FMD in Surrey, UK, 2007

Epidemiology report on the probable release of FMD virus at the Pirbright site and the transmission of infection to the first infected cattle herd, from investigations up to 29 August 2007 (Day 26)

National Emergency Epidemiology Group
Food and Farming Group
Defra, 1A Page Street
London

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Executive Summary

1. The virus strain, type O1BFS, that caused the outbreak of Foot and Mouth Disease (FMD) in Surrey in August 2007 has been shown beyond reasonable doubt to originate from the nearby Pirbright site where a commercial vaccine production plant and a research and diagnostic laboratory are co-located.

2. The estimated period during which the first infected premises (IP1) was infected with FMD virus is most likely between 12 - 25 July, as determined from examination of the animals at slaughter.

3. This likely period of infection was foreshortened to 19 -25 July, following the characterisation of the virus isolated from IP1 as the O1 BFS type. This strain was not handled in any quantity by either facility on the Pirbright site during the originally identified period until the week beginning 16 July. Subsequent investigations supported these assumptions and revealed no need to revert to the original, clinically derived infection period.

4. We have considered windborne transmission of aerosolised virus from the site to IP1. Expert investigations of the HEPA filtration systems, commissioned by the HSE investigation team, revealed no evidence of a breach of these systems. Although there is circumstantial evidence for such transmission from the site it is unlikely that there was a release of aerosilised virus to effect a transmission from the site to IP1.

5. Investigations indicate that release was most likely due to escape of live virus from the drainage system that connects the vaccine production plant to the sodium hydroxide treatment tanks on another part of the Pirbright site. Movement of the virus off site was most likely from movement of fomites created from soil, water or other material contaminated by effluent, and deposited on the road from which the track to IP1 leads.

6. Using the EFSA definitions of risk, the probability that live virus is present in the external environment on the Pirbright site or elsewhere, and could be transmitted to susceptible stock, is very low (i.e. this outcome is very rare but cannot be excluded). This risk is further mitigated by biosecurity measures in place on site and the remaining surveillance work.

7. Figure 1 in this report shows a diagram of the ‘timeline’ to show the temporal relationship of the key events reported.

Background

8. The virus strain that has been identified on the two FMD Infected Premises (IPs) in the 2007 outbreak in Surrey is O1 BFS, which is the strain recovered from the 1967 FMD epidemic in Great Britain. This strain only exists in a limited number of FMD research laboratories and pharmaceutical manufacturing plants, and is not in circulation in the field anywhere in the world.

9. The closest such facilities to the IPs are at Pirbright in Surrey; the next closest location where the virus is held is in laboratories in mainland Europe. We have no doubt that the virus causing this outbreak derived from one of the two facilities on the Pirbright site. We have not seen or found any evidence that the infection of the cattle herd (IP1) was the result of a malicious intent.

10. Foot and mouth disease was confirmed on two beef holdings close to the Pirbright site. Investigation of the timing of disease on these holdings, based on the age of lesions in the earliest clinical case on each, indicates that FMD virus reached IP1 between 9 – 28 July 2007, most likely 12 – 25 July 2007. Virus reached IP2 between 14 July – 2 August 2007, with a most likely date range of 17 -30 July 2007. The variability in the estimate for the date of exposure reflects the known error of +/- 3 days in estimating the age of FMD lesions over 6 days old (true for the earliest cases on both IPs).

11. The genetic sequencing results for the viruses recovered from both IPs are consistent with the epidemiological finding that IP2 was infected by IP1 (personal communication from Nick Knowles, Jemma Wadsworth, Eleanor Cottam, Don King and David Paton).

12. There are currently two mechanisms we believe to be the most biologically plausible means of transmission of FMD virus from the Pirbright site to the IP1. These are:

    - Fomite transmission via soil, water or other excavation by-products by personnel, equipment or vehicles

    - Windborne transmission of an aerosol

13. This report describes the progress of the current epidemiological investigations into the apparent release of Type O1 BFS FMD virus from the Pirbright site and the means of transmission to IP1, and assesses the risk that live virus may still be available in the environment to infect FMD-susceptible stock. Previous reports can be seen at http://www.defra.gov.uk/animalh/diseases/fmd/latest-situation/index.htm

14. The information in the report is derived from epidemiological investigations carried out by members of the National Emergency Epidemiology Group (NEEG), the HSE interim report published on 7 August 2007, specific information from the HSE investigation team, meteorological analyses carried out by John Gloster, and colleagues, of the Meteorological Office, based at the Institute for Animal Health (IAH), Pirbright and virological and clinical expertise provided by Dr David Paton and colleagues from IAH, Pirbright.

Availability of FMD virus O1 BFS for transmission off the Pirbright site

15. The FMD virus type O1 BFS was used in both of the facilities on the Pirbright site. Its use was for research and diagnosis at the Institute for Animal Health, and for vaccine production at the commercial facility. The use and disposal of virus has been investigated at both facilities. The dates and volumes of FMD virus used in research and to produce vaccine within the exposure window for IP1 are described in the timeline at Annex 1, and their temporal relationship to other events is shown in Figure 1.

16. Research and diagnosis: FMD virus Type O1 BFS was handled at the research and diagnosis facility 25 times in volumes of 7ml or less (usually much less) during June and July 2007. During the period 12 – 25 July a total of less than 11ml (0.011 litres) of live FMD virus type O1 BFS was used for bench based research and diagnosis on eight occasions, comprising a single volume of 7ml for disinfectant research, and seven volumes of 1ml or less to make up the remainder.

