AUSTRALIAN VETERINARY EMERGENCY PLAN

AUSVETPLAN

1999

Management Manual

Mapping

AUSVETPLAN is a series of technical response plans that describe the proposed Australian approach to an emergency animal disease incursion. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.

Agriculture and Resource Management Council of Australia and New Zealand

This Management Manual forms part of:

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This document will be reviewed regularly. Suggestions and recommendations for amendments should be forwarded to the AUSVETPLAN Coordinator (see Preface).

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PREFACE

This **Management Manual** for **mapping** is an integral part of the **Australian Veterinary Emergency Plan,** or AUSVETPLAN (Edition 2). AUSVETPLAN structures and functions are described in the **Summary Document**.

The first edition of this manual was approved out-of-session in February 1991 by the then Australian Agricultural Council, for use in an animal health emergency in Australia. The new edition has been considerably modified and was approved by the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) out-of-session in July 1999.

Detailed instructions for field implementation of the strategies are contained in the AUSVETPLAN **Operational Procedures Manuals** and other **Management Manuals.** Cross-references to strategies, manuals and other AUSVETPLAN documents are expressed in the form:

> Document Name, Section no.
> For example, **Decontamination Manual, Section 3**.

The manual will be reviewed regularly. Suggestions and recommendations for amendments should be forwarded to:

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This manual along with the rest of AUSVETPLAN is also available on the Internet at: http://www.brs.gov.au/aphb/aha/

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The writing group was responsible for drafting this manual. However, the text may have been amended at various stages of the consultation/approval process and the policies expressed in this version do not necessarily represent the views of all members of the writing group. Contributions may also have been made by other people not listed above and the assistance of all involved is gratefully acknowledged.

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1 INTRODUCTION

1.1 Aims and objectives

During eradication of an emergency animal disease, maps provide an important communication and planning aid that are useful in defining the location and extent of the disease and spatial relationships between properties within and adjacent to the declared areas.

Maps confer two major management advantages. The ability to encompass the incident within boundaries gives better definition and visualisation of the tasks and advances the probability of their achievement. Progress can be instantly recognised, for example the change of status from ‘red’ to ‘blue’ can be a powerful stimulus for encouragement.

This manual provides an overview of the application and suitability of various maps to animal disease emergencies. Further details should be available in State manuals.

The manual is primarily for use by mapping officers, epidemiologists, local and State disease control centre managers and trainers.

It provides guidance for:

- selection and acquisition of a suitable mapping system
- practical use of maps in local and State disease control centres
- location of disease and properties
- definition of declared areas
- tracing and surveillance.

1.2 Disease preparedness

In order to be prepared for a possible disease outbreak, it is necessary to determine the mapping systems that are available in your State/Territory. The two fundamental mapping systems for use in animal disease emergencies are:

- paper map sheets
- computer-based mapping using geographic information systems (GIS).

The selection of the most appropriate mapping system is explored in more detail in section 4 of this document. Even if both systems are available, it is likely that there will still be a need, at least at the start of the outbreak, for paper maps, so appropriate sheets should be selected and acquired for initial use.

The following preparations should be made:

- establish a memorandum of understanding or service level agreement and maintain liaison with agencies that have mapping expertise, both for paper maps and computer based electronic maps
- establish the sources of maps in their various formats — both digital and hard copy
- keep an up-to-date contact list so that maps can be procured at short notice
- identify potential mapping officers in each region of your State/Territory

- ensure that the manager (veterinary investigations) or some other individual employed as part of an emergency animal disease task force, maintains up-to-date knowledge of mapping technology.

Standing emergency arrangements should be put in place with the relevant State or Territory agency to provide:

- a prompt supply of large quantities of paper maps, on demand
- copying of non-standard maps on demand
- assistance with the definition, description and mapping of declared areas, and for the provision of certified maps including their boundaries.

These arrangements should be made under the auspices of the State emergency management plan for emergency animal diseases, to ensure maps are available at any time.

Maps often become out of date quickly, and it is not practical to keep up-to-date maps of all areas, either centrally, or in regional offices. A set of maps that are considered to be the most suitable, showing ownership and property boundaries, should be kept in each district office. These maps may be used for everyday activities, and while they may be out of date they may be the only ones available. They will nonetheless provide the best information at the beginning of an emergency animal disease outbreak until up-to-date maps are obtained.

1.3 What to do at the start of an outbreak

At the start of an emergency animal disease outbreak it will be necessary to activate arrangements made under the memorandum of understanding, including plans to use computer-based mapping (see Section 1.2, above).

The State mapping agency should be contacted to arrange for immediate supply of appropriate paper maps. The scale and number of maps required should be ascertained in conjunction with the Local Disease Control Centre (LDCC) controller (see Appendix 1: Potential uses of maps). Initially the maps obtained should be cadastral (ie showing boundaries of ownership) and provide unambiguous descriptions of all individual lots inside the boundaries of the declared areas (see Section 1.4).

The Operations Manager of the State Disease Control Headquarters (SDCHQ) will be initially responsible for acquiring the maps for both the SDCHQ and the LDCC and the SDCHQ will coordinate the supply of maps of the restricted area, but the choice of maps must be confirmed with the operations director of the LDCC. (This could vary from State to State and the location of the LDCC.)

Sufficient maps should be ordered (by map sheet number) from the State/Territory government mapping agency and delivered to the LDCC to get the field operation under-way. It is important not to underestimate the number of map sheets required. It is suggested that five copies of each map should be ordered. If maps at scale 1:50 000 are used, a map showing the infected premises location and the 8 maps surrounding that map will probably represent a minimal requirement. Only one set of maps should be maintained in both the SDCHQ and the LDCC. Other copies of the maps are spare.

Electronic maps should be obtained from appropriate government departments. (See Section 4.3.3)

For further information, see also Appendix 2 (Job description of a mapping officer).

