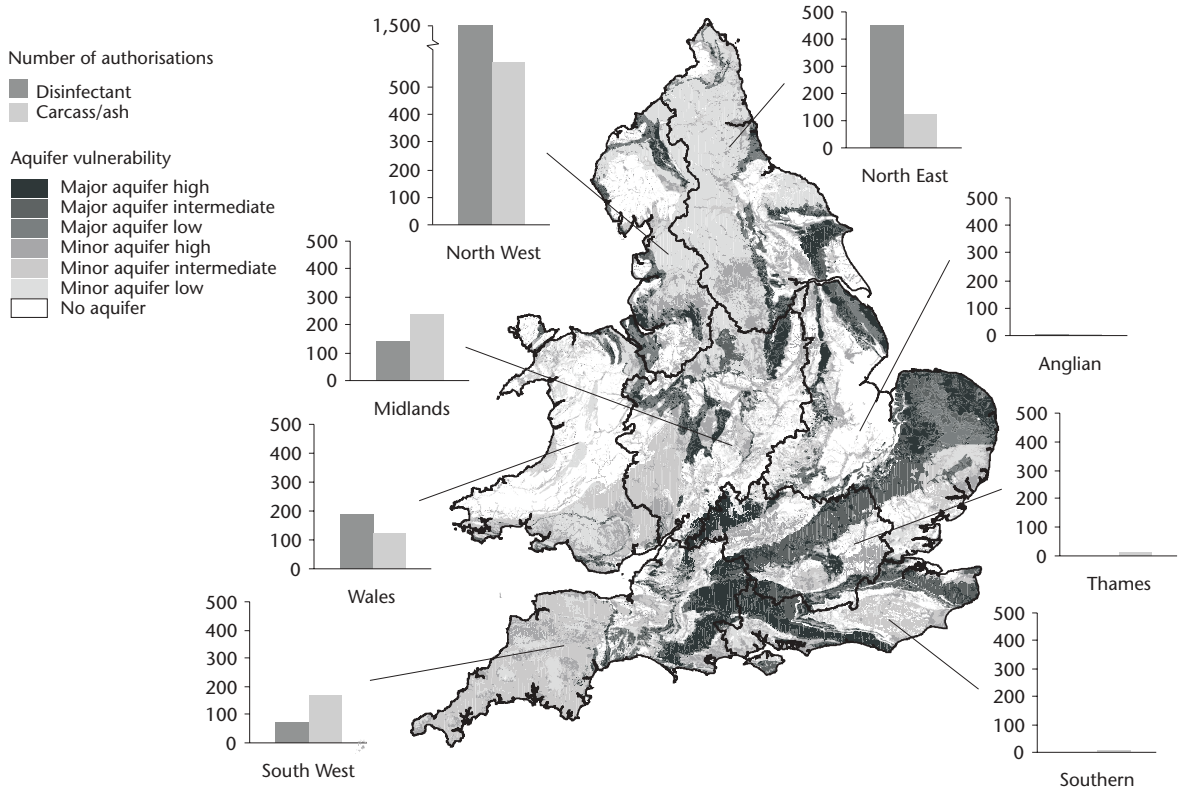
Ash burials required authorisation under the Groundwater Regulations *(Figure 5)*. Some ash was buried without authorisation and these sites are being assessed retrospectively. Ash from some sites may need to be removed if there are unacceptable risks to the environment. This has happened at 20 sites in Wales following further risk assessments for groundwater and private water supplies.

Ash samples were taken from 19 pyres and two air curtain incinerators. The samples were analysed for a range of substances including metals, PAHs, PCBs and dioxins. The concentrations were not a major hazard provided the ash was buried in approved landfills or at on-site locations where surface water or groundwater will not be contaminated, for example the site is secure from flooding or outside groundwater source protection zones (Zone I, see glossary).

Levels of copper, arsenic, nickel and zinc in ash were within the limits permitted for sewage sludge applied to land and so posed no risk to food production (DoH *et al.*, November 2001). Dioxin concentrations (as toxic equivalents) in ash were comparable with those in ash from industrial combustion processes and in urban soils. Leachate from ash had high concentrations of salts including potassium, sodium, sulphate and chloride; these could lead to failure of ammonium and potassium drinking water standards if burial was close to a groundwater source (Marsland and Ward, 2001).

The amount of gas released from ash burials is expected to be small. Some odour is possible and hydrogen sulphide could be released under certain conditions.

Figure 5. Provisional map of groundwater authorisations by Agency region for disinfectant and carcass/ash disposal, showing potential groundwater vulnerability



Source: Environment Agency

Burial on farm

Burial of carcasses creates the following hazards for groundwater (Marsland *et al.*, 2001).

- Body fluids will be released (about 16m^3 per thousand adult sheep and 17m^3 per hundred adult cows within two months).
- The leachate may contain very high concentrations of ammonium (up to 2,000mg/litre), have a high chemical oxygen demand (COD)(up to 100,000mg/litre, about a hundred times that of raw sewage) and contain potassium (up to 3,000mg/litre). Sheep dip chemicals, barbiturates and disinfectants may be released but have not been found in significant amounts.
- The leachate may contain pathogens including *Escherichia coli* 0157, *Campylobacter, Salmonella, Leptospira,* and the protozoa *Cryptosporidium* and *Giardia.*
- Leachate from cattle born before 1 August 1996 may carry BSE prions.

Most degradation will occur within five to ten years but leachate may be released for 20 years or more.

Carcass burial sites had to be authorised under the Groundwater Regulations. Assessments were made to ensure that burial sites did not pose a risk to the environment. In Cumbria, for example, the Agency assessed 508 potential disposal sites for risks to groundwater, surface water and conservation, of which only 47 sites were used. Some sites were refused because of the risks but most were not used because they were not needed. Much of Devon was waterlogged after an extremely wet winter, precluding burial on many farms due to the risk of water pollution.

The location of authorised carcass, ash and disinfectant disposal sites in relation to groundwater vulnerability provides an overview of the situation *(Figure 5).* The provisional total of authorisations under the Groundwater Regulations for carcass and ash burials in England and Wales is about 1,270. Authorisations were only granted after risk assessments had been performed. In some cases these were carried out retrospectively when disposal had already commenced, for example because of the need for speedy disposal. Details of specific site authorisations are available from local Agency offices.

Burial of carcasses was not permitted in a groundwater source protection zone I, or close to private water supplies or watercourses. Other constraints to protect ground and surface waters were applied in line with Agency guidance and the Code of Good Agricultural Practice for the Protection of Water (Marsland *et al.*, 2001). On-farm burials relied on dispersal and dilution of leachate in the ground to protect water so disposal in vulnerable areas had to be avoided. In mass burial sites the leachate was contained (apart from Widdrington, see below).

Before the risk from BSE was fully recognised in the first few weeks of the crisis, older cattle had been buried at some sites (including more than 100 sites in the North East). These are being retrospectively assessed to decide what measures, such as exhumation or groundwater monitoring, are needed.

Non-carcass material that would otherwise have required disinfection was also buried on farms. For example:

- farm equipment, scrap metal, plastics, animal feed and asbestos (a hazardous substance) were buried in some cases;
- at two farms near Worcester, the farmer reported burial of six cars, three pick-up trucks, a lorry, 45 vehicle batteries, paint, fertiliser, grain and feedstuffs;
- at a farm near Felindre in Powys, drums of sheep dip, paint, diesel, and a large amount of manure were buried near the farm's drinking water well, within 5m of a pond and 75m of a watercourse. The drums are to be recovered.

In some cases, excavation and safe disposal may be necessary at substantial cost and effort.

Mass burial

Mass burial sites were constructed at six locations in England and Wales, although one has not been used and carcasses have been removed from the Sennybridge site in Wales *(Figure 4, page 9).* At Sennybridge, unexpected seepage of carcass liquids was detected within a few days so the site was cleared and abandoned (Section 4.3). All these sites led to concerns from local communities.

The mass burial sites at Tow Law, Great Orton and Throckmorton were sited and designed to minimise the risks of surface and groundwater pollution, although some site management controls are still being developed. At Throckmorton, for example, the leachate is tankered away from the site. By September some 74,000m^3 of leachate had been collected and removed by tanker for treatment and disposal at sewage treatment works.

No special design was needed at Widdrington, as there is sufficient natural attenuation and breakdown of leachate pollutants before the water-table is reached.

Buried carcasses will release carbon dioxide and foul-smelling gases during the early stages of decomposition. The amount of methane should be small. Soil capping should minimise odour problems but additional gas control systems may be needed (Marsland *et al.,* 2001). At Great Orton gas is being monitored at 71 boreholes and manholes. Small quantities of carbon monoxide, methane and hydrogen sulphide have so far been measured.

3.2 Cleansing and disinfection

Disinfectants used during the cleansing of Infected Premises and at other farms and road access points, as a precautionary measure, may cause water pollution. The greatest risk is at Infected Premises where doses were high, but effects are possible through frequent use at other locations. Some 18 per cent of pollution incidents recorded during the outbreak were related to the use of disinfectants. Disposal of disinfectant to sewer is also a risk. It disrupted the biological sewage treatment process at some small plants, including two in north-east England.

Over 170 disinfectants are approved by DEFRA for control of the foot and mouth virus. An estimated 1.3 million litres of undiluted disinfectant had been used by October. These products have varying degrees of toxicity although they degrade fairly quickly. Any impacts should be short-lived.

Disposal of disinfectants to land usually requires authorisation under the Groundwater Regulations. By September, the Agency had assessed 1,252 disposal sites in Cumbria and refused 113 because of the environmental risk. There were about 2,370 authorisations for disinfectant disposal in England and Wales *(Figure 5, page 11).*

Many roadside cleansing and disinfection stations were set up. Around Penrith in Cumbria, ten such sites were operated, mainly for vehicles that visited farms regularly.

These stations used sealed systems with holding tanks or sewer connections to collect the wash-waters. At disinfection points without such controls, and where highways were disinfected at animal crossing points, wash-water is likely to have drained to surface water drains and into watercourses. The Meat and Livestock Commission listed 106 public disinfection centres at livestock markets and other sites. The Agency gave advice on the location of disinfection points in relatively few cases; it was not asked with regard to the others, so some rivers may have been at risk.

By 21 August, 70 per cent of the 9,126 farms where animals had been slaughtered had been treated by preliminary cleaning and disinfection. Half of these had also received the more intensive cleaning and disinfection that is required prior to restocking (NFU, September 2001).

Some temporary lagoons built to hold disinfectant wash-water and slurry were constructed in locations where watercourses or groundwater could be affected by spills. This occurred especially where the Agency was not consulted. Due to heavy rain many lagoons came close to overflowing and some did, requiring quick action to find suitable sites for spreading the excess to prevent water pollution. Guidance was issued on the safe disposal of lagoon contents and decommissioning of lagoons.

3.3 Disposal of wastes usually applied to land

Slurries and manure

When the outbreak started in February many slurry systems were already near capacity (a situation normal for the time of year). As herds were kept inside to reduce the risk of infection, slurry accumulated and temporary storage lagoons were needed. In Cumbria alone, the Agency sent almost 600 letters authorising the siting of temporary storage lagoons or above ground tanks for slurry and disinfectant wash-waters.