17. Waste from these procedures is treated (described below) to inactivate live virus before discharge to the drainage system. No animal experiments using this virus type had been conducted during this period or in the recent past. The HSE investigations revealed no evidence of failure of the HEPA filtration system at the research and diagnosis facility.

18. Vaccine production: In the three months preceding the occurrence of IP1 FMD virus Type O1 BFS was first handled at the vaccine facility on the Pirbright site on 10 July 2007. Half a millilitre of live FMD virus type O1 BFS was used to create each of two 5 litre volumes of virus commencing on 10 and 12 July respectively. These 5 litre volumes of live FMD virus type O1 BFS were seeded into 6000 litres of cell culture in two successive batches, on 17 and 19 July respectively, as the start of production of vaccine. The process of vaccine production involves a number of steps, including washing the equipment with citric acid after use.

19. Centrifugation is one of the stages in vaccine production when an aerosol can be generated. However the centrifuge is a sealed system with two in-line HEPA filters between it and the room it is in, which itself is also protected by HEPA filtration. The air then exhausts within the building which is also protected by two in-line HEPA filters that further clean the air exhausted to the external environment. Reports from the investigations by the VMD and the HSE indicate that all the air filtration equipment was correctly serviced, monitored and functioning during the risk period.

20. However the centrifugation step produces cell debris which might protect the virus from the antiviral effects of citric acid, and the effluent produced by this step is highly likely to contain live virus. The effluent from vaccine production is treated with citric acid before discharge; this is the start of an inactivation process that is completed in the sodium hydroxide treatment plant elsewhere on site. Effluent from the production of two batches of vaccine derived from FMD virus type O1 BFS was discharged from the effluent tank into the drainage system on 19, 22, 23 and 25 July.

21. In summary, it is very unlikely that an aerosol release of virus could have occurred from the contained area of either facility. The possibility of live virus being released in effluent was investigated further.

Detail of waste disposal during research and diagnosis

22. After each procedure during which live virus is handled, any remaining virus culture and the equipment used to handle the virus are placed in a discard jar and held for a minimum of 12 hours before disposal. The jar contains about 2 litres of disinfectant (FAM) at double the concentration required to kill FMD virus (to allow for the diluting effect of the liquid waste). This procedure dilutes any virus present at least 2000-fold, and is designed to completely inactivate any virus present before discharge to the drain.

23. These procedures make it highly unlikely that the virus would be made available outside the research and diagnostic facility's containment area. Also of note is that this facility handles orders of magnitude, greater than one million-fold, less live virus than the vaccine production plant. We therefore do not consider the IAH research and diagnosis facility as a possible source for the release of the virus further in this report.

Detail of waste disposal during vaccine production

24. All vaccine production equipment is washed through with 0.4% citric acid after handling live virus; this is discharged either directly, or via the discard tank, to the effluent tank (Figure 2). Directly discharged washings are neutralised with sodium hydroxide before discharge. The procedures are likely to be anti-viral in the liquid phase but may allow virus that is protected by more solid matter, such as the cell debris described below, to survive.

25. Part of the production process involves centrifugation to separate the supernatant that is used for vaccine, from the cell debris created by the cytopathic effect of the growing virus. This material, a 'watery slurry', is flushed into the discard tank by the citric acid wash, and held there for 48 hours without further treatment or agitation. The discard tank is a round bottomed vessel, and so provides the potential for any solid material to concentrate in the bottom during the holding period. After the holding period the contents of the discard tank are piped to the effluent tank.

26. The vaccine production unit's effluent tank has a volume of $4m^3$. On an average day, approximately 20 m^3 of effluent that might contain live virus is pumped from the effluent tank within the containment area of the vaccine facility into the site drainage system, which takes it via underground pipes to the sodium hydroxide treatment plant (NaOH plant) elsewhere on the Pirbright site. These relative volumes mean that effluent from vaccine production reaches the site drainage system on the same day as it is piped to the effluent tank.

27. Therefore, assimilating the exposure windows for the IPs, and the likely availability of the correct live virus strain and subtype in the drain, we conclude that the apparent first, and on balance probably only, release of virus from the

Pirbright site which caused infection of the cattle on IP1 occurred between 19 – 28 July 2007, and most likely between 19 – 25 July.

Results of investigations of the disposal and drainage system

28. There are two pumps which move the waste from the vaccine facility effluent tank uphill towards the first manhole inspection point. This length of pipe is approximately 30 m long and 4 inches in diameter. It is a cast iron pipe encased in concrete and from the HSE inspections is intact. When inspected it was discovered that the first manhole inspection point had a lid that was ill-fitting and not sealed. This is the shallowest point of the drainage system. From here, waste moves either to a second deeper, dead-end drain with an inspection manhole or towards the NaOH plant. The second manhole is a few feet away from this primary manhole and acts as an overflow when an excess volume of waste is pumped into the drain at any one time, from the vaccine facility effluent tank. When the flow is lessened, the waste flows back along the overflow route into the main drainage system.

29. When waste is discharged from the effluent tank, one pump starts to pump the waste up towards the manhole, however, if a large volume of waste is discharged at any one time the second pump will come into action. Each pump operates at 25,000 l / hr. When both pumps are in action the waste is pumped uphill at 50,000 l / hr.

30. Modelling of flow dynamics has been performed on the area from the effluent tank to the first inspection point (shallowest manhole) leaving the vaccine production facility. Preliminary results have indicated that if both pumps were in operation at the same time and coincident with the presence of a large amount of residual water in the drainage system, this force and volume of water would cause the second overflow drainage tank to become full in a very short time, leading to both manholes becoming overwhelmed with waste within a number of minutes.