1.4 Definition of declared areas

The declaration of a *restricted area* (RA) assists in preventing spread of disease by restricting movement onto and off the premises that are most likely to have had direct or indirect contact with the Infected Premises (IPs). The RA does not need to be circular but can have an irregular perimeter provided the boundary is initially an appropriate distance from the nearest IP. This distance is often an internationally agreed standard (see Appendix 1 of the appropriate disease strategy), for example 3 km for classical swine fever. The boundary will be fixed taking into account the distribution of livestock and traffic patterns to markets, service areas, abattoirs and areas that constitute natural barriers to movement (such as large rivers).

The declaration of a *control area* (CA) also helps to control the spread of the outbreak from within the RA. The CA is a buffer zone between the RA and the rest of the industry. The boundary again does not have to be circular, but will be as outlined above.

The boundaries must be legally definable and recognisable.

Zoning
The World Organisation for Animal Health (OIE) has documented requirements for the declaration of free zones within countries affected by certain diseases. Once the extent of an outbreak has been defined, consideration should be given to declaring the remaining part of Australia a free zone. A free zone should be based on geographic boundaries (not necessarily on political boundaries) and should comply with international requirements or as determined by, or negotiated with, international clients.

2 PAPER MAPS

2.1 General

Maps should always be placed vertically for use, rather than laid out horizontally on a table. Placing maps on a vertical surface improves the access of people to view the maps and prevents staff from becoming disorientated when locating things by coordinates.

Avoid directly marking the 'master' set of maps, by overlaying them with plastic film. Sheets of transparent 'map laminate' can be purchased but they are expensive. Commercial grade transparent plastic sheeting, which can be purchased in rolls, will suffice provided it is pinned to the map surface. Transparent 'Contact' is also useful, but is difficult to apply over large surfaces. If writing on the 'master' map cannot be avoided, use a soft lead pencil (2B or 3B) and keep a good quality eraser on hand.

Portions of the maps can be photocopied and distributed to patrols and other sections as needed. A supply of A4 size small-scale road maps and street atlases, showing the location of the LDCC and the RA boundaries and checkpoints is useful for briefing field staff working in both urban and agricultural areas. Local tourist or garage maps may also be suitable for this purpose. Use a black felt pen to add the required information, and a photocopy machine to reduce for printing on A4 paper.

Briefing sessions for field staff should include map orientation. This is particularly important in remote area operations.

2.2 Using paper maps

2.2.1 Map border information

All emergency animal disease outbreak control staff should be familiar with the information available in written and pictorial form around the edges of a map. This information identifies and explains the map, giving details not only for use in connection with the map itself, but also the date of the information and the sources from which it has been compiled.

The type of information and the layout may differ slightly from one map to another. Listed below are the items that are normally part of the standard layout:

- contour interval
- authorisation and production data
- grid reference block
- legend of symbols
- linear scale bar
- magnetic variation diagram
- map edition and sheet number (required when ordering maps)
- map title (top centre and bottom right)
- publication date and usually the date of photography
- representative fraction (the scale of the map)
- title information
- type of map (eg cadastral, topographical).

2.2.2 Grid references

Maps are oriented so that north is at the top, south at the bottom, east towards the right and west to the left.

Maps are over-printed with a system of squares called a grid. The lines that form the squares are usually quoted in the marginal information on the map. On a 1:100 000 topographical series map the ground distance represented between the grid lines is 1000 metres or 1 km. On many maps every tenth line is in heavy black print and is also numbered at various places along its length.

The values quoted for the grid lines are their distance from a selected point that is outside and to the bottom left of the map, so that they increase to the right (east) for the north–south lines and towards the top (north) for the east–west lines.

The grid lines are defined as follows:

- *Eastings* — the vertical grid lines which run from top to bottom (north to south) and divide the map from west to east, are commonly known as the 'eastings'. Eastings are numbered in an easterly direction (left to right).
- *Northings* — the horizontal grid lines, which run from left to right (west to east) and divide the map from south to north, are known as 'northings'. Northings are numbered in a northerly direction (bottom to top).

The squares that are formed where eastings and northings cross are known as *grid squares*. Each grid square on the map can be given a *grid reference*, by giving the easting reference (the number of the line which forms its left edge) followed by the northing reference (the number of the line which forms its bottom edge).

In a grid reference the eastings are always quoted first and it is very important to remember this. (**Memory aid:** 'Get to the right door number, before you go upstairs'. If you forget, look at the map's legend.)

There are two methods that can be used to indicate position on a grid map (the four or six-figure grid reference method). The method used depends on the degree of accuracy required and, to a large extent, the scale of the map being used. The principle for each method is the same and is explained below.

Four-figure grid reference

This method indicates the position of one grid square only. To indicate a particular grid square, first select the easting which forms the left, or west, boundary of that square. Next select the northing which forms the bottom, or south, boundary of the square. The two figures for the easting and the two figures for the northing combined give the four figure reference required. For example, the four-figure reference to square A in Figure 1 is made up of the easting that forms the west boundary of the shaded square (easting 30) and the northing that forms the west boundary of the shaded square (northing 68). The four figure reference for the shaded square is therefore 3068.

Note: Grid references generally commence with the letters GR to show that they are, in fact, grid references and nothing else. The grid reference should also be preceded by the number and name of the map.

Remember: ALWAYS DEAL WITH EASTINGS FIRST, THEN NORTHINGS.

Figure 1 Four-figure grid reference
[The four-figure grid reference to the shaded square is GR 3068]

Six-figure grid reference

This method is much more accurate than the four figure method and is used to indicate the position of an object within a grid square; such as the homestead, or main property entrance, on an IP. It should be used on maps of 1:100 000 or larger scale and, wherever possible, in preference to the four-figure reference.

To do this, imagine each grid square divided into 100 smaller squares and estimate which small square the particular object is in. Figure 2 shows grid square 7448 divided into 100 smaller squares and some map detail has been drawn in to help explain the procedure. The numbering of the lines forming the small squares indicates the number of tenths of a unit they are east of easting 74 or north of northing 48. The homestead A is in the small square 4/10 east and 5/10 north; in other words easting 74.4 and northing 48.5. Deleting the decimal points, the six figure grid reference to homestead A is GR 744485.