The storage of manure and slurry that would otherwise have been spread to land increased the chance of spillages. Some spreading to land was allowed and the Agency worked with farmers to find safe spreading areas to alleviate the problem. This was generally successful but some spills affecting watercourses still occurred. Some 44 per cent of pollution incidents during the outbreak were due to slurry (where sources of the incidents are known). In a case at Wigton in Cumbria, a tank was overfilled and collapsed, releasing some 140m^3 of pig slurry which was tackled before it reached a watercourse.

Sewage sludge

Access restrictions and the need to retain some sludges potentially infected with foot and mouth disease stopped most applications of sewage sludge to farmland. This created storage problems as stocks built up. In some cases stocks were already high due to the wet winter and saturated ground reducing access to land. The water industry normally spreads half a million tonnes per year of sludge on land (compared with 93 million tonnes of farmyard manure).

Water companies, in consultation with the Agency, increased storage at some sewage works and reduced the volume by drying or 'caking' the sludge. This practice increases the release of odour and may cause ammonia in the effluent to breach consent conditions. Monkmoor sewage works on the River Severn apparently failed its discharge quality limits due to extended retention of sludge in its treatment tanks, while Roden Kennels sewage works in the same area failed its discharge limits because sludge could not be taken to Monkmoor.

South West Water and North West Water sent excess sludge to landfill. This should not have any environmental impact apart from the waste of sludge as a resource. In Yorkshire, the extra cost of diverting sludge from farmland to incineration was some £0.5 million.

Overall, environmental problems were minor. Sludge spreading restarted in July outside the 10km zones around infected farms and the backlog has largely been cleared.

3.4 Changes in livestock and farming practices

Up to eight per cent of livestock have been lost during the outbreak (Section 2). In Cumbria the proportion culled was over 20 per cent and in other badly affected areas more than 10 per cent of animals were culled *(Figure 6, page 14)*. Livestock contribute 80 per cent of UK ammonia emissions and 40 per cent of methane emissions (a greenhouse gas)(Environment Agency, 2000). If the stock are not replaced, or are replaced at lower densities,

then these pollutants will be reduced as a consequence. Since restocking cannot take place for at least six months in Infected Premises and some of the breeding stock has been lost, then these pollutants could be reduced by a roughly corresponding amount. However, cattle, pigs and poultry tend to emit the most ammonia, while over 80 per cent of slaughtered animals have been sheep.

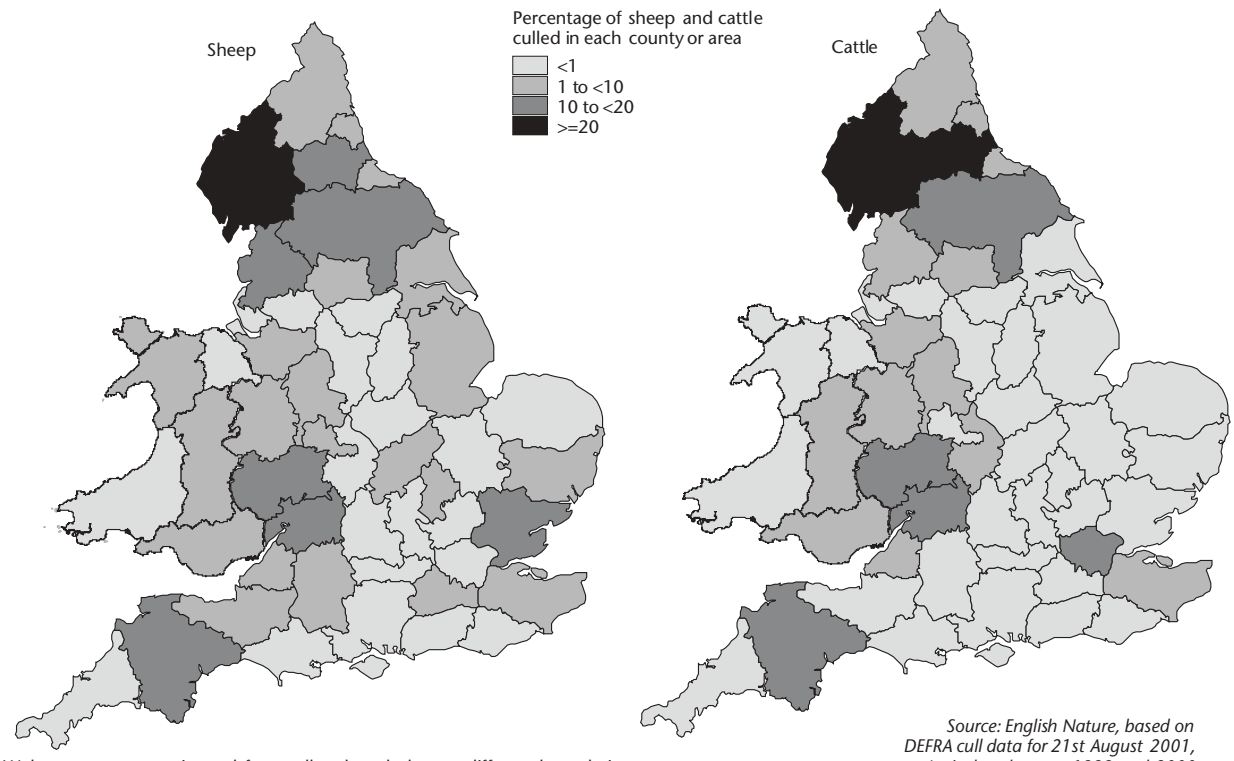
At certain times during the outbreak, especially early on, there were probably more animals on farms than normal. This was due to movement restrictions limiting the number entering the food chain. Some light lambs were kept on the hills for an extra two or three months. This would have meant a short-term increase in emissions and a greater risk of soil erosion.

Overgrazing is one of the major pressures on some upland habitats and wildlife. There are large upland tracts in the counties most affected by the outbreak. Since restocking could not take place for at least six months, this was effectively the whole of the growing season for 2001. This means much less grazing in the uplands in 2001 than normal, benefiting some, but not all, wildlife, particularly in semi-natural areas. Some areas depend on a certain level of grazing to maintain their species and diversity. The issue of grazing has been considered in more detail by English Nature (English Nature, 2001).

Overstocking has also been linked to accelerated soil erosion and phosphorus loss, and to eutrophication (an imbalance in the ecosystem caused by excess nutrients) in some waters (Environment Agency, 2000). Less stock locally should reduce these impacts this year, although it is unlikely that aquatic ecosystems will be greatly affected by such short-term change in nutrients. There may be benefits locally, but the full national impact can only be assessed when we know the extent to which stocking practices may change as a result of the outbreak.

Livestock restrictions have led to alternative land uses in some places. For example, there has been an increase in potato farming in the Upper River Severn and Vyrnwy catchments. This has increased demand for water abstraction from ecologically rich rivers and increased the amount of silt likely to run-off into rivers. Any long-term changes in livestock farming policies need to consider the consequences of other land use changes.

Figure 6. Proportions of sheep and cattle culled by county



Wales percentages estimated from cull and stock data on different boundaries

Source: English Nature, based on DEFRA cull data for 21st August 2001, Agricultural census 1999 and 2000

Livestock movement has been reduced in 2001 due to the outbreak so there may be environmental benefits in fuel savings. Account also needs to be taken of reduced exports and any changes in import practices. Some meat imports from the Republic of Ireland may travel less distance than meat moved to England from Scotland. However, managing the outbreak required a lot of transport activity. Overall, these effects may possibly balance out.

Movement restrictions led to overstocking on some farms and in some specific fields. Increased grazing in these areas, particularly in lowland areas, may have caused local soil damage with consequences for runoff to streams, but this should have been a limited and temporary problem.

3.5 Fewer tourists and visitors

There has been much publicity about the impact of the outbreak on tourism. Details of the social and economic impacts are given in a report by the Countryside Agency (Countryside Agency, 2001). Others have predicted that the outbreak will lead to a 19 per cent loss in tourism in 2001, and up to a 31 per cent loss of revenues in the most affected areas (Nottingham University Business School, 2001). While the reduction in tourism has caused economic and social losses, there may have been some benefits in terms of reduced pressures on the environment.

A quarter of the 5,500 million annual day trips for leisure in the UK are made to the countryside and a further four per cent to the coast. In 1996 some 41 per cent of the total number of domestic tourism nights were spent in the countryside, villages or small towns. Most people travel to the countryside by car so a reduction in access could mean benefits in terms of less fuel use and consequently less emissions from transport.

An estimated four per cent of all journeys made by people in a year are for holidays or day trips to the countryside. Transport accounts for about a third of energy use in the UK, so reducing day trips and holidays to the countryside could save about one per cent of our daily energy consumption. This assumes that journeys are not made to alternative locations. Domestic visits to the English countryside were lower than in 2000, especially in areas like Cumbria and south west England (English Tourism Council, 2001).

Additional pollution could have been caused if people took flights abroad instead, but this would have been offset by visitors to the UK. Eleven per cent fewer overseas residents arrived in the UK for holidays in July 2001 than in the previous July (National Statistics, 2001). It is not known, though, to what extent this reduction was due to the foot and mouth outbreak or other factors such as the recession in the USA. More information is needed to quantify and understand these changes.

Visitors to the countryside can cause soil erosion through trampling and disturbance of wildlife. There may have been benefits from the outbreak in terms of reduced erosion of footpaths, but this is difficult to quantify. No disturbance during April and May when new growth is taking place may lead to more robust plants for the rest of the year. Nesting birds, particularly upland species such as golden plover and dunlin, may also benefit from less disturbance.

Visitors are thought to be responsible for 40 per cent of the litter found on beaches. Some of this litter may affect wildlife and all of it spoils the environment. If visits to some beaches were reduced due to the outbreak, then this may have led to less litter.

3.6 Restrictions on environmental work

Much of the Agency's work involves site visits for monitoring, pollution prevention and attending incidents. We also undertake capital and maintenance programmes for flood defence, navigation and fisheries.

Much of our routine work was suspended due to the outbreak and staff resources were diverted to dealing with the outbreak. All 26 operational areas were affected although six were most seriously affected: North West Northern Area (Cumbria), Northumbria, Dales, Upper Severn, South East Wales and Devon.

The consequences of this disruption included the following.

- Some flood defence maintenance work and non-emergency capital works were stopped, including repairs to defences damaged during the winter of 2000/2001. Major capital projects have not been delayed significantly, but it is not yet clear whether all the backlog of essential work will be cleared.