31. Thus when there are large volumes of waste to be discharged from the effluent tank and high levels of residual water in the drainage system, there is clearly a potential for an overspill of the contents of the drain onto the surrounding hard surface. On inspection, a layer of solid deposits had formed at the neck of the manhole inspection cover to the overflow drain. This indicated that it had become full on previous occasions.

32. There is evidence that there were known concerns by the staff of the two facilities about the capacity of the drainage system. Heavy rain on 20 July (see Figure 3) lead to both the research facility and the vaccine facility on the Pirbright site ceasing the discharge of waste into the drainage system. The request, to cease discharging, was apparently rescinded in the early afternoon and pumping of effluent from the vaccine facility resumed at about 16:00 hours. It seems likely that at this time the drains contained an unusual volume of residual water from the rainfall.

33. Building works have been in progress on the Pirbright site. These include plans to replace the drains. Eight inspection holes to determine the location of new drains were dug between 11 July and 3 August, with work continuing on most days in this period. Thus there was construction activity on site

throughout the exposure period, providing the opportunity for fomite transmission.

34. Examination of inspection holes did not apparently reveal any visible leakage from the existing drains, however it is possible that soil contaminated by leakage from the drains could have been brought to the surface. None of this soil has left the site, and was reported to be cordoned off from the rest of the site on 8 August.

35. We do not believe that these exploratory investigations were in any way instrumental in allowing the release of the virus from the containment facility for potential transfer from the site. We do, however, believe that the above average rainfall around the risk period and the notable surge of rainfall on 20 July, and further relatively high rainfall on 21/22 and 23/24 July (see Figure 3) resulted in the drainage system being compromised. Such high volumes of rainwater could have maintained high residual levels of waste and rainwater in the drains, and so resulted in effluent escaping from the system and gaining access to the surface soil. This effluent might have contained "packets" of virus contained in the cellular debris which was discharged from the vaccine production containment facility. The role of the disposal and drainage systems in the release of the virus are discussed below.

Hypothetical routes of spread from the Pirbright Site to IP1

Field epidemiology investigations.

36. Extensive field epidemiological investigations of the two Infected Premises (IPs) have been carried out. These investigations are part of the standard procedure for Animal Health Veterinary Officers whenever a notifiable disease is confirmed. Their purpose is to discover the most likely time that the animals on the IP were exposed to infection, the route by which they could have been exposed and the routes and scale of any possible spread of onward infection from the premises. In the case of IP1 and IP2 the investigations were assisted by the presence of experts from the World Reference Laboratory, Pirbright to examine the lesions and assess their age, which aids the determination of the time of the initial exposure.

37. People and objects are 'traced' to establish their movements and potential contact with susceptible stock, as they may be carrying 'fomites'. A fomite is any inanimate object or substance capable of carrying infectious organisms and so transferring them to a susceptible host.

38. The investigations identified all of the possible methods by which FMD virus could have been transmitted from the Pirbright site to the infected premises and examined each in detail to assess the likelihood of each happening. Figure 5 shows a map of IP1 and its orientation to the Pirbright site.

Water.

39. We investigated the possibility that virus may have moved from Pirbright to the IPs by backflow down the Hoe stream. This stream runs through the fields where infected cattle were grazing on both IPs and then flows on past the Pirbright site. Heavy rains caused flooding on the Pirbright site on 20 July and

flooding was also noted on the field where the infected cattle were grazing on IP1. However, no flooding was reported at IP2, so the flooding at IP1 was probably due to local conditions rather than from the stream itself flooding

40. Advice was sought from the Environment Agency which confirmed that the natural water flow is from the IPs towards Pirbright (approximately 4.5 km away) and it is extremely unlikely that the floods on 20 July would have caused a backflow to the IPs, which are approximately 10 metres higher than the Pirbright site.

Sewage

41. Investigations found evidence that there had been a leakage of sewage into the field at IP1 during the flood on 20 July. Advice from Thames Water was that the flow of sewage is from west to east i.e. FROM the IP TOWARDS Pirbright and the Hockford sewage treatment plant.

42. In addition, records at Thames Water confirm that there was a blockage, exacerbated by heavy rainfall, in the area to the east of IP1. Because of the location of the blockage and the direction of flow it is very unlikely that the land was contaminated by sewage from Pirbright.

Vehicles

43. There is a protocol for the removal of soil and rubble, as a result of the site development, which, if originating from a hazardous area, is required to be stored on site for a 6 month quarantine period before being removed. It is therefore not thought to constitute a risk of source or spread in relation to the current outbreak. Other soil and rubble could be removed without quarantine.

44. This protocol did not cover the possibility that the vehicles carrying material from non-hazardous areas could themselves become contaminated during their activities on site. Therefore these vehicles were considered in the vehicle tracings.

45. Investigations to assess whether vehicles could have been responsible for infection of IP1 via fomite transmission are described in detail in a later section of this report, which describes the possibility of fomite transmission off the Pirbright site.

46. The vehicle movements were also assessed for risk of other spread. The risk period for this was considered to be 19 July - 7 August (when contractor work on the site ceased). Likely degree of contamination, distance and direction of travel from Pirbright, and expert advice on virus survival characteristics given the prevailing weather conditions were all considered and no further vehicle movements of concern were identified other than those already investigated.

Personnel

47. A questionnaire was produced for laboratory staff at the two facilities on the site. Only two individuals are believed to have connections with the area in which the first and second IP's are situated and none were identified as having contact with susceptible species. Additional work has also been carried out to assess the risk posed by field workers who may have accessed agricultural land. In all cases no contact with susceptible livestock was identified.