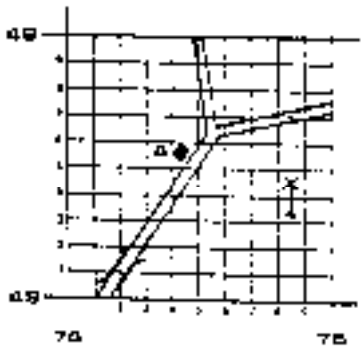

Figure 2 Six figure grid reference
[The six-figure grid reference to homestead A is GR 744485]

2.2.3 The Australian Map Grid

The Australian Map Grid (AMG) is a horizontal plane coordinate system adopted by the National Mapping Council in 1966 for the production of maps with small and medium scales. The units are in metres and the coordinates have an origin in each zone of E–5 000 000 and N–10 000 000. Each zone is six degrees of longitude wide. For mainland Australia, the zones are 49 to 56.

AMG coordinates may be used when inputting data to GIS systems. In these cases, the full AMG grid reference must be used, eg 3102000 for eastings and 61258000 for northings. The zone must also be used, eg zone 54. The system of using map number and 4 or 6 figure grid

reference is not suitable for GIS systems. Full grid references may be read off most global positioning system (GPS) devices (see section 3.2).

2.2.4 Latitude and longitude

While all GPS systems can give readouts of latitude and longitude (see Section 3.1.3), not all paper maps have sufficient reference points marked on them to allow easy and accurate interpolation of coordinates using this system.

2.3 Aerial photographs

There is comprehensive coverage of much, possibly all, of Australia by aerial photographs. These are available in various scales, black and white, colour or infra-red, and with various enhancements and modifications. *Orthophoto maps* are rectified (flattened) aerial photos giving the same accuracy as line maps. They have been enhanced with major road and place names, as well as contours. These are available usually for more densely populated areas.

Aerial photograph libraries are updated on a regular basis, and as such can be useful supplements to paper maps in that recent photos will show vegetation boundaries, houses, subdivisions, etc.

3 COMPUTER-BASED MAPPING

3.1 Geographic information systems

GIS attach information to a spatial location. The information is stored on a computer disk as a series of numbers, comprising the spatial coordinates of the location and other attributes of the information, eg 'This is a property boundary'. There are two fundamental types of GIS: *raster* and *vector*.

3.1.1 Raster GIS

In a raster system, each piece of information refers to one unit or raster, and all rasters refer to equal sized, contiguous areas. Raster systems are limited in their applications by the pre-defined nature of the raster (you cannot vary its size or shape), and by the fact that only one number can be attached to each raster. File size will depend on the area covered and resolution especially if in colour. The advantages of raster systems lie in their simplicity: easy to use; cheap software; no need for sophisticated computer hardware (disk space or memory).

3.1.2 Vector GIS

Vector GIS is concerned primarily with lines and boundaries rather than areas. These lines may be used to define the boundary of an area, which is then referred to as a *polygon*. Polygons may be any shape or size, and can have any amount or type of information attached to them. Standard database files (eg. dBASE, ACCESS, INFORMIX) are readily linked to such polygons.

A vector GIS file defining the boundaries of all properties in a shire can therefore be linked to a dBASE file, eg those used in the Animal health emergency information system (ANEMIS ; see **ANEMIS Manual)** giving owners' and managers' names, addresses and telephone numbers, stock numbers, types of farming enterprise, and infection status. Each property is represented by a polygon. Converting the spatial coordinates defining line and point features on a map into a file on a computer disk is called *digitising*. Once digitised, the data has been *captured*.

Vector systems allow enormous flexibility in the amount and type of data linked to the spatial location, and in the scale of the data (from detailed breakdowns of individual paddocks to the whole continent). They also allow point and line information to be stored. They can reproduce quite effectively the traditional map sheets, yet have the additional capacity of linking any items on the map to traditional computer database files. By this means maps can be produced that display far more than any paper map ever could, even if it could be kept up to date.

The disadvantages of vector GIS are:

- the generally high cost of the software
- the large computer memory needed to run the software effectively
- the large size of the data files
- the cost and availability of large paper size printers (plotters)
- the time needed to digitise complex map features
- the complexity of the software.

Vector and raster data may be superimposed if required.

3.1.3 Latitude and longitude

All GIS systems can use reference points derived from latitude and longitude. Usually these points are read in decimal degrees rather than degrees, minutes and seconds.

The advantage of latitude and longitude over grid references is that you do not need to know the zone and points can be in more than one zone. The computer database need only have two numeric fields instead of three.

For the Southern Hemisphere, the latitude figures must be entered as negative values. The longitude figures for Australia are entered as positive values.

3.2 Global positioning system

The Global Positioning System (GPS) is a satellite navigation system that was first developed for use by the United States armed forces and its allies. It is owned and operated by the United States Department of Defence and is operational 24 hours per day, 7 days per week. Its 24 satellites allow users to determine their position (latitude, longitude and altitude) quickly and unambiguously, anywhere in the world. This is done by way of a small receiver that can be hand-held or installed in a vehicle. The position is displayed by direct digital print-out on a screen.

The system is now finding increasing favour with the international civilian community, and is being used to position everything from jumbo jets to favourite fishing spots. In order to obtain a position, a GPS device must be able to receive signals from at least four satellites. A clear line-of-sight to the satellites is essential for the system to work properly. A degraded performance is possible in heavily forested areas. Naturally, the device will not work at all under bridges or in tunnels.

Most GPS receivers are capable of producing a new position determination every second. The level of accuracy achievable is dependent on the equipment and measuring technique used. The highest accuracy is reserved for military users. These organisations are able to achieve 10–20 metre accuracy with a single GPS receiver. Naturally, the military is keen that their systems should not be used against them. The signals available to civilian users are therefore degraded so that only 100 metre accuracy (95% confidence level) can be achieved with a single receiver. The policy regarding degradation of the signals is referred to as ‘selective availability’.
(**Note:** A better result can be achieved by occupying a point for a few minutes and averaging a number of position determinations.)