- The lack of routine clearance of trees and other material from small watercourses may have reduced levels of flood protection and land drainage in some areas although it may have had benefits for wildlife.
- Some 42 category two pollution incidents could not be attended although all category one incidents were attended.
- Sales of fishing rod licences were down by some £1.6 million by the end of May, but recovered after an advertising campaign to a deficit of £0.5 million, or two per cent, by the end of August.
- A reduction in enforcement activity may have led to higher rates of rod licence evasion and illegal stocking of carp and bream without checks on fish health.
- Navigation licence enforcement and site maintenance were severely reduced (90 per cent in Southern Region). However, navigation licence sales usually reflect the weather and no obvious decline related to the outbreak has been apparent.
- Water resources inspections and capital expenditure were curtailed.
- Many biological and fisheries surveys were cancelled and the resulting lack of information will affect our environmental management programmes. Water quality monitoring was less affected because it relies less on access to farmland. Even so, some enforcement monitoring was restricted and reporting will be affected.
- Visits to farms in nitrate vulnerable zones and elsewhere to advise on water protection measures were suspended.

It is difficult to evaluate the effects of this disruption. In most cases it is possible to reschedule delayed work but there may be some cases where flood risk is temporarily increased or where there are impacts on the environment.

Environmental work by other organisations was also curtailed. For example, English Nature's wildlife monitoring and research were restricted. Water companies had to delay maintenance and capital programmes which protect and improve watercourses.

For example:

- South West Water delayed up to 20 capital schemes and maintenance at some 300 sewage treatment works;
- Severn Trent Water and North West Water suspended maintenance at some rural sewage works;
- mains and sewer replacement schemes have been delayed for several months by Wessex Water and Northumbrian Water.

4. Impacts on the environment

4.1 Air quality

Air quality monitoring took place at a number of pyres in England and Wales (Table 4).

Monitoring sites were generally between 800m and 2km from pyres. One or more inorganic air pollutants (particles, sulphur dioxide, nitrogen dioxide, carbon monoxide) were measured. A range of organic pollutants (dioxins, PAHs, PCBs) were also measured at Holsworthy, Okehampton, Sennybridge, Welshpool and, to a limited extent, at Hazelsprings Farm.

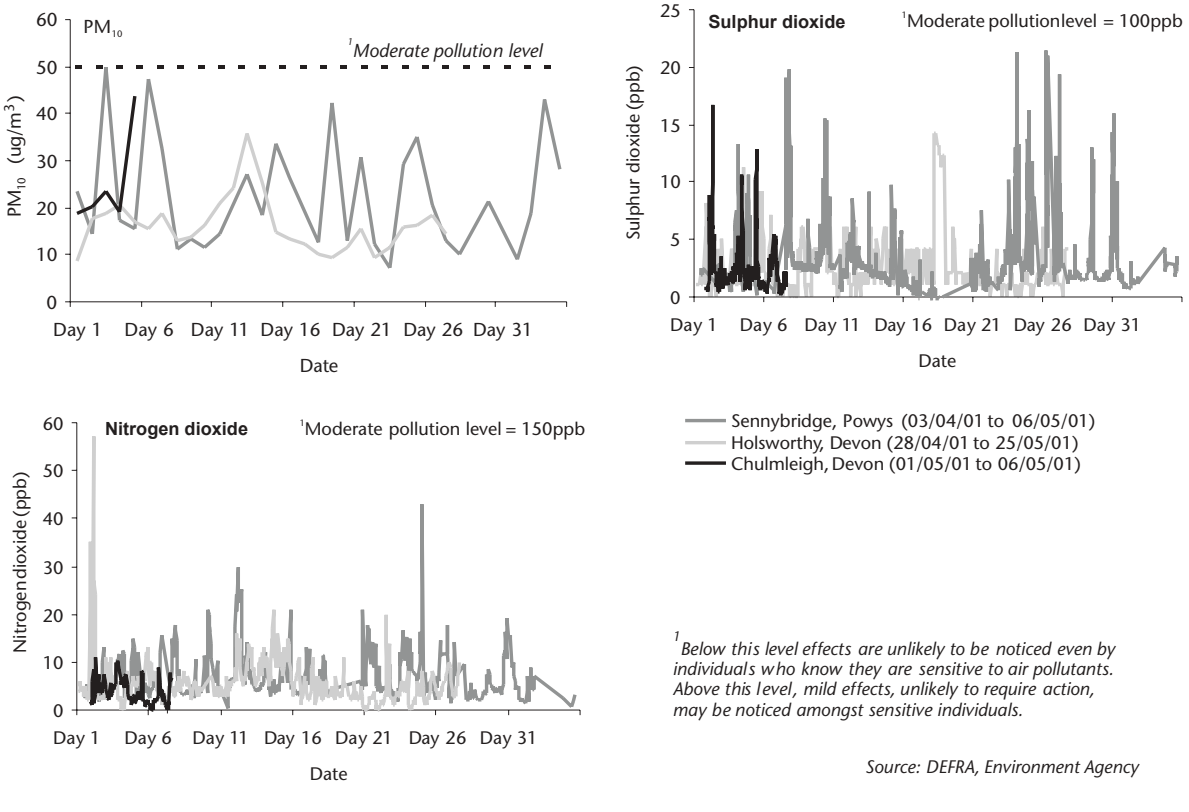
All concentrations of inorganic substances fell within the DoH/DEFRA 'low' air pollution band (Figure 7; Appendix 5)(DoH *et al.*, November 2001).

Table 4. Air quality monitoring of pyres

Site	Agency Region
Chulmleigh[1]	South West
Coleford[1]	Wales
Ellonby[1]	North West
Hazelsprings Farm[2]	North West
Holsworthy[1,3]	South West
Little Bampton[1]	North West
Longtown[1]	North West
Okehampton[3]	South West
Sennybridge[1,2]	Wales
Welshpool[2]	Midlands/Wales

[1]Sites monitored by the Agency.
[2]Sites monitored by local authorities.
[3]DETR monitored air quality in the centre of Okehampton.

Figure 7. Air quality near three pyres



[1] *Below this level effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants. Above this level, mild effects, unlikely to require action, may be noticed amongst sensitive individuals.*

Source: DEFRA, Environment Agency

Low concentrations of persistent organic pollutants were measured in air around pyres. There are no air quality standards for toxic organic pollutants except benzo[a]pyrene (Appendix 5). The monitoring showed that:

- benzo[a]pyrene, an indicator for PAH concentrations, occurred for periods of a few days above the recommended annual standard, but with the exception of Sennybridge, the concentrations averaged over a year were at or below the standard;
- dioxin concentrations (as WHO toxic equivalents) during burning were comparable with background urban quarterly concentrations but much lower when converted to a quarterly average;
- dioxin-like PCB concentrations (as WHO toxic equivalents) were much higher over a few days than annual urban levels, but averaged over a year they fell at the low end of the urban range (DoH *et al.,* November 2001).

The air quality results at Sennybridge were in good agreement with those predicted by modelling for PM_{10}, sulphur dioxide and nitrogen dioxide. The models therefore provided a reasonable basis for assessing the risks from major pollutants in this situation. The dioxin measurements did not agree well with estimates made for Sennybridge or a pyre at Dumfries. Further investigation to account for this difference is needed (DoH *et al.*, November 2001).

Air curtain incinerators were also used to burn carcasses. They enable greater control of combustion and produce little visible smoke. Monitoring at Holsworthy when air curtain incinerators were operating confirmed that the pollutant concentrations were low (DoH *et al.*, November 2001).

4.2 Surface water

Impacts on streams and rivers related to the outbreak have so far been limited to a few places. There were 212 reported water pollution incidents (Table 5). Of these, three were category 1 incidents (which cause major damage to the aquatic ecosystem) and 11 were category 2 (which cause significant damage to the aquatic ecosystem) (Appendix 6). The total of 14 category 1 and 2 incidents is about one-tenth of those caused by livestock farming in 1999.

For those incidents where the cause was known, 44 per cent were caused by slurry, 24 per cent by carcasses during burial, 18 per cent by disinfection and 13 per cent by runoff from culling and carcasses prior to disposal *(Figure 8)*. There were three major incidents:

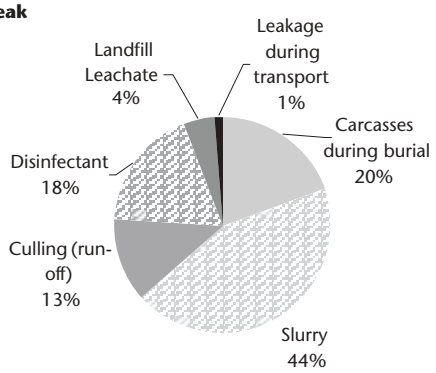
Table 5. Water pollution incidents related to foot and mouth activities[1]

Region	Incidents caused by foot and mouth activities			Category 2 incidents not attended due to foot and mouth[2]
	Category 1 (major) incidents	Category 2 (significant) incidents	Total incidents (categories 1-4)	
Anglian	0	0	3	5
Midlands	1	1	27	9
North East	0	3	27	2
North West	0	4	99	6
Southern	0	0	10	2
South West	1	1	43	1
Thames	0	0	0	0
Wales	1	2	4	17
Total	3	11	212	42

[1]Only incidents reported to, or identified by, the Agency are recorded.
[2]Incidents not attended due to access restrictions or workload related to foot and mouth.
Source: Environment Agency

- Several thousand fish were killed in a tributary of the River Tean near Uttoxeter, when slurry and disinfection wash-water were lost from a containment lagoon.
- Another slurry spill near Tiverton in Devon occurred when a slurry tank could not be emptied in an Infected Area, killing fish over 4km of a tributary of the River Exe.
- Disinfectant runoff from an abattoir on Anglesey killed a large number of eels in a tributary of the Afon Braint.

Figure 8. Causes of surface water pollution incidents related to the foot and mouth outbreak



Source: Environment Agency

Mass burial sites have been the main focus of surface water monitoring.

- At the Great Orton mass disposal site monitoring of 20 surface water sites since April 2001 recorded only one incident caused by leachate which was quickly stopped.
- Surveys around the Tow Law and Widdrington mass burial sites found no impact on surface waters.
- At the Throckmorton mass burial site, the airfield drains showed some contamination with leachate and disinfectant but no effect on downstream watercourses either chemically or biologically (five sites).
- At the Sennybridge mass burial site, a stream showed some contamination near the site (Box 3).

Other effects, mainly from cleansing and disinfection on farms, have been assessed at sites surveyed for stream invertebrates between July and September 2001. A few sites have shown evidence of impacts and will be investigated further (Table 6).

Box 3. Water contamination at the Mynydd Epynt mass burial site, Sennybridge

The site is in the headwaters of the rivers Usk and Tywi. Burial started on 6 April and ceased on 10 April when groundwater contamination was found. Carcasses were removed and burnt. Contamination by organic material and ammonia occurred in one of the six boreholes around the site. Chemical oxygen demand peaked at a very high 13,000mg/litre *(Figure 9, page 20)*. High chemical oxygen demand and biochemical oxygen demand can kill freshwater life by removing oxygen from the water.

A corresponding pattern of contamination was found at a stream downhill from the site, although at 1.5km further downstream the effects were greatly reduced by dilution *(Figure 9, page 20)*. Contaminant levels in the borehole and stream have since declined substantially. Surveys showed that invertebrates and young trout downstream of the area were unaffected.