Wildlife

48. The site is surrounded by a six foot high wildlife-proof perimeter fence so the risk of transmission from the site via various types of wildlife, was assessed as negligible.

Fomite

49. Personnel, equipment or vehicles on site could have become contaminated with liquid drain overflow, or soil/building waste contaminated by drain overflow which was transferred off site.

50. There is a footpath to south of the affected field which is reported to be infrequently used so it is unlikely that infection was introduced by walkers carrying fomites.

51. Over 1000 vehicles are recorded as entering the Pirbright site during the period 16 - 25 July. The HSE and the Police have reviewed both vehicle and people movements into Pirbright during that time period. A gate log is maintained recording vehicle registration numbers for vehicles entering site, but this does not routinely record contractors' vehicles which make multiple visits to site.

52. The HSE have ranked movements of staff and vehicles into five categories of risk, which we agree with for our epidemiological assessments. Category 1 is the highest risk, associated with movements of contractors vehicles that could have come into contact with potentially contaminated soil/earth, down to category 5 being pedestrian movements which posed the least risk. Vehicle journeys and other destinations after leaving the Pirbright site for the five contractors that were ranked as being category 1 have been ascertained.

53. Analysis of the available records indicated that approximately 40 – 50 visits were carried out by the category 1 contractors during the period 16 - 25 July. Of note is that, after leaving the site on 20 July, four vehicles transported soil down Westwood Lane in Normandy. The drivers reported the road in Westwood Lane (see Figure 5) as being flooded. On 25 July a further two vehicles transported soil along Westwood Lane, and there was rain on this day as well. Another driver delivered plant equipment in the Normandy area but no date could be provided. Many other category 1 vehicle movements involved journeys back to Contractor's Depots. These journeys were away from the Normandy area.

54. We investigated premises with susceptible stock adjacent to the route of these vehicles and apart from IP1 there is no evidence of FMD on any of these premises. However, the road cannot be negated as a possible route of introduction of FMD to IP1.

55. We do not believe that the transported soil and subsoil was the vehicle of infection. However, lorries defined by the HSE investigation as risk category 1 were driven over the potentially infected area and could therefore have picked up contaminated "soil" on their tyres. It is notable that the surface "soil" had a high content of claggy clay, which would therefore readily adhere to tyres and the underneath of the wheel arches. There were no washing or disinfection facilities for vehicles leaving the site.

56. While the exact mechanism of spread has not been identified there remains a very low probability that live virus is still present in the external environment on site. However no further cases of FMD have been detected despite heightened awareness among livestock keepers and intensive clinical and serological surveillance within the Protection Zone and 10km radius Surveillance Zone as depicted in Figure 4. Thus if contamination exists, it has not gained access to susceptible livestock.

Windborne

57. Meteorological data over the 10 year period 1994 – 2003 shows that the wind direction comes from around the compass, and that the prevailing wind in the area is south westerly, *i.e.* from the IPs towards the Pirbright site. The wind blows from the north or north-east, i.e. the necessary direction of the wind for the IPs to be infected by aerosol spread from the Pirbright facility occurs, on average, 15% of the time, and from the west or south west 40% of the time. For the remainder of the year the wind direction is distributed relatively evenly from other directions.

58. The parts of the vaccine manufacturing process likely to generate a suitable aerosol for windborne transmission of virus are the fermentation process and the centrifugation step. Both steps are carried out daily on weekdays with a range of different viruses (usually two per week,) depending on the vaccine that is being manufactured at the time.

59. There is therefore a 15% probability on any week day that a process that produces an aerosol (fermentation or centrifugation of vaccine) is carried out, and the wind blows from the Pirbright site towards IP1. Thus the coincidence of the wind blowing in the right direction on a day when there is potential for aerosol generation is not particularly unusual. In addition, as described above, HSE investigations revealed no evidence of failure of the HEPA filtration system at the vaccine production plant.

60. Another potential source for windborne virus could be escape of an aerosol from the drain, if the mechanics of the drain and fluid dynamics were able to create an FMD-infected aerosol that could be carried over several kilometres.

61. There was a period of a few hours on 23 July, and transitory periods on 15, 19 and 20 of July, when the wind direction was suitable for FMD transmission to the IPs from the Pirbright site (John Gloster, personal communication).

62. On all other days in the risk period the wind was not blowing in a suitable direction to infect the IPs, and if there was airborne release of virus it would have been taken by the wind in directions in a sector from north west of the facility through north to south east.

63. The majority of holdings with susceptible animals within 5km of the Pirbright facility lie to the north west and south west, with smaller numbers to the east (see Figure 4). Thus if aerosol release from Pirbright occurred, it would be most likely to affect animals on holdings to the north-west; these unaffected holdings have all been under intensive surveillance since 3 August, and there has been no evidence of FMD infection on these premises. Therefore it is

unlikely that windborne spread of virus occurred over any length of time, if at all.

64. This is supported by the genetic sequencing data and the location of IP2 which is in a direct line between the Pirbright site and IP1. This makes aerosol transmission less probable than fomite transmission as the source of infection on IP1 as, if an aerosol was generated, it would have reached IP2 first, yet the evidence indicates that IP1 was the first infected premises.

Summary of investigations into routes of spread from the Pirbright site

65. These investigations indicate that it is very unlikely that virus was transmitted from Pirbright via the only (small) natural waterway (the Hoe stream) sewage, topsoil and subsoil from uncontaminated areas, airborne transmission, wildlife or personnel. The most likely means of transmission of FMDV from the site was via fomites transferred by lorries which had driven over the potentially contaminated area.