Civilian users can largely overcome GPS accuracy degradation by using a differential positioning technique. This involves operating a pair of GPS receivers. One of the receivers (the ‘base’ receiver) occupies a point with known coordinate values. It is assumed that, at any instant, the positions determined by both receivers are in error by the same amount. By comparing the base receiver’s known and ‘received’ coordinates, a correction factor can be calculated. This can then be applied to the ‘rover's’ received coordinates, either during post-processing in the office, or in real time through radio transmission. Commercial services for the transmission of differential corrections are available.

The prices of GPS receivers range from a few hundred to many thousands of dollars depending on their capabilities and sophistication. Radio equipment to receive differential position corrections is available with the more expensive systems.

GPS could be used in the context of an emergency animal disease outbreak:

- to record the site of observations during routine surveillance work
- in wild or feral animal monitoring.

It would be especially valuable in pastoral and semi-urban regions.

It should be noted that GPS produces coordinates referenced to the World Geodetic System (WGS84) datum (see glossary) and not to the Australian Geodetic Datum (AGD) which supports the coordinate system for most of Australia's maps. The latitude and longitude (or easting and northing) of a point derived within the WGS84 system will differ from equivalent ADG values by approximately 200 metres in both coordinates. A number of GPS receivers have the capability to transform WGS84 coordinates to AGD values. However this capability is not universal.

Australia will soon start to produce maps on the Geocentric Datum of Australia (GDA), which is closely aligned with WGS84. The GDA will supersede the AGD and maps produced on the GDA will be directly compatible with the GPS system. As noted above, the coordinates of a point will change by about 200 metres in a north-easterly direction. The actual size and orientation of the change will vary from area to area.

It is vitally important that all users are aware of the coordinate datum associated with the displayed coordinates, and also of the corrections which may be needed to ensure compatibility with available mapping. Further information can be obtained from the Australian Surveying and Land Information Group (AUSLIG) in Canberra http://www.auslig.gov.au/ or from State mapping agencies.

3.3 Digital aerial images

Digital aerial images are visually very similar to aerial photos (see Section 2.3). Since the image is recorded digitally it can be stored on computer disks, and is readily available to computer software for modification or incorporation with other data. Images may then be printed out on computer printers. This is fairly recent technology and there is no widespread coverage by the medium. Before images can be accurately geolocated there is a need for surveying and marking of reference points on the ground. The resulting images need to be rectified. Cloud cover prevents the recording of images in the visible spectrum. Most experts work in the private sector, and are thus less accessible to the outbreak managers. Continuous images covering a large area pose considerable practical difficulties.

There are two techniques in use. The one-camera technique uses a single high quality camera. It may be viewed as a continuous fly-past film, or still images may be extracted and utilised as described above. The four-camera technique uses four aligned cameras simultaneously, and can thereby record at different wavelengths simultaneously, eg infra-red on one, visible on another. Such techniques are used to view minerals, vegetation, soil types, etc.

3.4 Satellite images

The Australian Centre for Remote Sensing (ACRES) maintains a library of satellite images. The interval between satellite passes is 16 days. The best obtainable resolution is 10 metres (raster images with 10-metre raster diameter). Higher resolution (2–5 metres) is to be available 'soon'.

Satellite images need to be rectified before they can be used as maps. Cloud cover can prevent acquisition of new images in visible wavelengths, although radar can be used to obtain images through cloud; this gives a resolution of 10–15 metres. Satellite images depend on vegetation boundaries for identification of land features, so roads, boundaries and other features may not show up clearly. Most roads are recognisable.

It normally takes 10–14 days to obtain a rectified, geolocated digital image from ACRES, although an archive library is maintained, and for emergency animal disease outbreak purposes a less current image is adequate. Contact ACRES (a business unit of AUSLIG) for further information on availability and delays.

3.5 Scanning

Paper maps and aerial photographs can be scanned into a computer. This is not equivalent to digitising, in that the resultant image is stored as a complete entity, and information cannot be attached to elements of the image, nor can the relative positions or other attributes of parts of the image be altered. The process is, however, rapid, and a scanned map or photo can form the background for digital overlays, eg property boundaries and associated databases.

Once scanned, map images can be held in a library in readiness for an emergency animal disease outbreak, in just the same way as paper maps, except that they take up less space, and you only need to keep a few copies.

4 SELECTING A MAPPING SYSTEM

4.1 Paper vs electronic maps

As described, the two fundamental options for a mapping system for use in the LDCC or SDCHQ are paper map sheets and computer-based mapping using GIS. Whatever system is installed, it is likely that there will be a need, at least at the start of the outbreak, for paper maps, so appropriate sheets should be selected and acquired for initial use.

The advantages of a GIS-based mapping system are considerable and revolve around the integration of property and spatial information. Everybody needs up-to-date maps in a constantly changing outbreak situation. A single, centrally located master copy must be maintained, and if copies are needed elsewhere they must be made from the original. This is something that computers do well: creating multiple copies of an original at high speed and with great accuracy. When using GIS, current maps showing all conceivable details of infection status, livestock numbers, wildlife occurrence, and security arrangements, are always available on a computer monitor, and may be printed at the scale, size and detail required at a few minutes' notice. Electronic mapping assists the publication of suitable maps in newspapers, as is required by law and for public awareness.

After the initial period, therefore, the ideal mapping system would be computer-based, fully integrated with all outbreak information and accessible to all LDCC and SDCHQ users via a network. Up-to-date copies could then be printed as required showing specific data requirements, at any scale. At the time of writing, obstacles to achieving such a system include:

- digital topographical and cadastral maps are available for most of Australia, but the scale (mostly 1:250 000) may not be suitable;
- most States do not have an agricultural property database (APD; see Section 4.3.3), let alone a GIS-linked database (but this format is being developed for some locations); and
- a long time is needed to create digital maps if they are not already available.