Source: Environment Agency

Plans for further surveys of watercourses are being considered in all affected regions. They include:

- further monitoring of stream invertebrates in surface waters potentially affected by farm disinfection in the Upper Severn;
- stream biological surveys adjacent to heavily used vehicle disinfection points in Wales;
- surface water monitoring at Great Orton, Cumbria, will continue along with monitoring next to eight ash burial sites;
- chemical, biological and microbiological surveys around the mass burial sites at Tow Law and Widdrington will continue;
- monitoring upstream and downstream of 10 key sites in Devon.

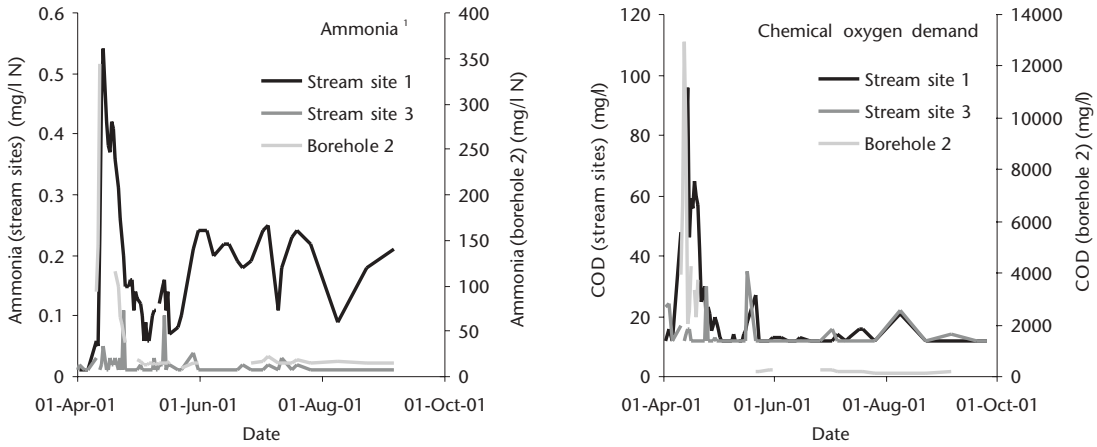
Table 6. Stream invertebrate surveys to assess foot and mouth outbreak effects

Agency Region	Number of sites surveyed[1]	Results
Midlands	31	No impacts from Throckmorton mass burial site. No impacts from farm disinfection on the Cinderford Brook, Westbury Brook or River Rhiw (Wales); 1 site impacted on the Llifior Brook (Wales), possible impacts at 5 sites on the Lack Brook (partly in Wales). No impact from a burn site on the Blackpool Brook (Gloucestershire).
North East	8	No impacts from Tow Law and Widdrington mass burial sites
South West	11	No impacts from farm disinfection on the R.Lew, R.Lyd, R.Thrushel, R.Ottery, R.Wolf, and Quither Brook
Wales	30	No impacts from farm disinfection on the Afon Braint, Afon Cefni, Afon Bodwrog, Afon Honddu, Afon Tarell, and in the Swansea/Neath area. Evidence of disinfectant impacts at 3 sites on a tributary of the Afon Braint on Anglesey and 1 site on the Ty Draw Brook near Neath.

[1]Refers to sites downstream of affected areas and does not include upstream reference sites

Source: Environment Agency

Figure 9. Stream and groundwater chemistry at Mynydd Epynt mass burial site, Powys



[1]River ecosystem class 1 ammonia standard = 0.25mg/l as a 95 percentile (i.e. can be exceeded five per cent of the time)

Source: Environment Agency

4.3 Groundwater

Groundwaters provide public and private drinking water supplies, and feed streams and rivers. Any pollution of groundwater may therefore contaminate potable supplies and surface waters. Such pollution typically takes years to clear up because water in aquifers is replenished very slowly. Groundwater protection was therefore a major concern at carcass burial sites and pyres, and for disposal of disinfectant washings to land.

Small private water supplies were at the greatest risk of contamination because records of their locations are incomplete (DoH, June 2001). While the Agency liaised with local authorities and landowners to try to identify all private sources potentially affected, some may have been missed.

Monitoring to assess the effects of disposal focused initially on mass burial sites. The Sennybridge site is the only one to have caused serious problems so far. These were rapidly detected and environmental damage averted (Box 3). The site is now closed.

Groundwater sampling at mass burial sites is being carried out by consultants for DEFRA, with regular reporting to DEFRA and the Agency. The Agency also carries out audit monitoring. Great Orton has 68 monitoring boreholes, Tow Law 32, Throckmorton 28, Widdrington six and Mynydd Epynt at Sennybridge had six. Boreholes are at varying distances from the burial cells and samples are taken, in some cases at several depths, to be analysed for a range of substances (Appendix 7). Microbiological analysis is performed at selected sites. Surface waters around the sites are also

sampled. The results are assessed for any trends in contamination that may be a cause for concern. This work is at an early stage and more detailed data analysis will be made as the programme progresses. Monitoring will need to continue for a number of years.

The Agency is undertaking some groundwater and stream monitoring around on-farm burials. The evidence to mid-October indicates that carcass disposal sites on farms have not significantly affected groundwaters or water supplies. This supports the conclusions of risk assessments, although these are subject to uncertainties. Long-term monitoring is essential as any contamination could take years to appear.

The Agency is carrying out an interim monitoring programme for the six months to March 2002, prior to DEFRA establishing a long-term monitoring strategy. Current monitoring includes intensive sampling at the four mass burial sites, a survey of about 26 sites across the Eden Valley, and sampling of selected carcass and ash burial sites in the most affected areas. This amounts to approximately 270 groundwater sites in addition to routine monitoring and audit of operator sampling at landfill sites.

A project to evaluate possible impacts on groundwaters in Cumbria, especially the major Eden Valley aquifer, is to report in March 2002. Modelling here and elsewhere is being carried out to help define the areas around burial sites that must be avoided when siting abstraction points in the future. In Wales, better geological information is needed for the risk assessment of proposed disposal sites.

4.4 Soils and vegetation

Soils were sampled at 18 sites, typically within one to three kilometres of pyres in Devon, Carmarthenshire and Anglesey. Concentrations of dioxins were within the range found previously in rural soils (Table 7). Concentrations of dioxin-like PCBs were not elevated compared with a reference sample (Food Standards Agency, September 2001).

The results for herbage and silage around pyres were similar to the reference site.

Information from further studies is expected later this year. This includes data being co-ordinated by the National Assembly for Wales on dioxins, PCBs and PAHs from pyre sites in Wales. A UK soil and herbage pollutant survey of organic substances (and metals) will provide further context. Evaluation of these data should help to determine how significant pyres were as sources of persistent organic pollutants.

Table 7. Organic contaminants in soils around pyres (results to 31 August 2001)

Region	Sample type	Number of samples	Concentration (ng WHO-TEQ/kg dry weight)[1]		
			Dioxins	Dioxin-like PCBs	Dioxins and PCBs
Anglesey	soil	7	1.1 - 2.0	0.2	1.2 - 2.2
Carmarthenshire	soil	2	1.5 - 1.6	0.1 - 0.2	1.6 - 1.7
Devon	soil	9	0.8 - 1.5	0.1 - 0.2	0.9 - 1.7
Gwynedd (reference)	soil	1	4.4	0.2	4.6
Anglesey	herbage	6	0.2 - 1.4	0.1 - 0.3	0.3 - 1.8
Carmarthenshire	herbage	2	0.9 - 1.0	0.1 - 0.2	1.1
Devon	herbage	9	0.2 - 0.8	<0.1 - 0.2	0.3 - 1.0
Gwynedd (reference)	herbage	1	0.6	0.1	0.6
Anglesey	silage	1	0.4	-	-
Devon	silage	3	0.2 - 0.3	<0.1 - 0.1	0.3

[1]The typical concentration range for dioxins in rural soils is 0.7 - 1.7 ng WHO-TEQ/kg dry weight. The typical range for PCBs in soils is unknown.
Source: Food Standards Agency, September 2001

4.5 Wildlife

Deer, wild boar, grey squirrels and hedgehogs can be infected with foot and mouth disease, while birds can carry the virus on their bodies. The effect on wildlife populations is unlikely to be significant although they may transmit the disease between farms. The advice from DEFRA is that the risk is low and that culling wild animals could spread the disease over a wider area.

The fact that the disease died out in the UK after the 1967 and 1981 outbreaks suggests that wildlife is not an important carrier of the disease (English Nature, March 2001). Sick and injured deer culled in Cumbria during the present outbreak did not test positive for the disease.

The Agency helped to advise on conservation sites as part of the assessment of proposed carcass disposal sites, so damage to wildlife from pyres should have been largely

Table 8. Potential impacts of foot and mouth outbreak on different types of habitat

Habitat	Potential impacts	Main areas affected and examples
Lowland grasslands	Overgrazing due to movement restrictions	
	Undergrazing due to movement restrictions – competitive grasses and scrub spread, biodiversity declines	Culm Natural Area (South West) Dean Natural Area (Gloucestershire)
Lowland heathland	Overgrazing – nutrient enrichment may harm heathland flora	
	Undergrazing – reptiles may benefit, some invertebrates may decline	East Devon Pebbled Heath New Forest
Lowland wetlands	Overgrazing of grasslands – increased erosion and nutrients in runoff	River Wye
	Carcass disposal – pollution of ground water from burial sites, or deposition from pyres	
Coastal (sand dune, salt marsh, grazing marsh, cliffs)	Undergrazing – marshes become rank, biodiversity (including geese and natterjack toad) declines	Solway Firth saltmarshes
	Overgrazing	Ainsdale sand dunes (Liverpool)
Lowland woodland, wood pasture and scrub	Reduced deer control due to restrictions on human movement – increase in population	Moccas Park Nature Reserve, Herefordshire
Upland grasslands	Undergrazing – nesting waders may benefit because of reduced trampling	North Pennines, Cumbria Fells and Dales and Yorkshire Dales.
	Overgrazing	
Upland woodlands and scrub	Undergrazing – blue ground beetle and some fungi may suffer Reduced deer control – increased population	North Pennines, Cumbria Fells and Dales and Yorkshire Dales.
Upland calcareous grassland, limestone pavement, wetland and fresh water	Undergrazing – short term benefits to flora usually suppressed by grazing	Habitat found in Northern England
Upland moor, blanket bog, flushes and fresh water	Undergrazing - no negative effects if grazing reinstated	North Pennines, Cumbria Fells and Dales and Yorkshire Dales.
	Loss of many hefted flocks	Hexhamshire Moors SSSI (Northumberland) Cotherstone Moor SSSI (Durham) Skiddaw Massif, Haweswater Fells (Cumbria)
Montane	Loss of livestock should aid the recovery of overgrazed areas. Flora and invertebrates such as the ground beetle may benefit	Yorkshire Dales, Cumbria Fells and Dales, North Pennines, Boarder Uplands

Source: English Nature 2001

avoided. However, bats and birds such as owls and swallows that roost in farm buildings are likely to have been displaced by cleansing activities.