Introduction onto IP1

66. The owner of IP1 did not report taking any specific biosecurity measures when attending the livestock. However, the fact that significant spread of infection between the different land parcels associated with the IP did not occur tends to suggest that the risk of fomite spread is very low.

67. Access to the IP1 was always via the track from Westwood Lane. The owners routinely drove a farm vehicle along this track and occasionally into the field to inspect the stock. Additionally, following the flooding of the field on 20 July, a tractor and trailer was driven into the field to deliver supplementary feed daily. There is therefore, potential for fomite spread from the road if it had been contaminated.

68. Our investigations indicate that the most likely means of transmission of FMD virus from the Pirbright site to IP1 is via contaminated soil from the area around the drainage system carrying effluent from the vaccine production facility. This occurred because virus-contaminated effluent from the drainage system is likely to have contaminated an area over which lorries were driven that were not cleaned and disinfected on leaving the site.

Most likely scenario

69. The epidemiological assessment of all the evidence available to us to date leads us to conclude that fomite transmission is the most likely means by which the O1BFS FMD virus moved from the Pirbright site to IP1. The probable sequence of events is

    1. Escape of virus from drains on Pirbright site into surrounding area, 22-25 July
    2. Contamination of vehicle or heavy plant with virus, aided by claggy consistency of the soil/clay mixture.
    3. Deposition of contaminated soil on roads in the area near IP1 on 25 July

4. Transfer of contaminated soil on wheels of farmer's vehicle into IP1 field, possibly on 25 July
5. Infection of cattle on IP1 by exposure of abrasions, most probably gum lesions in the mouth as a result of teething, to contaminated soil.
6. The most probable date of this transfer from the Pirbright site to Westwood Lane and thence to IP1 was 25 July.

70. The delivery of silage to the Normandy field via tractor and trailer following the flooding on 20 July is likely to have increased the risk of transferring infected material into the field due simply to the greater carrying capacity of tractor tyres. Also, of note is the fact that the cattle were at a very inquisitive age and would have been attracted to the tractor and trailer as a novelty as well as the presence of the silage. Their natural investigatory behaviour notably licking, nosing and sniffing increases their risk of infection, a phenomenon recorded during the FMD epidemic in 2001. A current risk factor study is in progress which may elucidate the importance of this particular practice.

71. It is unlikely that all of the cattle became infected at the same time as there is evidence that there were at least two cycles of infection within the group (see the Epidemiology Report of 10 August on the outbreak: : http://www.defra.gov.uk/footandmouth/pdf/epi-report-third130807.pdf.

Risk Assessment

72. Large numbers of people and vehicles were moving on and off the Pirbright site throughout the risk period for infection of both IPs. The majority had no contact with agricultural premises. Only two holdings in the locality have been infected with FMD to date in this outbreak. Therefore if the release was via fomite transmission, the probability of the virus coming in contact with susceptible stock was, and remains, very low.

73. There is evidence that suggests that FMD virus was released from the drains on the Pirbright site. Therefore we would recommend that any vehicles that could potentially be contaminated with soil are thoroughly cleansed and disinfected (C&D) before leaving site. In particular this applies to large plant such as JCBs that have been moving earth round the site. Ideally dedicated C&D facilities should be established on the premises at strategic points to facilitate this. Consideration should also be given to the establishment of a wheel wash for other vehicles which carry a lower risk that leave the site. This would supplement the voluntary measures requested of premises in the Temporary Pirbright Biosecurity Area (Figure 4).

74. There is circumstantial evidence for windborne infection of both IP 1 and IP 2 on 23 July. Expert investigators have concluded that this is very unlikely from the vaccine production facility, and our evidence to date supports this conclusion. However there is a possibility of an aerosol being produced as a result of the mechanics of waste flow in the drain, possibly coupled with particular weather conditions.

75. If windborne spread occurred this was a single, short-lived event and there is no current risk. The unusual weather, the state of the drains, and the reported volume of vaccine produced could be contributing factors.

Caveat

76. This report is based on reports received during the current investigations. To the best of our knowledge it is accurate, however some details have yet to be fully verified.

Acknowledgements

77. The views expressed in this report are those of the National Emergency Epidemiology Group. However we would like to express our thanks to a number of colleagues for their assistance in providing the results of various investigations and their specialised expertise. They are Dr David Paton, Institute for Animal Health, Pirbright and colleagues, mentioned within the report, together with Drs John Anderson, Eoin Ryan, Bryan Charleston, Nicholas Juleff, Ryan Waters and Bartek Bankowski, John Gloster and colleagues, the Metereological Office, staff of the Environment Agency and Thames Water and members of the Health and Safety Executive's investigation teams