On the positive side, the necessary hardware and software together with the expertise to assemble and run a computerised mapping system is generally available around the country and generally also available although not necessarily in the State departments of agriculture. Data in ANEMIS 4 files (see section 4.2.5) can be linked to GIS cadastral polygons, and establishing a functional link should only take a few hours. This would be a point that falls inside the property, usually the homestead. Preferably, preparation should be made for this beforehand.

An APD linked to a GIS would additionally allow the scale of each copy and the information printed to be determined at the time of printing. Purely from a logistical point of view, such a system has great advantages over a paper map system, although how well GIS works depends on the accuracy of the original data. A spatially-linked APD can print a list of all properties within a given radius of an IP, along with relevant property data that has been included in the database. This is an enormous time-saver compared with compiling such a list from a paper map on which the radius has been marked.

Digital images are preferable to scanned images for overlay with APD/cadastral data, but either is possible, and will give a useable mapping system which, because of its link to property data, is preferable to sole reliance on paper maps.

It is therefore desirable to install a GIS-based mapping system in the LDCC. At the start of the outbreak the veterinary investigations manager, the LDCC and SDCHQ epidemiologists, and the mapping officer should determine the feasibility of doing so, and unless it is considered impractical, set it up. A recent example of the use of current mapping technology was in the 1997 Victorian anthrax outbreak and is described in Appendix 3.

To assess the practicality of establishing a functional GIS in the LDCC, those officers should consult with a person who works with GIS, and has a good knowledge of the digital maps and cadastre available locally (referred to here as the *GIS consultant*).

4.2 Designing a mapping system

When designing the mapping system to be used in a particular outbreak, a number of factors have to be taken into account, including the likely extent and duration of the outbreak, availability of an APD, and other factors, as discussed below.

4.2.1 Likely extent and duration of the outbreak

Foot-and-mouth disease in an intensive livestock production area is likely to spread and could take months to resolve, whereas virulent avian influenza in an isolated flock may be dealt with relatively quickly with no other properties involved. In the latter case it is probably not worth investing a week or two in establishing a working GIS, while it may well be considered worthwhile in the former.

4.2.2 The mapping needs of the outbreak

GIS does not have to fill all the mapping needs of an outbreak to be worthwhile. Appendix 1 gives a table of the likely requirements of map users during the outbreak. GIS linked to ANEMIS or an APD might be used for restricted area management and security, by veterinary investigations and epidemiologists, while individual property mapping and all SDCHQ mapping needs are dealt with using paper maps.

4.2.3 Availability of an agricultural property database

A spatially-linked APD is highly desirable but not essential. If it is not available, property data such as names, addresses, tailtag numbers and status must be attached individually to each property boundary polygon in the GIS, via a property descriptor of some sort. This is the same process involved in defining properties and their owners etc on a paper map.

If a spatially-linked APD is available, outbreak information will still need to be attached to each property. Although data from the APD can be read into ANEMIS at the start of the outbreak, ANEMIS has no facility for storing spatial coordinates.

4.2.4 Point mapping

Where a spatially-linked APD is not available, point mapping of properties overlaid on maps of road and river systems will still provide a useful tool to assist in disease management and reporting. In this case mapping would generally be limited to properties that are either infected or under surveillance, unless point locations are available for all properties.

Implementation of point mapping would be dependant on the recording of coordinate information for each property, in a format compatible with both ANEMIS data and the mapping software being used (for example in a simple database file that can be linked to ANEMIS data for attribute mapping).

4.2.5 ANEMIS

ANEMIS Version 4 is written in *Clipper* and the data files used are dBASE-style DBF files and indexes created using the *Comix* driver. These are theoretically accessible to GIS software, but the degree of linking possible varies with the GIS software in use. The capacity of the GIS to link to data in DBF files will determine the nature of any link that can be established. The structure of all relevant ANEMIS 4 files is listed at the back of the **ANEMIS Manual.**

The file CASE.DBF is the one containing fields for unique property references and identification numbers. The property status is not stored in this file and, in ANEMIS, it is determined by the program when run. The field PROP_NO (prompted for as *Property No.*) is a 10-character field that will be used for unique property identification within the State. However, this field is not present in other ANEMIS files, and if links are sought to other files they will need to be based on CASE_NO, a 4-character field containing the LDCC case number.

Linking GIS cadastral polygons to ANEMIS data is highly desirable, and a high priority for any GIS used in the LDCC. A dynamic link is theoretically possible, but may prove impractical with the resources available. The GIS consultant should investigate what can be achieved.

4.2.6 Necessary expertise and equipment

Expertise and equipment can be drawn from other departments, organisations or the private sector if necessary so lack of GIS capability in the local department of agriculture is not a sufficient reason for not setting up GIS mapping in the LDCC.

Printers and plotters

Printing maps takes time, and there will be times in the LDCC when demand for hard copies is high. Inkjet and laser printers are much faster than plotters, which are probably too slow for most LDCC purposes. The use of colour is important. Multiple printers shared on an LDCC network should be considered. Photocopiers should be used for street maps and multiple copies of an existing map sheet.

4.2.7 Digital maps

Digital topographical maps at appropriate scales (ie with fine detail) are only patchily available around Australia. Preparation of a single topographical map sheet into vector GIS format (see section 3.1.2) takes considerable time, and is not a practical option. Alternative sources of digitised land features should be considered.

Digital aerial images

Currently, a library is being investigated and developed. To create rectified images suitable for use in a GIS to cover a small area will take many days from start to finish, and will be expensive, but it is possible (see Section 3.3).

Digital satellite images

Libraries of such images are maintained. Maximum resolution is 10 metres, but 2–5 metre resolution may become available. Acquisition of a suitable geolocated, rectified, totally up-to-date image normally takes 10–14 days, but it might be possible to speed this up in an emergency (see Section 3.4)

Non-topological scanned map sheets or rectified aerial photos or orthophoto maps (see Section 2.3) can be used as a background for GIS mapping. Scanning sheets of a suitable

scale takes only hours, as opposed to the much longer time to prepare digital maps with topology. It is possible, and even desirable, to maintain a library of such scanned images in preparation for an emergency animal disease outbreak.

