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

(EXTRACTS FROM)

ENVIRONMENT AGENCY

December 2001

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.

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.

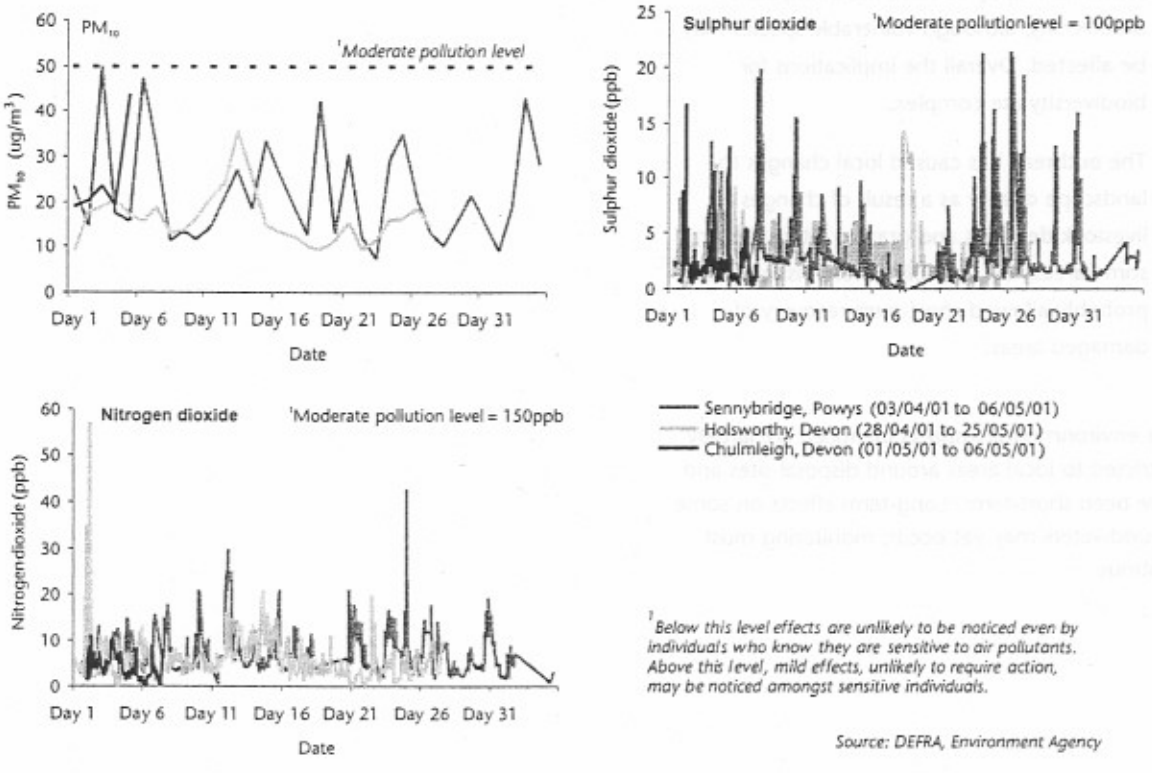
All concentrations of inorganic substances fell within the DoH/DEFRA 'low' air pollution band (Figure 7; Appendix 5)(DoH *et al.*, November 2001).

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:

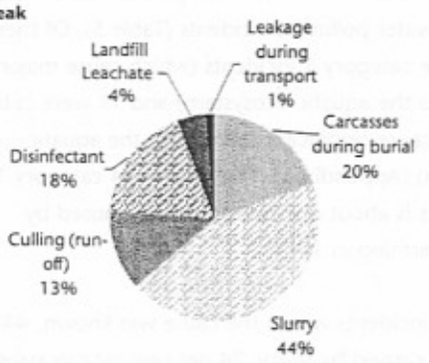
Table 5. Water pollution incidents related to foot and mouth activities[1]

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.

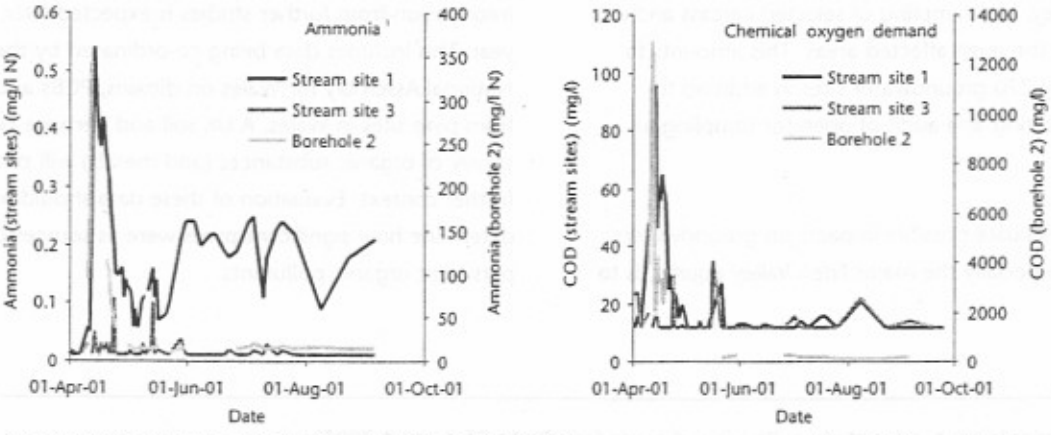
Table 6. Stream invertebrate surveys to assess foot and mouth outbreak effects

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	North Pennines, Cumbria Fells and Dales and Yorkshire Dales.
	Reduced deer control – increased population	
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.