Pest control chemicals used to prevent rats spreading the foot and mouth virus from infected farms posed a threat to wildlife. Poisoned rats may be eaten by birds of prey and scavengers such as crows. Snares were also set around sites while carcasses were exposed. No data are available on the extent of effects on wildlife.

English Nature has assessed the potential changes to habitats and their associated species (Table 8). The possible effects depend mainly on changes in grazing patterns. These are likely to be more significant in heavily affected areas, for example in the upland grasslands of the north of England. Some important species and plant communities could be affected if grazing levels remain reduced for several years, although other species may benefit.

Reduction in grazing and walking access may have allowed some recovery of overgrazed and trampled vegetation, thus reducing soil erosion and the silting up of watercourses. Some observers have reported more flowers on pasture land. Conversely, loss of grazing, for example of upland vegetation and coastal saltmarshes, allows coarse grasses to spread, reducing vegetation diversity and habitat for some species such as grazing wildfowl.

With the exception of three reported large fish kills (Section 4.2), the effects of management of the outbreak on fish populations are unknown because most monitoring ceased. Large effects are not expected but it is possible that detergents could have harmed some juvenile fish populations. The prevention of angling for spring salmon may have helped stocks to recover slightly from their present low levels.

The impacts on other animals and plants of managing the outbreak are unknown. Wildlife surveys such as national bird surveys were severely curtailed during the outbreak. Few effects are expected in the short term, while long-term changes will depend on how individual farms restock and changes to agricultural policy and the industry.

4.6 Landscape quality

Landscape quality cannot yet be assessed in any objective way but it is an important contributor to the quality of life for those who live in or visit the countryside. The images of mass burial sites and pyres created a strong impression that the outbreak and its management were spoiling the countryside. Footpaths were closed and even where they were open people stayed away due to the uncertainty, the risk of spreading the foot and mouth virus and the fear of seeing the disposal of animals (English Tourism Council, 2001). Most of these impacts were short-lived although the impact on tourism was large (Countryside Agency, 2001).

The change in stocking patterns and grazing patterns throughout 2001 will have changed the look of the countryside. The absence of sheep grazing the hillsides has affected the landscape in many upland areas. This is due to changes in the type and growth of vegetation compared with what is familiar and associated with a visit to the countryside.

The outbreak showed the synergies between tourism, farming and landscape quality (Countryside Agency, 2001). Farmers play a role in maintaining the landscape. They are responsible for land management including the maintenance of hedges, fields, woods and walls. Any long-term changes to agricultural policy as a result of the outbreak must recognise the contribution of farmers to landscape quality and seek to enhance this.

4.7 Public health

Risks

The disposal of slaughtered animals involved risks to health, including (DoH, June 2001):

- inhalation of particles (PM_{10}), sulphur dioxide and other air pollutants released from pyres (Sections 3.1 and 4.1);
- food chain contamination by dioxins, PCBs and PAHs deposited on the ground from pyre emissions (Section 4.4);
- contamination of private drinking water supplies by chemicals and pathogens released from carcass disposal sites into groundwaters (Sections 3.1 and 4.3).

Table 9. Summary of assessment of risks to public health from disposal of carcasses during the outbreak

Hazard	Health effects	Potential exposure[1]	Risk evaluation
Sulphur dioxide from pyres	Linked to respiratory and coronary illness	Air quality standard could be exceeded up to 3km or more from a large pyre	Low if pyres are well managed
Airborne particles from pyres	Linked to respiratory and cardiovascular disease. May worsen asthma.	Air quality standard could be exceeded up to 3km or more from a large pyre	Low but may be significant in areas affected by major plumes
PAHs from pyres	Range of serious toxic effects	Proposed air quality standard could be exceeded up to 4km from a large pyre	Low but potentially significant
Dioxins from pyres	Range of serious toxic effects	Uncertain, could be significant from food produced in the vicinity	Low but potentially significant
PCBs from pyres	Range of serious toxic effects	Uncertain, expected to be low	Low
Verotoxin-producing strain of *E.coli* from private water supplies	Mild to severe, can cause acute renal failure	Possible in private water supplies	Moderate
Campylobacter from private water supplies	Diarrhoea, stomach cramps, recovery within a week	Possible in private water supplies	Low
Cryptosporidium from private and public water supplies	Diarrhoea, stomach cramps, nausea, recovery within a few weeks	Possible, especially in private supplies	Significant
BSE prions from burning and burial	Fatal	Infection risk low but uncertain	Any significant risk would be considered unacceptable

[1]Potential exposure includes estimates from modelling of emissions and air concentrations that were used for risk assessments (see Section 4 for actual findings).
Source: Environment Agency; DoH, June 2001; DoH et al., November 2001

These exclude any occupational health risks. Potential exposure to radiation from the disposal of sheep contaminated by Chernobyl was negligible according to the National Radiological Protection Board.

Procedures were designed to reduce health risks to very low levels on the basis of existing knowledge and models (Table 9). Risks were assessed using the Agency's framework developed in line with national guidance (DETR *et al.*, 2000). Assumptions were tested by monitoring and assessment to allow any necessary additional steps to be taken.

Full details of assessments on risks to public health are available in reports published by the Department of Health and the Food Standards Agency (DoH, June 2001; DoH *et al.*, April 2001; DoH *et al.*, November 2001; Food Standards Agency, September 2001).

Drinking water

Monitoring by water companies has found no contamination of public supplies. Monitoring by local authorities of private water supplies in affected areas has been limited. Contamination to date has been restricted to two cases.

- At the farm near Felindre where material was buried near a drinking well (Section 3.1) the water was microbially contaminated although this was not proven to be due to carcass burial.
- At a farm near Tow Law the water supply pipe was broken by contractors' heavy equipment, leading to contamination from the farm tip.

There have been isolated cases of interruptions to local supply pipes:

- The public water supply to Crook was disrupted by burial of carcasses at the wrong farm location. Northumbrian Water has now diverted the supply.
- A domestic mains supply broken by digging near Stoke on Trent was repaired.

The locations of disposal sites and risks to private supplies are being reviewed by DEFRA, the Agency and local authorities. For example, two private water supplies in North West England are potentially at risk of contamination from nearby pyres. Long-term monitoring is essential to ensure that any contamination is detected.

Impact of air quality

The monitoring results indicate that, at a reasonable distance from pyres, health effects were unlikely to be noticed even by sensitive individuals (assuming that the monitoring sites reflected general conditions around the pyres)(DoH *et al.,* November 2001). The North and East Devon Health Authority conducted a rapid assessment which found that pyres did not appear to affect consultations or prescriptions for asthma (DoH *et al.*, November 2001).

Air concentrations of PAHs, dioxins and PCBs within 2km of pyres were higher than rural background levels but comparable with urban situations. Inhalation of these substances was therefore not a cause for concern (DoH *et al.*, November 2001).

Complaints were received from the public about odour from carcasses taken to landfill sites. In North West England there were some 300 complaints related to six landfills (including the Great Orton mass burial site), of which two-thirds were about the Distington site in Cumbria. Odour can be a serious concern, although the health risks are low. The complaints are being investigated further to clarify the scale of the problem, and what was and can be done to address it.

Food quality

The Food Standards Agency and DoH have sampled food near pyres and assessed contaminant levels in relation to health effects (DoH *et al.,* November 2001; Food Standards Agency, September 2001). Food samples, including milk, eggs and meat, were taken up to 4km from pyres, most within 2km. By 20 September, 120 samples from Anglesey, Carmarthenshire, Cornwall, Devon, Cumbria, Dumfries and Galloway and County Down had been reported (results from the final 48 samples will be reported later).

The concentrations of dioxins and dioxin-like PCBs were within normal ranges in most cases. The exceptions were dioxin-like PCBs in milk from two farms and hen eggs from one farm on Anglesey. These cases are under investigation (Food Standards Agency, September 2001).

No significant harm from consuming food produced near pyres is expected. The Food Standards Agency has withdrawn its initial precautionary advice regarding the consumption of milk products from animals within 2km of pyres. These conclusions do not exclude the possibility of higher concentrations of dioxins or PCBs in soils or food, for example in the immediate vicinity of a pyre (DoH *et al.*, November 2001).

5. Conclusions

The main interim conclusions on the environmental impacts of the outbreak are as follows (Table 10):

- Air emissions from pyres were a small proportion of national emissions and did not significantly affect air quality beyond their immediate vicinity.
- Surface water pollution has been limited to a small number of incidents. Contamination has affected a very small number of private water sources and no public supplies.
- Groundwater contamination from carcass burial, ash burial and disinfectant disposal has so far been minor.
- Soil contamination by organic pollutants from pyres was negligible.
- There is no evidence of significant harm to wildlife. Changes in grazing patterns may have some short-term impacts and some vulnerable species may be affected.
- There is no evidence of harm to public health.
- Landscape quality has changed in areas where the livestock have been slaughtered. The long-term impact will depend on restocking practices.

Table 10. Summary of the environmental effects of the foot and mouth outbreak

Impact	Short-term effects during the outbreak	Medium-term effects (within a year)	Long-term effects (more than a year)
Air pollution	Pyre emissions elevated local concentrations of some pollutants but did not breach air quality standards. The fumes and odour caused public concern (-). Odour from some landfills caused public concern (-).	Small reduction in ammonia and methane emissions from fewer livestock (+).	Possible soil contamination from emissions of dioxins, PCBs and PAHs (see below).
Groundwater pollution	Seepage from burials and pits under pyres has contaminated a small number of groundwaters (-).	Seepage will continue and could contaminate groundwater (-).	Seepage to groundwater could occur over 20 years (-).
Surface water pollution	212 reported pollution incidents, 14 causing significant harm, mainly from disinfection, carcass fluids and slurry (-). Unable to access farmland to maintain small sewage works or to attend pollution incidents (-).	Seepage from burials and pits under pyres could reach surface waters (-). Removal of stock locally could reduce diffuse pollution (organic, nutrients, sediment) (+).	
Soils	Decreased local soil erosion where animals culled (+); increased local soil erosion where animals could not be moved (-). Reduced soil erosion from walkers (+). Pyre emissions led to small risk of local soil and food contamination by dioxins, PCBs and PAHs (-).	Reduced soil erosion in overgrazed areas where animals culled (+).	Any significant dioxin, PCB or PAH contamination could persist for several years (-)
Wildlife and fisheries	Less disturbance from visitors (+). Rat poison could be picked up by birds of prey (-). Three large fish kills reported; unrecorded disinfectant pollution could cause local harm to fish populations (-). Reduced fishing could benefit spring salmon (+).	Local changes in grazing pressure would benefit some habitats and degrade others (+/-).	Changes depend on the response of the farming industry and any changes to agricultural policy.
Landscape	Pyre smoke (-), loss of farm stock (-), footpath restrictions (-).	Lack of farm stock in some areas and changes in vegetation will affect the landscape.	Changes depend on the response of the farming industry and any changes to agricultural policy.

Key: + is a benefit; - is a disbenefit
Note: This assessment ignores the effects of any permanent changes in the livestock sector.

These results indicate that management of the outbreak has been effective in avoiding environmental harm in the short term. They reflect the major efforts of Agency staff and others in reducing potential problems. Monitoring is essential to ensure that any long-term impacts on groundwaters are detected.