A digitised cadastre suitable for use in GIS is essential for computerised mapping in the LDCC. It will usually be available but, if not, it can be prepared from a printed sheet in a period of days, depending on the detail involved, the area to be covered and the quality required. Very high quality is not necessary. The largest scale to be used should be taken into account when deciding on the quality needed.

4.3 Assessment of availability

4.3.1 Computer software

There are many different software packages available for handling the types of data discussed above. This has advantages (variety, choice, competitive pricing) and disadvantages (potential for incompatible data formats). A further disadvantage is that there is no standard data format in use in Australia, or even within individual States. However, some reasons for optimism are as follows:

- it is possible to transfer data from one format to another, although this takes time and is inconvenient
- unofficial standards are developing
- AUSLIG, (the Commonwealth Government mapping agency) supplies digitised maps covering the whole of Australia, and these are available in various formats, although the scales available may not be appropriate for LDCC purposes
- a spatial data transfer standard (SDTS) is being developed, and should be generally adopted in the near future
- the software from AUSLIG and other software packages such as MapInfo and Epimap are useful during an outbreak.

Mapping software

A wide variety of software packages are available for GIS and desktop mapping applications. There are three main levels of software capability to select from:

1. *Full GIS systems* — dedicated, fully-featured GIS packages, such as ARC-Info, capable of handling a wide variety of functions. Generally these systems are quite expensive and require extensive training in their use. Most State and Territory departments of agriculture have groups using such packages, and their services could be called upon to assist as necessary. Use of these systems would require access to a comprehensive geographically linked APD or at least cadastral data to justify their use in an emergency animal disease outbreak.
2. *Desktop mapping packages* — such as Arc View and Map Info. These tend to have limited GIS capability, but excellent desktop mapping features which make them an ideal tool for use in emergency disease management. Costs range from about $1000 to $3000, and these packages are generally much easier to use and learn than true GIS systems.
3. *Basic mapping packages* — such as Epimap and add-ons to MS Excel/Access. These provide very simple mapping capability at low cost, and are generally cheap (or free) and

easy to use. To be used successfully appropriate boundary (polygon map) files must be available in suitable format, usually generated by other programs such as MapInfo.

Expertise

As with the mapping officer and many other roles in the LDCC, currently available GIS expertise will need to be brought in from wherever it resides. Most States have such expertise within the department of agriculture. In all States and Territories there is expertise in other government departments, particularly lands and environment.

4.3.2 Computer hardware

Computers

Vector GIS software requires large amounts of computer memory for efficient operation, and the data files occupy large amounts of disk space. Scanned images of photographs or paper maps also take up a lot of disk space, and therefore need large memory for rapid changes of display. Computers with adequate memory, disk storage, and monitor size and resolution are becoming increasingly common within Government departments.

The following factors combine to make the availability of suitable computers likely in the event of an emergency disease outbreak:

- software that will run on readily available PCs
- greater computing power, memory, and disk storage in commonly available PCs
- increasing number of machines dedicated to GIS in State and Territory departments
- rapidly developing computer network communications among regional centres
- State and Territory departments of agriculture currently operate suitable equipment (although its availability may be another matter).

Printers and plotters

Paper sizes from A4 to A0 (84 x 119 cm) can be handled by suitably sized plotters. A1 is a size that is becoming more commonly available.

High resolution, photograph-quality printouts require expensive electrostatic plotters, which may not be readily available. An A0 sheet takes the order of 10 minutes to print, regardless of how much detail it contains.

Inkjet plotters may be more readily available for LDCC use, and they work at a similar speed to electrostatic plotters.

Pen plotters are generally available and suitable for standard GIS output, but an A0 sheet can take from 5 minutes to 2 hours to print, depending on the amount of detail.

In the event of an emergency disease outbreak it is likely that appropriate plotters could be found for use in the LDCC and the SDCHQ, wherever in Australia the outbreak occurred.

Computer hardware availability should not be a limiting factor in determining whether or not to use digital mapping systems in an emergency disease outbreak.

Digitisers

Digitisers are devices for tracing lines and boundaries on paper maps to include these features on electronic maps.

They vary in the size of map they can handle with A0 digitisers available at about $10 000.

They consist of a tablet to which the map is fixed. Known reference points on the map are located with the pointing device and keyed in to geolocate the map. Then the lines are traced

with the pointing device which may be a puck with cross hairs situated inside a perspex cover or a pen-like implement.

These devices may be used to trace declared areas on a map or if a suitable paper property map is available they could be used to produce an electronic paddock map.

Their main disadvantage is cost.

4.3.3 Databases available

The important elements of a useable GIS for mapping are:

- property boundaries with property polygons linked to other property data
- roads and waterways.

If digital maps and cadastre are available locally, then all necessary hardware, software and expertise will be reasonably available. The limiting factor in deciding whether or not to rely on a GIS-based mapping system at the start of an outbreak will therefore be the availability of digital maps and cadastre for the locality. This situation will change over time as more and more such data are captured around Australia.

AUSLIG sells its 1:250 000 topographic maps in digital format, covering the whole of Australia. Unfortunately this scale may be inappropriate for LDCC mapping. They are working on the 1:100 000 series, but even this may lack sufficient detail for LDCC purposes.

Agricultural property database

A necessary component of any GIS-based mapping system for disease management is a database containing information on property owners and managers, linked to the actual boundaries of the properties.

Location boundaries are referred to as *cadastral* data. Most cadastral data in Australia has been digitised by the relevant State or Territory government departments. This process is not complete in all States/Territories. Pure cadastral data is often limited because most agricultural properties have boundaries that incorporate numerous individual land parcels, which are not necessarily contiguous. Land title data also suffer from the fact that the person actually farming the land is often not the person whose name is on the title.