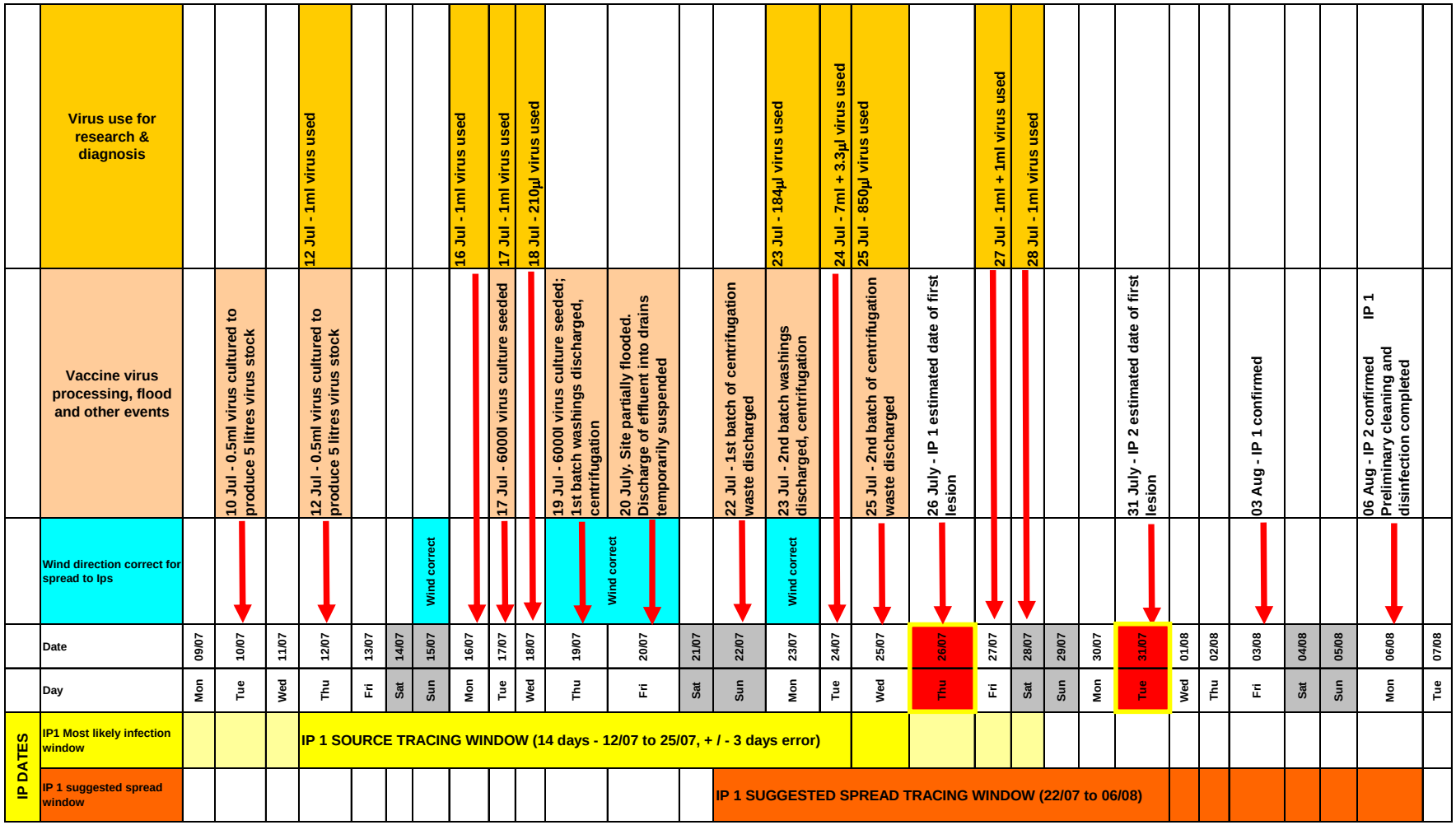
National Emergency Epidemiology Group
29 August 2007

Annex 1. Dates of relevant events

- 10 July: 0.5ml Type O1 BFS virus added to 5l culture medium for first batch of O1BFS vaccine.
- 12 July: 0.5ml Type O1 BFS virus added to 5l culture medium for second batch of O1BFS vaccine. 1ml Type O1 BFS virus used in research facility
- 15 July. Transitory wind in correct direction to infect IPs
- 16 July: 1ml Type O1 BFS virus used in research facility
- 17 July: 5l Type O1 BFS virus seeded into 6000l cell culture initiating fermentation process for first batch of O1BFS vaccine. 1ml Type O1 BFS virus used in research facility
- 18 July: 210μl Type O1 BFS virus used in research facility
- 19 July. First washings from 6000l FMD Type O1 BFS virus culture for first vaccine batch discharged to effluent tank. Centrifugation of first batch of Type O1 BFS FMD virus. 5l Type O1 BFS virus seeded into 6000l cell culture, initiating fermentation process for second batch of O1BFS vaccine. Transitory wind in correct direction to infect IPs
- 20 July. Heavy rains flooded part of the Pirbright site; discharge of effluent into drains temporarily suspended. Transitory wind in correct direction to infect IPs. Four lorries leaving Pirbright site travel down Westwood Lane.
- 21 July. Relatively high rainfall.
- 22 July. Discharge of effluent containing the centrifugation waste from the first batch of Type O1 BFS virus culture from the effluent tank
- 23 July. First washings from 6000l FMD Type O1 BFS virus culture for second vaccine batch discharged to effluent tank. Centrifugation of second batch of Type O1 BFS FMD virus. 184μl Type O1 BFS virus used in research facility. Wind in correct direction to infect IPs for several hours. Relatively high rainfall.
- 24 July: 7ml and (separately) 3.3μl Type O1 BFS virus used in research facility.
- 25 July. Discharge of effluent containing the centrifugation waste from the second batch of Type O1 BFS virus culture from the effluent tank. 850μl Type O1 BFS virus used in research facility. Two lorries leaving Pirbright site travelled down Westwood Lane.
- 27 July: 1ml and (separately) 1ml Type O1 BFS virus used in research facility.
- 28 July: 1ml Type O1 BFS virus used in research facility.
- 11 July – 3 August: Inspection holes dug to establish the locations of new drains
- 8 August: Potentially contaminated excavation waste cordoned off

- 21 August: Further biosecurity measures put in place to minimise any further risk of fomite transmission off site, in case live virus is (still) present outside the laboratory containment area.
- 24 August: Temporary Pirbright Biosecurity Area established; this is a precautionary measure where Defra will be working with animal keepers and vets to ensure enhanced vigilance is maintained as we await the conclusions of the HSE investigation and the findings of the independent review led by Professor Brian Spratt.