There was, however, local annoyance and distress caused by a number of disposal sites and operations. This has been recognised and should be addressed in future contingency plans.

As more information becomes available, it will be posted on our web-site and those of others (www.environment-agency.gov.uk/yourenv/footandmouth; Appendix 8).

Research needs

The foot and mouth outbreak has raised many questions where research might help us to be better prepared for future emergencies of a similar kind. The following areas are being considered by the Agency for its own and collaborative research:

- Monitoring and assessing the impacts. This needs to consolidate what has been learned about the impacts and monitoring of major incidents.
- Reviewing pollutant sources, pathways and impacts. We need to improve the technical information, for example on microbiological contaminants in groundwaters from the burial or burning of carcasses and pollutants from the disposal of other material.
- Environmental risk assessment of management actions. We need to carry out a comprehensive re-evaluation of the environmental risks that had to be managed during the crisis, including other risks such as increasing the spread of the disease.
- Assessment of management options. The balance of environmental, social and economic impacts needs to be reviewed for alternative management strategies.
- Decision-making framework for management. There is a need to review the 'best practicable environmental options' for the disposal of carcasses to protect human health and the environment.
- Contingency planning. We need to assess the Agency's capacity, preparedness, information management, communications and co-ordination with others for responding to national scale emergencies.
- What constitutes sustainable land use and agriculture? The implications of the epidemic, such as the effects of animal stocking levels and movements, on the sustainable management of the land in the long-term need to be assessed.

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Appendix 1. Legislative background

This appendix provides an overview of legislative responsibilities relevant to environmental protection during the foot and mouth outbreak.

Waste disposal

Agricultural wastes arising on farms are broadly excluded from the definition of 'controlled waste' and so are not covered under waste management legislation. Carcasses are controlled under the Animal By-Products Order 1999, regulated by DEFRA through the State Veterinary Service and local authorities. If they go to commercial landfills (which are regulated by the Agency), carcasses and other on-farm wastes, such as those from cleansing and disinfection, are controlled under the terms of waste management licences.

The responsibility for carcass and ash disposal rests with DEFRA subject to compliance with the Groundwater Directive (below). Mass burial sites are controlled under the Animal By-Products Order 1999 and groundwater authorisations.

If certain hazardous materials such as asbestos are buried, the site may be subject to contaminated land legislation. It is not likely that ash residues will fall under such controls as the levels of contaminants found to date are relatively low.

In some cases, disposal sites have been dealt with by retrospective planning permissions issued by local authorities. These require consideration of risks to all receptors – humans, controlled waters, and flora and fauna.

Groundwater

The EC Groundwater Directive requires groundwaters to be protected from List I and List II substances. These hazardous substances include ammonia, other animal breakdown products and the constituents of some disinfectants. The Agency partly administers this Directive through the Groundwater Regulations 1998. The Regulations require a prior investigation or risk assessment before authorising disposal of listed substances to ensure the protection of groundwater. An authorisation is required in most cases for carcass and ash burials, and for disposal of disinfectant.

While the Agency is responsible for protecting groundwater, it is the responsibility of local authorities to keep records of private water supplies and to monitor them.

Surface water

The Agency regulates point discharges to water and is generally responsible for the control of water pollution. It does not directly control diffuse runoff, for example from farms, but advises on implementation of the Code of Good Agricultural Practice for the Protection of Water and may take action when pollution occurs. The code, supplemented by additional guidance, was applied to farm activities during the foot and mouth outbreak.

Air

Local authorities are responsible for local air quality control issues such as those related to burning carcasses on pyres. Dark smoke is normally prohibited from trade premises including farms under the Clean Air Act 1993, although the Clean Air (Emission of Dark Smoke) (Exemption) Regulations 1969 allow carcasses to be burned if there is no other practicable method. The statutory nuisance provisions of the Environmental Protection Act 1990 may apply. Local authorities also regulate rendering plants as Part B processes under the Environmental Protection Act 1990.

The Agency has no statutory role over air pollution from pyres, but it has provided advice and undertaken air quality and deposition monitoring at some pyre sites at the request of local authorities. The Agency regulates the burning of animal carcasses in incinerators under the Environmental Protection Act 1990 (Part A processes) and under the Pollution Prevention and Control Regulations. Permits for air curtain incinerators could not normally have been issued in time by the Agency, but revised regulations allowed their use for a limited period.

For open burning it was agreed that the Code of Good Agricultural Practice for the Protection of Air would apply. This advises burning in a shallow pit with dry fuels; the use of tyres, rubber, plastics or liquid fuels is not permitted.

Other Agency duties

The Agency is also responsible for other aspects of the environment affected by the foot and mouth outbreak.

The Agency:

- regulates the abstraction of water from groundwaters and surface waters;
- aims to conserve and enhance the water environment;
- maintains and improves freshwater fisheries and issues angling licences;
- manages navigation on 800km of rivers and canals;
- supervises all flood defence matters.

Appendix 2.
Foot and mouth terms

Types of slaughtered animals	
Infected premises (IPs)	Premises where foot and mouth disease has been confirmed. (Confirmed cases for which the subsequent laboratory tests prove negative are still included in the figures because a negative test does not necessarily mean that the animal is not infected.)
Dangerous contacts (DCs)	Premises where animals have been in direct contact with infected animals or have in any way been exposed to infection. This includes animals slaughtered as part of a 3km cull.
Contiguous premises (CPs)	A category of dangerous contacts where animals may have been exposed to infection on neighbouring infected premises. This does not include animals slaughtered as part of a 3km cull.
Slaughtered on suspicion (SOS)	Premises where a veterinary inspection detects some symptoms of disease, but these are insufficient to confirm that foot and mouth disease is present. Animals are culled and cases confirmed subsequently are classified as IPs.
Livestock Welfare (Disposal) Scheme	This scheme is a last resort for farmers whose livestock are facing welfare problems as a result of the movement restrictions related to foot and mouth. The scheme has been extended to include light lambs.
Disease control classifications	
Infected areas (IAs)	On confirmation of foot and mouth disease an infected area is imposed which extends to a minimum of 10km around the infected place. Its size may be increased if necessary. Where IAs would overlap, a single IA may be declared.
Protection zones	The area within a 3km boundary of Infected Premises. No stock can move within this area.
Surveillance zones	The 10 km area around an infected place.
Risk classifications of counties	
High risk areas and mouth not resolved.	Areas with outbreaks of foot and mouth in the past 30 days, or with surveillance in 3km around outbreaks not completed, surveillance in the 3-10km zone not completed, and flocks at risk of foot
At risk areas (ARAs)	Areas that are not infected areas but where infected sheep may be present.
Provisionally free areas (PFAs)	Areas where there is no current evidence of disease.

Appendix 3. Environment Agency operational guidance

The following guidance was produced or used during the foot and mouth outbreak. The documents have not been formally published as they have been subject to revision. Copies are available from the Agency on request (Tel: 01454 624411).

Document	Reference code/date
General operational guidance	
Joint Statement From MAFF and the Agency on Foot and Mouth	MD/OPS/26_02_01/2/1
Regional Incident Procedures	-
Guidance Note on the Disposal of Animal By-products and Catering Waste	FMD/OPS/12_03_01/4/1
Burial or Burning of Fallen Stock on Farm	FMD/OPS/01_03_01/5/1
Supplementary Guidance on the Burial of Animal Carcasses During the Foot and Mouth Outbreak	FMD/OPS/01_03_01/6/2
Guidelines On The Disposal Of Waste Milk In Non-Affected Areas	FMD/OPS/05_03_01/8/1
NFU advice to farmers on slurry disposal	FMD/OPS/12_03_01/9/2
Explanation of Disease Control Terms Used by MAFF	FMD/OPS/06_03_01/11/1
Foot and Mouth disease - Treatment and use of sewage sludge & Abattoir Waste	FMD/OPS/18_07_01/12/5
Guidance on Managing Organic Wastes on Farms During the Current FMD outbreak	FMD/OPS/27_07_01/14/3
Guidance FMD Nuclear Site Radiological Monitoring Programmes	FMD/OPS/03_05_01/19/2
Generic Risk Assessments For Common Environmental Protection And Water Management Activities	FMD/OPS/12_03_01/21/1
Guidance On The Disposal Of Infected Carcasses To Existing Licensed Landfill Sites	FMD/OPS/16_03_01/23/1
Impact on Hydrometry Briefing Note	FMD/OPS/19_03_01/24/1
Environmental Assessment - Burials and Burning	FMD/OPS/21_03_01/25/1
Guidance for Agency Staff who live on Agricultural Holdings	FMD/OPS/23_03_01/26/1
Proposed import of railway sleepers as support fuel for burning of animal carcasses	FMD/OPS/27_03_01/27/1
Gatekeeper Duties At Landfill and Mass Disposal Sites	FMD/OPS/04_04_01/33/2
Welfare Disposal Scheme Landfill Sites as at 4 April 2001	FMD/OPS/17_04_01/34/4
19 April 2001, Landfill Sites LWDS	FMD/OPS/20_04_01/34A/5
Welfare disposal scheme landfill sites as at 29 April 2001	FMD/OPS/27_04_01/34A/6
Protocol for the use of Licensed Landfills for the Disposal of Animal Carcasses during the Foot and Mouth Outbreak	FMD/OPS/20_04_01/35/3
Foot and Mouth Guidance Variation to Animal Carcass Incinerator authorisations to permit them to incinerate sheep	Policy Number: 24_01, 06/04/01
Advice To Public Health Doctors: Risks To Health Posed By Substances Emitted From Pyres	FMD/OPS/06_04_01/37_1
Guidance for Environment Agency Staff on the Resumption of Operational activities	FMD/OPS/09_04_01/38/1
Environment Agency Advice On Environmental Protection Measures For Disposal of Carcasses From Foot And Mouth Slaughter Operations	FMD/OPS/10_04_01/41/1
Disposal Of Bonded Asbestos Materials From Agricultural Premises Within A Foot & Mouth Disease Infected Area	FMD/OPS/11_04_01/42/1