An APD is equally useful for a paper mapping system in an outbreak, although when paper maps are used there is clearly no requirement for the cadastral data to be digitised. The essential element of an APD is the linking of property boundaries with owners, managers, stock numbers, infection status, etc.

The current approach of ANEMIS to managing property information is to build up a property database as the outbreak progresses, only recording a property in the database as it is included in the infection or surveillance or tracing processes. ANEMIS 4 caters for the use of an APD if it is available.

In similar fashion it is possible to use a GIS-based mapping system without a pre-existing APD, using a digital cadastre, defining property boundaries as they are encountered. This is true whatever the underlying map that is being used, be it a digital video image, a satellite image, a digitised 1:25 000 topographical map sheet, or a scanned paper map sheet.

Digital maps

Digital data are generally available to other government departments within a State or Territory at the *cost of transfer*. This cost is up to the agency holding the data.

For digital map data to be shared, agreements among departments need to be set in place if GIS is to be used in outbreaks in places where the department responsible for agriculture is not the custodian of relevant digital map data.

APPENDIX 1 Potential uses of maps

Mapping systems may be used to store and communicate a wide variety of information, including:

Property information

- Ownership (including legal owners and legal description)
- Location coordinates, case number, other property identifier
- Boundaries
- Size
- Inspection status
- Disease status.

Restricted and controlled areas

- Boundaries
- Locations of traffic control points
- Locations of high risk enterprises
- Planning changes in boundaries
- Aerial survey
- Tracing
- Surveillance — tasks to complete/undertaken
- Monitoring — tasks to complete/undertaken

Field staff

- Briefing
- Tasking
- Navigation (finding their way about)
- Reporting
- Personnel and logistic information

Wildlife section

- Population
- Distribution
- Zone boundaries
- Monitoring areas
- Operational areas
- Buffer zones
- Survey/sampling patterns
- Water courses
- Airstrips

Epidemiological information

- Hydrology
- Temperature and humidity
- Rainfall
- Soil features

The following table suggests the most appropriate maps to use for specific circumstances.

Table 1 A guide to types of maps and their operational uses

User	Use	Map	Scale
Controller	Define declared areas	Topo-cadastral	1:50000 to 1:250000
Veterinary investigations (surveillance)	Navigation by field teams property mapping	Roads, topographical Cadastral topographical GIS, aerial photos	>1:25000 <1:25000
Veterinary investigations (SDCHQ)	Tracing outside RA	Cadastral topographical	1:250000
Site supervisor/ Diagnostic team	Property management	Cadastral + topographical soil hydrology	1:50000
Epidemiologist	Modelling, predicting & analysing spread	Various	Various
Restricted area movement and security		Cadastral, roads, waterways	1:50000+
Wildlife officers	Wildlife tracing & management	Topographical + cadastral	1:50000
Media officer	Briefing media	Laundered cadastral (remove names of people/properties)	1:50000+
Information/briefing	Briefing LDCC/SDCHQ staff	Cadastral + topographical	1:50000+
Trade and incident management group	Advise OIE and overseas animal health authorities	Topographical preferably computer generated	1:250 000+

APPENDIX 2 Job description of a mapping officer

This description is taken from the Control Centres Management Manual Part 2, LRD 104

Skills

- Good local knowledge of RA (and surrounding areas) including landholders, roads, rivers, crown land and national parks and shire boundaries.
- Experience in reading maps and accurately recording property information.
- Ability to procure appropriate maps and other relevant information.

Line relationships

- Responsible to LDCC veterinary investigations manager.

Roles and responsibilities

- Record details on appropriate maps of all relevant information, including RA boundaries, IPs, dangerous contact premises (DCPs), and other premises with susceptible stock.
- Map information on wild animal details and control operations where required.
- Provide maps to field personnel as required showing the locations of IPs, DCPs, roads, etc.

Duties

- Obtain suitable cadastral maps preferably showing road names and property locations.
- Accurately define the RA and other areas of operation and plot the status of premises on the maps (show IPs, DCPs, other premises visited).
- Maintain a rough working map and mark off each property as visited from information on ANEMIS form 1.
- Develop a colour coding of pins, coloured lines and numbers to display and identify information on a master map.
- Identify on a master map (by colour and numbers) IPs, DCPs, RA and CA boundaries, location of check-points and decontamination units, Crown land, river/lakes, national parks and urban areas by:
  a) developing a colour code for each class of property and prominently displaying the key to this code;
  b) maintaining an operational log book and recording in sequential order the property number, owner, stock numbers and area (from ANEMIS form 1) and crown allotment numbers of IPs and DCPs (through liaison with local government);
  c) marking the status of premises visited (and altering as information is updated) on the master map;
  d) developing a colour code for wild animal populations and operations and marking the disease status of wild animals on the master map;
     – premises on which there are no stock or material likely to be contaminated so that these can be eliminated from further surveillance visits; and
     – key risk enterprises such as feedlots and abattoirs.
- Update information on the master map as it is received.

- Provide copies of road maps for veterinary investigations field teams (RA movement and security unit) and other staff as required:
  - mark route of travel; and
  - give verbal directions to field teams and illustrate route on master road map.

SDCHQ

The operations manager has the responsibility for mapping and ANEMIS at SDCHQ. A dedicated mapping officer may be used. This person's duties will be similar to the above but will concentrate on statewide mapping (especially if there is more than one LDCC). Activities in the control area must be fully depicted. In addition, this person may assist the LDCC in the procurement of any special maps that may be required.

See also the **Control Centres Management Manual Part 2, SRD 203**

APPENDIX 3 An example of utilising mapping resources in an emergency

In late 1996 the Victorian Department of Agriculture, Energy and Minerals, joined with the Dept of Conservation and Environment, the Land Titles Office, the Office of Geographic Data and the Surveyor General. All information regarding 'land' is now within the one department.

Each section of the mega-department (Department of Natural Resources and Environment) uses different data storage systems, which have compatibility difficulties or show discrepancies in common data. The cattle tailtag program does not contain geographic data at present, but has provision to accept it.