Figure 1. Timeline to show the temporal relationship of the events reported



Note: Ppossibility of error of +/- 3 days in 9 day old lesions results in source tracing window extending from first lesion (FL) + 2 days to FL -17 days

Note: The spread tracing window covers the period 1st lesion - 4 days, to the date the cull completed

Figure 2: Diagram of drainage from vaccine production process

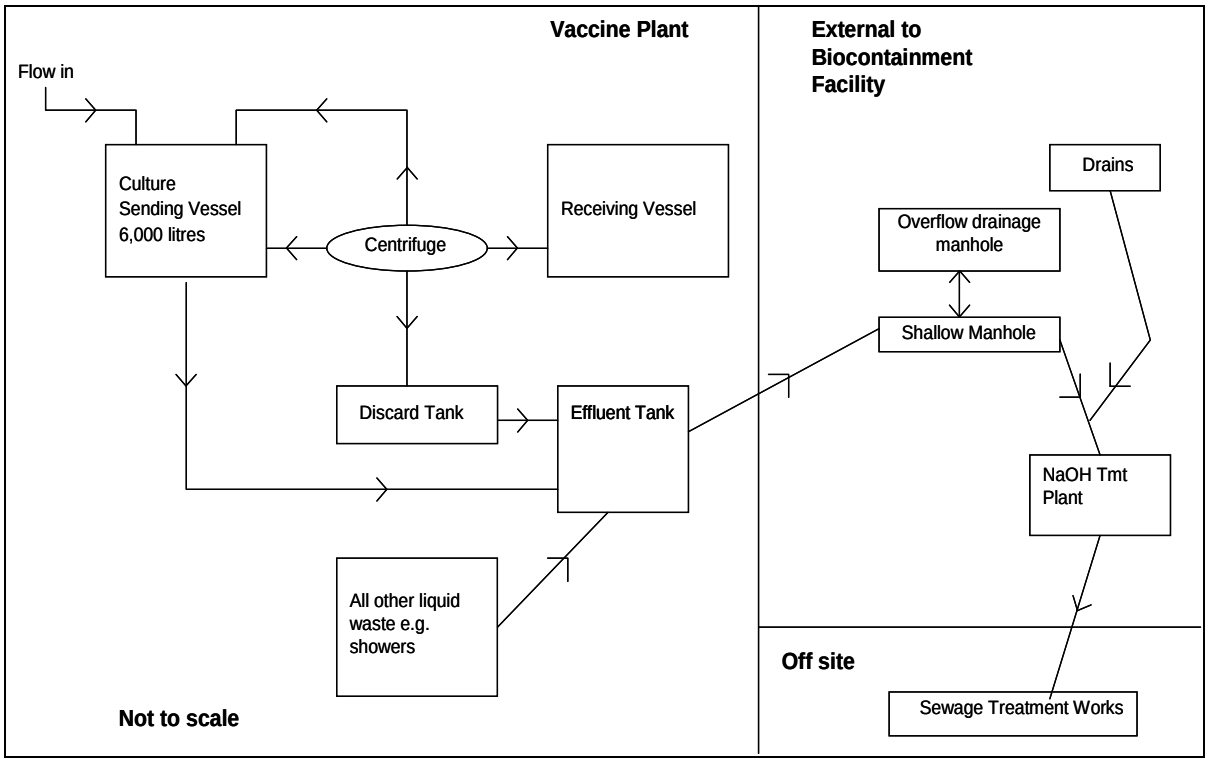


Figure 3. Relative humidity (red) and precipitation (blue), 9 July - 6 August 2007

(Note: raw data)