Agency Involvement In Air Pollution From Burning Animal Carcasses	FMD/OPS/17_04_01/43/1
Guidance On Ash Disposal Arising From Pyres And Mobile Incinerators	FMD/OPS/24_04_01/44/4
Human Foot and Mouth Disease	FMD/OPS/26_04_01/45/1
Policy Line On The Past Burial Of Over Five Year Cattle	FMD/OPS/03_05_01/46/1
Generic Risk Assessment FMD Sites - Working With Pyre Ash	FMD/OPS/08_05_01/47/1
Permit with Introductory note: Pollution Prevention and Control Regulations 2000	FMD/OPS/04_06_01/50/1
Work Instruction Issuing Air Curtain Incinerator Permits	FMD/OPS/04_06_01/51/1
Permitting Air Curtain Incinerators used to dispose of animals slaughtered as a result of the Foot and Mouth disease outbreak	FMD/OPS/04_06_01/52/1
An Information Note on Restocking with Sentinel Milking Animals	FMD/OPS/28_06_01/53/1
Q Fever: Information for Environment Agency employees	FMD/OPS/09_07_01/54/1
FMD sites - Pyre Ash Tracking Protocol	FMD/OPS/09_07_01/55/1
Pyre Ash Removal - Site Assessment	FMD/OPS/09_07_01/56/1
FMD sites - Working with Pyre Ash Method Statement - Collection of Ash	FMD/OPS/09_07_01/57/2
Inspection of and liaison on the removal of ashes - Environment Agency protocol	FMD/OPS/09_07_01/58/1
Control of Substances Hazardous to Health Regulations: Material Safety Data Sheet	FMD/OPS/09_07_01/59/1
Pyre Ash Classification form	FMD/OPS/09_07_01/60/1
Draft Guidance on the Potential application of Contaminated Land Regulations to FMD Burials	FMD/OPS/16_07_01/61/1
Proposed FMD inquiries	FMD/OPS/24_08_01/63/1
Disinfectant guidance	
COSHH Assessment For ANTEC Virkon S (Memo)	FMD/DIS/27_02_01/2/1
MAFF Guide to Approved Disinfectants	27/02/01
Statutory Instrument - 30 New Disinfectants Approved By MAFF	01/03/01
Midlands Region Direct Works COSHH Assessment	FMD/DIS/08_03_01/6/1
Guidance on the Use and Disposal of Disinfectants for Foot & Mouth Disease	FMD/DIS/15_03_01/4/4
Suggested Disinfection Procedures for Agency Offices, Staff and Contractors during the current Foot & Mouth Outbreak	FMD/DIS/14_09_01/8/4
Disinfectants approved for use in the control of Foot and Mouth disease - environmental information	FMD/DIS/05_09_01/9/4
COSHH Risk Assessment for Steril Tabs	FMD/DIS/20_03_01/11/1
Operations on FMD affected farms: A Guidance Pack for Environment Agency Staff	FMD/DIS/08_06_01/12/2
Information sheet for Collection/Disposal of Disinfectants	FMD/DIS/22_05_01/13/1
Revision of Viper Chapter 3 Section N - Cleansing and Disinfection	FMD/DIS/08_06_01/15/1
Groundwater Regulations	
Implications for Groundwater Regulations Work	FMD/GRW/26_02_01/1/1
Guidance on Issuing Emergency Groundwater Regulations Authorisations	FMD/GRW/05_04_01/2/3
Disposal by Burial (Groundwater Regulations 1998)	FMD/GRW/08_03_01/3/2
Disposal of Disinfectant (Groundwater Regulations 1998)	FMD/GRW/28_02_01/4/1
Criteria For Authorisation For Burials	FMD/GWR/06_04_01/5/3
General Guidance to Minimise the Risk to Groundwater From Burials	FMD/GRW/05_03_01/6/1
Guidance on assessing risks to groundwater from the burning of cattle	FMD/GRW/18_04_01/8/2

Framework For Qualitative Risk Assessments For Controlled Waters With Respect To Disposal Of Carcasses And Burnt Remains Of Carcasses	FMD/GRW/04_04_01/10/1
Quantitative Risk Assessment For Cattle Burning	FMD/GRW/02_04_01/11/1
Data Sheet for Quantitative Groundwater Risk Assessment - Foot and Mouth Epidemic	FMD/GRW/04_04_01/12/1
Results Of Groundwater Risk Assessment For Burning Of Cattle Carcasses Due To Foot & Mouth Disease	FMD/GRW/04_04_01/13/1
Summary Guidance On Assessing The Risks To Controlled Waters From The Burial Of Livestock Slaughtered As A Result Of The Foot And Mouth Epidemic	FMD/GRW/09_04_01/14/1
Guidance On The Identification Of Strategic Sites For The Large-Scale Burial Of Culled Animals Resulting From The Foot And Mouth Outbreak	FMD/GRW/02_04_01/15/1
Guidance and Risk Assessment Documents (Water Quality)	FMD/GRW/14_08_01/16/2
Groundwater Regulations Authorisations - Reviews	FMD/GRW/22_05_01/17/1
DEFRA Memo on the Disposal of used Sheep Dip	FMD/GWR/04_07_01/18/3
Requirements for Slurry/Disinfectant washwater Disposal	FMD/GRW/07_08_01/19/1
Spreading a mix of slurry, disinfectant and disinfectant washwater	FMD/GRW/03_08_01/20/1
Disposal of culled stock by burial: Guidance and Reference Data for the protection of controlled waters	FMD/GRW/04_09_01/21/2
Disposal of ash from burning of stock: Guidance and Reference Data for the protection of controlled waters	FMD/GRW/14_08_01/22/1
Interim Groundwater Quality Monitoring Strategy - BioSecurity Measures	FMD/GRW/13_09_01/23/4
Frequently asked questions	
Liaison with MAFF	FMD/FAQ/12_03_01/1/2
Routine Environment Agency Work	FMD/FAQ/15_03_01/2/3
Disposal of Carcasses	FMD/FAQ/12_03_01/3/3
Disinfectant Issues	FMD/FAQ/12_03_01/4/3
Questions Still Waiting Answers	FMD/FAQ/28_03_01/5/5
Waste Management Licensing Issues	FMD/FAQ/14_03_01/6/2
Removal Of Pyre Ash	FMD/FAQ08_07_01/7/1
Fisheries, Ecology, Recreation	
Environment Agency - Fisheries Function Foot and Mouth, Update for Fisheries staff (Monday 12 March 2001)	FMD/FER/04_04_01/1/3
Environment Agency - Fisheries Function line to take Foot and Mouth, advice to anglers	FMD/FER/04_04_01/2/2
Environment Agency Recreation and Navigation functions - guidance on Foot and Mouth Outbreak	FMD/FER/04_04_01/3/3
Use Of Environment Agency Navigations During Foot And Mouth Disease Outbreak	FMD/FER/04_04_01/4/2
Risk Assessment Of Use Of Environment Agency Navigations In Respect Of Foot And Mouth Disease	FMD/FER/04_04_01/5/2
Risk Assessment Of Environment Agency Navigations - FMD River/Reach Action Plan	FMD/FER/04_04_01/6/2
Foot and Mouth Disease - Advice for Boaters on Environment Agency Navigations	FMD/FER/04_04_01/8/2
Regional lists of fisheries open to angling during the Foot and Mouth crisis	19/04/01
Access to the Countryside for Angling	28/06/01
Press Releases	
Press Release: Foot and Mouth Disease - Environment Agency Advice	28/02/01
Fish Stock Management and Closure of Environment Agency Fisheries	28/02/01
Environment Agency Urges Care With Disinfectants	05/03/01
Environment Agency Issues New Guidance to Waterways Users During Foot and Mouth Outbreak	30/03/01

Appendix 4. Best practicable environmental options for carcass disposal

To minimise environmental impacts the disposal of carcasses should follow the 'waste hierarchy':

- first, minimise the number of carcasses needing disposal by reducing the number of animals slaughtered for disease control and welfare;
- second, maximise the value derived from carcasses;
- and third, use disposal options with least impact, minimising the risks to human health and the environment (as well as minimising other risks such as spreading foot and mouth disease).

Minimisation of carcasses from welfare slaughter was pursued by DEFRA by re-establishing markets through the Animal Movement Licensing System and promoting the consumption of British lamb. The National Assembly for Wales promoted the consumption of Welsh lamb. The success of these measures is believed to have resulted in only 600,000 light lambs being registered for slaughter. These were out of an estimated two to eight million lambs without a market in the autumn, although there is still a possibility these lambs will end up in the Livestock Welfare Disposal Scheme.

A preferred hierarchy of disposal options was agreed by the Agency, DEFRA and DoH on the basis of qualitative appraisal of their environmental sustainability and impacts. It was recommended by the Agency on 23 February and agreed on 15 March 2001.

The hierarchy exploited the traditional and licensed routes for disposing of animal carcasses. Rendering, incineration in properly constructed incinerators and licensed landfill were at the top. Burning on-farm, burial on-farm and mass burning or mass burial were jointly bottom. However, because MAFF vets wished to dispose of diseased animals close to the farm to reduce the risks from movement, and because suitable landfills were not initially identified, there was a preference for burning and burial on site. As much of England and Wales was waterlogged in the first few months of 2001, burial was precluded on many farms due to the risk of contaminating surface water, groundwater and private drinking water supplies. Therefore burning was next in the hierarchy after rendering, incineration and licensed landfill. Burial was least favoured, but remained an option subject to an assessment of environmental risks.

A major factor in decisions on disposal was the risk of BSE infectivity. Cattle over five years old may carry BSE and about 0.72 per cent of the dairy herd is BSE infective. It was agreed by MAFF, DETR, the National Assembly for Wales and the Agency that carcasses of cattle over five years old (born before August 1996) were not allowed to be buried or landfilled. This was due to the risk of BSE transmission by groundwaters or other pathways as assessed by the Agency and DEFRA (DNV, 1997; Marsland *et al.,* 2001). The National Assembly for Wales also banned the burial of cattle of any age.

The risks from disposal of older cattle on pyres were also assessed. Analysis of pyre ash showed that over 90 per cent of protein material was destroyed, much reducing the risk of BSE prions in ash from older cattle. Burial of ash on-site, subject to assessment under the Groundwater Regulations, was therefore considered acceptable by DEFRA. Where ash had to be removed from the site, DEFRA identified landfill as the best available option due to the lack of suitable capacity to re-incinerate the ash, the handling risks involved with incineration, and the need to move the ash quickly.

Some of the key factors for each option were as follows.

- Rendering derives value from carcasses in the form of condensate, meat and bone meal and tallow. The condensate may be landspread, meat and bone meal can be burnt in some cases to generate heat, and tallow can be used in place of heavy fuel oil. However, during the foot and mouth outbreak the large quantities produced meant that disposal, for example of meat and bone meal to landfill, also had to be carried out.
- Incineration produces emissions to air although these are tightly controlled to meet EC limits. Energy recovery is possible but no carcass incinerators currently have this.

- Landfill sites produce odour, leachate and landfill gas, although sites are managed, regulated and monitored to minimise the pollution risks.
- On-farm burials create similar pressures to landfills but they are more numerous, not contained and so more difficult to manage. Mass burial sites can be engineered to control pollution but the short lead-in time for location, design and public consultation made this a difficult option.
- On-farm burning releases substances to air that may exceed health standards and create a public nuisance. The ash has to be disposed of safely on site or transported to landfill.

Research is needed to provide a more complete life cycle analysis of disposal options. This would include factors such as the distances carcasses must be transported to the disposal site. It would also analyse in more detail the effect of the local circumstances and other risks that will influence the choice of option in each case. This information would support contingency planning for any future situation of this kind.