In spite of these deficiencies, mapping during the anthrax outbreak in 1997 was of a high standard. The Institute of Sustainable Irrigated Agriculture, Tatura, held topographic information of the area of interest in digital form. This information included soil type, soil pH, soil calcium content, elevation, water supply and drainage.

Cadastral information in digital form was obtained from the Land Titles Office and local government. There was approximately a 20% discrepancy in ownership information between the two.

During the outbreak, maps were generated daily using both cadastral and topographic information superimposed on the Victorian digital map information selecting roads/waterways/towns.

Changes to property boundaries and property status as regards vaccination, infection, non-susceptible species, etc were updated daily, the process taking approximately 4 hours. In this way, current information could be kept on (eventually) 1000 holdings in an area 20 km x 30 km.

(Information supplied by Terry Thomas Victorian Department of Natural Resources and Environment)

GLOSSARY

Agricultural Property Database	An electronic list of all agricultural enterprises containing details of ownership, type of enterprise, land use and geographical location data.
ANEMIS	*An*imal Health *Em*ergency *I*nformation *S*ystem. A system for the collection, assimilation, actioning and dissemination of essential disease control information using paper documentation and a computer database.
Australian Geodetic Datum	the framework used for coordinates in Australia since 1966, that is now being replaced by the Geocentric Datum of Australia. This system uses datum based on the earth's centre of mass (or geocentre); as distinct from taking into account the shape and size of the earth.
Area	A defined tract of land for the time being subject to disease control restrictions under emergency disease legislation.
AUSVETPLAN	A series of documents that describe the Australian response to emergency animal diseases, linking policy, strategies, implementation, coordination and emergency-management plans.
Cadastral map	A map showing boundaries and ownership of land.
Cadastre	An official register of property, with details of boundaries and ownership
Control area	An area usually surrounding a restricted area (possibly as big as a State) where restrictions will reduce the chance of the disease spreading further afield.
Dangerous contact premises (DCP)	Premises containing dangerous contact animal(s), animal products, animal waste or things that have been recently introduced from an infected premises (usually up to 21 days before declaration of the premises being infected) and are likely to be infected or contaminated or any of these items that may have been in substantial contact with people that have been associated with an infected premises within three days of visiting the DCP.
Declared Area	A defined tract of land for the time being subject to disease control restrictions under emergency disease legislation. Types of declared areas include *restricted area; control area; infected premises;* and *dangerous contact premises.*
Exotic animal disease	Affecting animals (which may include people) and which does not presently occur in Australia.
Geocentric Datum of Australia	The Geocentric Datum of Australia (GDA) is a co-ordinate system that uses the centre of the earth for its origin. The GDA is compatible with other geocentric datums worldwide and with Global Positioning System (GPS) observations. (Surveying can be either plane or geodetic. Plane surveying does not take curvature of the earth into account. Geodetic surveying does.)
Geographic information system (GIS)	GIS is a computer program for storing, retrieving, analysing, and displaying cartographic detail.
Global positioning system (GPS)	GPS involves surveying from satellite signals based on the centre of the earth – rather than the surface of the earth.
Grid reference	A network of lines superimposed upon a map and forming squares for referencing, the basis of the network being that each line in it is at a known distance either east or north of a selected origin.

Infected premises	A defined area (which may be all or part of a property) in which an exotic disease exists or is believed to exist. An infected premises is subject to quarantine served by notice and to eradication or control procedures.
Local disease control centre	The field centre from which all operations in the Centre's Restricted Area are controlled.
Operations manual	Document containing specific, stepwise instructions on carrying out operational procedures.
Orthophoto map	An aerial map that is true to scale.
Polygon	An area enclosed by many sides (see vector).
Plan	An agreed course of action; applied only to AUSVETPLAN or the plans of support agencies.
Raster (GIS)	A grid-based system, in which information is stored uniformly in relation to each cell that forms the grid. Compare with a vector-based system
Restricted area (RA)	A relatively small declared area (compared to a control area) around an infected premises that is subject to intense surveillance and movement controls.
Risk enterprise	A livestock or livestock related enterprise with a high potential for disease spread, eg an abattoir, milk factory, artificial breeding centre or livestock market.
Section (disease-control centre)	Major subdivision of a disease control centre responsible for a particular segment of eradication operations.
State disease control headquarters	The emergency operations centre that directs the disease control operations to be undertaken in the State/Territory.
Surveillance	A systematic program of inspection and examination of animals or things to determine the presence or absence of an emergency disease.
Suspect premises	Containing suspect animal(s) which will be subject to quarantine and intensive surveillance.
Topographical map	A map delineating the natural and artificial features of an area.
Tracing	The process of locating animals, persons or things that may be implicated in the spread of disease.
Traffic control point	Road check point or barricade to maintain compliance with movement control restrictions.
Vector (GIS)	A system based on the use of points and lines to represent geographical features. Areas enclosed by lines are termed polygons.
World Geodetic System (WGS84)	From time to time an earth-centred reference system is adopted which is a best fit for the whole earth, based on the latest information. The reference system adopted in 1980 (GRS80) was used by the United States Defense Mapping Agency as the basis for the World Geodetic System 1984, which is currently used for the GPS satellite navigation system.

ABBREVIATIONS

ACRES	Australian Centre for Remote Sensing
AGD	Australian Geodetic Datum
AMG	Australian map grid
ANEMIS	Animal health emergency information system
APD	Agriculture property database
AUSLIG	Australian Surveying and Land Information Group
AUSVETPLAN	Australian Veterinary Emergency Plan
CA	Control area
DCP	Dangerous contact premises
GDA	Geocentric datum of Australia
GIS	Geographic information system
GPS	Global positioning system
IP	Infected premises
LDCC	Local disease control centre
OIE	World Organisation for Animal Health [Office International des Epizooties]
RA	Restricted area
SDCHQ	State/Territory disease control headquarters
SDTS	Spatial data transfer standard
WGS	World Geodetic System

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