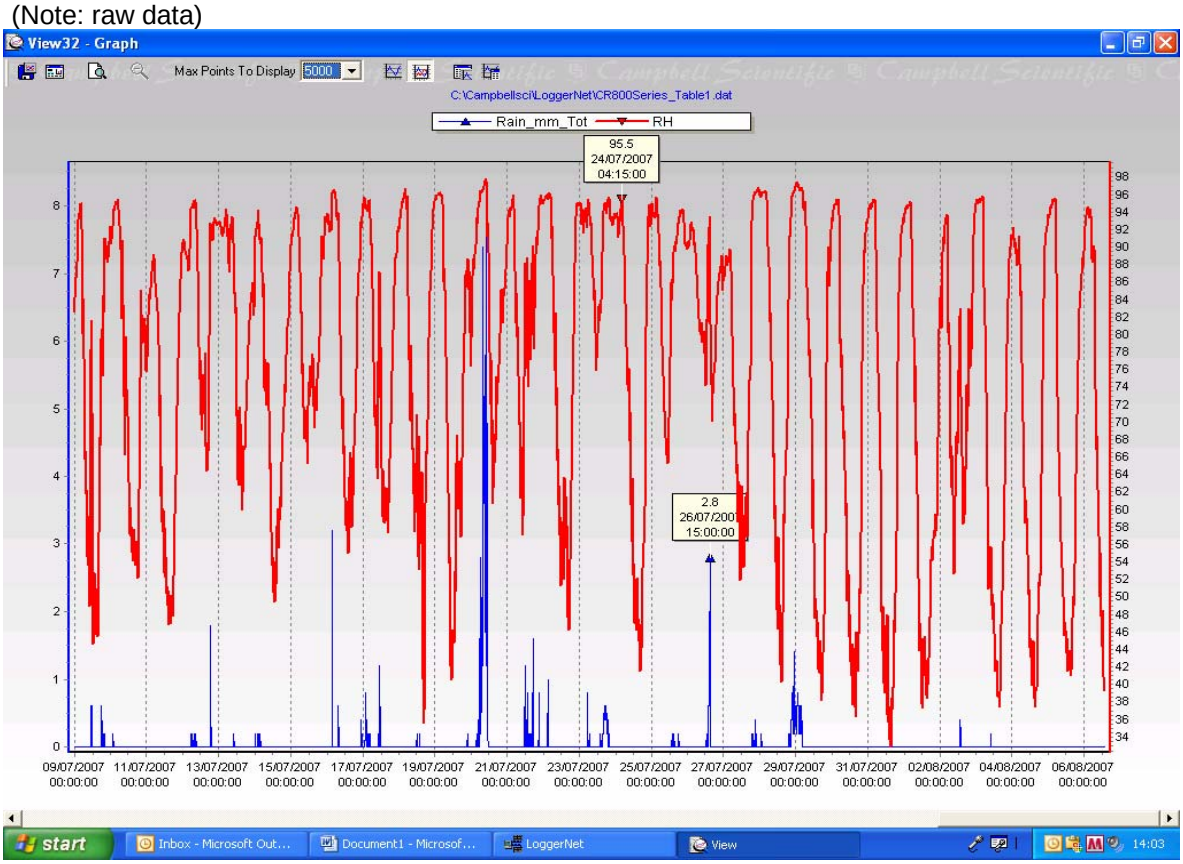


Figure 4: Location of premises with susceptible livestock around the Pirbright Site

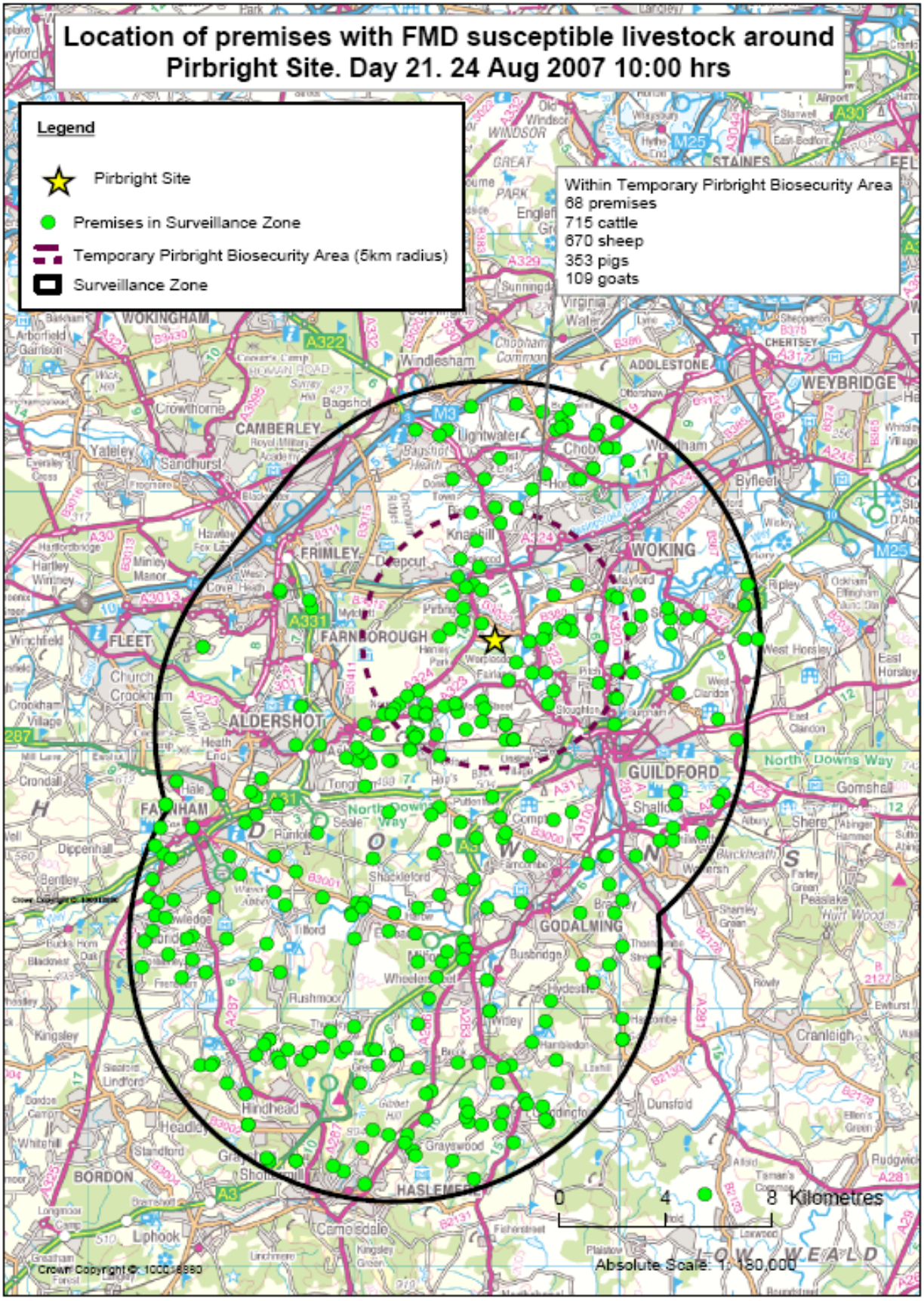


Figure 5. Map of IP1 (FMD2007/1a) to show field containing infected cattle and access from Westwood Lane

(inset shows relationship to Pirbright site)