Appendix 5. Air quality monitoring around pyres

Table A5.1 Results of inorganic pollutant monitoring at four pyre sites[1]

Site and population[2]	Period	Pollutant	Maximum pollutant concentration[3]	Distance from pyre	Size of pyre	Site downwind of pyre (% of time)
Holsworthy 1,892	24/04/01 to 28/04/01	NO_2 SO_2 PM_{10}	69 ppb (low) 12 ppb (low) 20 $\mu g/m^3$ (low)	~ 1.4 km	5 pyres each of 1000 cattle equivalents, 100m x 5m	No
Okehampton 4,841	28/04/01 to 06/05/01	NO_2 SO_2 PM_{10}	29 ppb (low) 23 ppb (low) 27 $\mu g/m^3$ (low)	Various pyres		Various pyres
Chulmleigh < 1,000	30/04/01 to 06/05/01	NO_2 SO_2 PM_{10}	12 ppb (low) 17 ppb (low) 42 $\mu g/m^3$ (low)	~ 850 m	Approximately 800 cattle equivalent, 10m x 150m	19%
Sennybridge < 1,000	02/04/01 to 07/05/01	NO_2 SO_2 PM_{10}	35 ppb (low) 21 ppb (low) 40 $\mu g/m^3$ (low)	~ 2.1 km	5/4 to 11/4 1613 cattle, 2021 sheep (1723 cattle equivalents)	~ 12%

'Low' indicates concentrations below the air quality standard.
[1]The four sites are those with the most comprehensive data.
[2]Population data from 1991 Urban Population Census
[3]Concentrations are given for the time relevant to the air quality standard:
nitrogen dioxide (NO_2) 1 hr average 150 ppb
sulphur dioxide (SO_2) 15 min average 100 ppb
particles (PM_{10}) 24 hr average 50 $\mu g/m^3$

Source: DoH et al., November 2001

Table A5.2. Results of trace organic pollutant monitoring at three pyres.

Pyre location	Dates	Sampler site	Pollutant	Concentration (BaP in ng/m^3, dioxins and PCBs in fg WHO-TEQ/m^3) [1]	Distance from pyre	Size of pyre	Site downwind of pyre (% of time)
Sennybridge	05/04/01 to 10/4/01	Waunlwyd	BaP	6.24	1km	5/4 to 11/4 1613 cattle and 2021 sheep (1723 cattle equivalent)	16%
			dioxins	8.0-42.7			
			PCBs	35.2-130			
		Agency site	BaP	2.73	2.1 km		19%
			dioxins	2.25-39.3			
			PCBs	5-110.3			
		Flag 7	BaP	0.06	1.4km		7.5%
			dioxins	2.79-123			
			PCBs	0-330			
		Bwlch-gwyn	BaP	<0.03	0.6 km		14%
			dioxins	0 –123			
			PCBs	1-330			
		Farm 16	BaP	0.01	4.5 km		3.5%
			dioxins	0.5-41.9			
			PCBs	1-110			
	02/05/01 to 11/05/01	Flag 5/Pyre	BaP	12	1/0.2 km	18,000 sheep (978 cattle equivalent)	Uncertain[2]
			dioxins	2.51-29			
			PCBs	2.7-30			
		Relic	BaP	1.6	0.75 km		Uncertain[2]
			dioxins	0.86-32			
			PCBs	1-30			
		Agency site	BaP	0.02	2.1 km		Uncertain[2]
			dioxins	2.23-25.4			
			PCBs	2.1-30			
		Farm 16	BaP	0.06	4.5 km		Uncertain[2]
			dioxins	0.32-21.0			
			PCBs	0.2-20			
Holsworthy	24/04/01 to 28/04/01	Hospital	BaP	0.20	1.4 km	5 pyres each of 1,000 cattle equivalent	0%
			dioxins	7.1-23			
		Blagdonmoor Wharf	BaP	1.6	0.75 km		34%
			dioxins	8.2-38			
		Crossparks Water Works	BaP	0.03	1.9 km		3.4%
			dioxins	7.2-42			
		Middle Merryfield	BaP	0.06	0.8 km		2%
			dioxins	3.7-24			
Okehampton	28/04/01 to 06/05/01		BaP	0.35	Various	Various pyres	
			dioxins	2.6-151			
			PCBs	3.01-37.66			

[1] See glossary for explanation of units. The lower figure in the ranges for dioxins and PCBs assumes that if an individual dioxin or PCB is not detected then the true level is zero. The upper end of the range assumes that the true level is at the limit of detection.
[2] Due to equipment failure the times the monitoring sites were downwind of the pyre were unknown.
Figures for benzo[a]pyrene (BaP) underlined would lead to an exceedance of the air quality standard of 0.25 ng/m^3 as an annual average when added to rural background levels and averaged over a year (Section 4.1). There are no air quality standards for dioxins or PCBs.
Source: DoH et al., November 2001

Appendix 6. Category 1 and 2 water pollution incidents

Region	Location	Date	Description
Category 1			
Midlands	Uttoxeter	25/6/01	Slurry and disinfection washwaters lost from a containment lagoon killed several thousand fish in Picknall Brook.
South West	Tiverton	27/5/01	About 70m^3 of slurry spilled from a farm into a tributary of the River Exe, killing about 350 brown trout plus other fish over 4km and requiring closure of a water supply intake.
Wales	Anglesey	16/3/01	Disinfectant runoff from an abattoir killed about 500 fish over 5.5km in a tributary of the Afon Braint.
Category 2			
Midlands	Rocester, Staffordshire	17/4/01	Pig slurry discharged from a farm under animal movement restrictions to the River Tean, killing about 50 fish.
North East	Huddersfield	29/4/01	A slurry tank burst and released thousands of gallons of slurry. No pollution to watercourses.
North East	Wear Valley	22/3/01	A private water supply pipe to Low Houselop Farm was broken by carcass burial work, contaminating the water.
North East	Widdrington mass burial site	10/4/01	Runoff from the cleansing and disinfection area polluted 1km of the Steads Burn.
North West	Stoney Beck	28/3/01	Blood from pig carcasses entered the watercourse.
North West	River Ellen	24/5/01	Slurry spill polluted the river.
North West	Silloth	31/5/01	Slurry spill polluted the watercourse
North West	Great Orton mass burial site	01/8/01	Carcass liquid seeped into the Pow Beck.
South West	Okehampton, Devon	2/10/01	Slurry spill polluted the Medland Brook.
Wales	Mona Airfield	29/3/01	Liquid from carcasses temporarily stored on the old runway ran through cracks into the airfield's surface water drainage system, affecting 2km of a tributary of the Afon Cefni.
Wales	Mynydd Epynt, Sennybridge	10/4/01	Liquid leached from a sheep burial pit into the Nant Gwydderig, a tributary of the Afon Tywi, causing growth of sewage fungus.

Appendix 7. Chemical and microbiological analysis of groundwaters

The following is a typical range of chemicals and micro-organisms included in the analysis of groundwater samples at mass burial sites. The range varies between different sites, and other chemicals such as sheep dip have been included in some samples.

Chemistry

pH
alkalinity
conductivity
dissolved solids
total organic carbon
biochemical oxygen demand
chemical oxygen demand
ammonia
sulphate
sulphide
nitrate
chloride
potassium
calcium
magnesium
sodium
iodide
non-ionic detergents

Microbiology

total coliforms
faecal coliforms
faecal streptococci
Escherichia coli (0157)
Salmonella
Campylobacter
Cryptosporidium
Giardia

Appendix 8. Useful web sites

Department for Environment, Food and Rural Affairs
www.defra.gov.uk/footandmouth – for general guidance and statistics.

Department of Health
www.doh.gov.uk/fmdguidance – for reports and guidance on public health.

Environment Agency
www.environment-agency.gov.uk/yourenv/footandmouth – for guidance on disinfectants, advice to anglers and boaters, and information on environmental monitoring.

Food Standards Agency
www.foodstandards.gov.uk – for reports and guidance on food safety.

Local authorities
www.ukonline.gov.uk/quickfind/local – for local authority web sites for local information on foot and mouth (for example, www.cumbria.gov.uk and www.powys.gov.uk).

National Environmental Technology Centre
www.aeat.co.uk/netcen/airqual – for air quality monitoring data including pyres.

Glossary

Air curtain incinerator	A type of mobile incinerator.
Aquifer	Permeable rock capable of storing significant quantities of water.
Benzo[a]pyrene (BaP)	A polycyclic aromatic hydrocarbon (PAH), often used as an indicator for this group of substances.
Biochemical oxygen demand (BOD)	A measure of the microbial uptake of oxygen used as an indicator of organic pollution in water.
BSE, BSE prions	Bovine spongiform encephalopathy. BSE prions are sub-viral agents made of protein which cause BSE.
Chemical oxygen demand (COD)	An indicator of water quality that measures oxygen demand chemically.
DEFRA	Department for Environment, Food and Rural Affairs (includes the former Ministry for Agriculture, Fisheries and Food and parts of the former Department of the Environment, Transport and the Regions).
Dioxins	A group of about 300 persistent organic compounds, polychlorinated dibenzo-p-dioxins; the term also includes polychlorinated dibenzofurans or furans. 17 substances of the group have significant toxic properties. Dioxins are produced by combustion under certain conditions.
DoH	Department of Health
fg/m^3	femtogrammes (10^{-15} grammes) per cubic metre
Groundwater source protection zone	Area around a groundwater source defined to avoid pollution from certain activities. Source protection zone I is defined on the basis that groundwater beneath the site will take less than 50 days to reach the water supply source. Zone I aims to provide protection from the risk of microbiological contamination.
Leaching, leachate	The movement of substances through soils and rocks to groundwater and surface water is 'leaching', and the solution they are carried in is 'leachate'.
$\mu g/m^3$	microgrammes (10^{-6} grammes) per cubic metre
ng/m^3	nanogrammes (10^{-9} grammes) per cubic metre
Nitrate vulnerable zone protect	Area designated under the EC Nitrate Directive where agricultural practices are controlled to waters vulnerable to nitrate pollution.
Nitrogen dioxide (NO_2)	An inorganic air pollutant commonly formed by combustion.
Pathogen	An organism which can cause disease.
Pollution incident categories	The Agency classifies pollution incidents into four categories. For water incidents, category 1 involves major impacts, category 2 is significant impacts, category 3 minor impacts and category 4 no impact.
Polychlorinated biphenyls (PCBs)	A group of organic chlorine chemicals manufactured for use in electrical equipment that are now banned because of their persistence, bioaccumulation and toxic properties.
PHLS	Public Health Laboratory Service
PM_{10}	Microscopic airborne particles with a diameter less than 10 micrometres.
Polycyclic aromatic hydrocarbons (PAHs)	PAHs are formed by the incomplete combustion of organic material, notably coal, wood, petrol and diesel. Several PAHs have toxic properties.
ppb	parts per billion
Protozoa	Single celled organisms.
Rendering	Heating process used to breakdown animal carcasses, principally to meat and bone meal and tallow.
Sewage sludge	Solid waste remaining after sewage treatment.

Slurry	Excreted animal waste in liquid form.
Sulphur dioxide (SO_2)	An inorganic air pollutant formed from the burning of material containing sulphur.
WHO-TEQ	Concentrations of dioxins are given in toxic equivalents (TEQ), that is the amount of a mixture that would have the same effect as the most toxic dioxin. The units now in general use are WHO-TEQs (after the World Health Organization).

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