Report on

Mycoplasma bovis casing and liaison backlog

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Manatū Ahu Matua

Glossary

AQ	AsureQuality
ARDB	Animal Response Database
AS	Active Surveillance
BAU	Business as usual
BLT	Bovis Leadership Team
BTM	Bulk Tank Milk
C&D	Cleaning and Disinfection
CP	Confirmed Property
DCANZ	Dairy Companies Association of New Zealand
DMW	Disease Management Workflow
EDIR	Exotic Disease Investigation Report
EDR	Estimated Dissemination Rate
ELISA	Enzyme-linked immunosorbent assay
MPI	Ministry for Primary Industries
NAIT	National Animal Identification and Tracing
NCC	National Control Centre
NOD	Notice of Direction
NZVA	New Zealand Veterinary Association
PCR	Polymerase chain reaction
RCC	Regional Control Centre
RP	Restricted Place
TAG	Technical Advisory Group

EXECUTIVE SUMMARY

On April 12th 2019, the Director-General of the Ministry for Primary Industries was formally advised by the Head of Biosecurity New Zealand that there was a '*Mycoplasma bovis* Programme casing and liaison backlog' of 666 properties in the *Mycoplasma bovis* (*M. bovis*) disease management queue. At a Governance meeting on the 15th April, the size of the 'backlog' was revised to 1,100 properties, of which 300 were reported to be Urgent and High risk properties and 800 Medium and Low risk properties[1]. On 15th April, the Director-General asked me to review the reasons for and impact of the backlog, to recommend measures and reporting that would prevent a re-occurrence, and to predict what volume of casing and notification would be reasonable for resourcing against into the future. I worked closely with the *M. bovis* directorate staff through the course of my review so that they could implement recommendations in real time. I must note that staff were very helpful and engaged quickly to provide solutions to problems.

Following interviews with disease management experts, both domestically and internationally, we recommend that:

1) the number of categories for properties should be reduced to two: Urgent and Routine; and
2) the time between identification of the Confirmed Property (CP) and the placement of movement controls, where necessary, or the initiation of Surveillance on Cased farms should be no more than:
    a. one month for Urgent properties; and
    b. four months for Routine properties.

When we apply the 'good disease' management standards defined above to the disease management queue, the magnitude of the 'backlog'[2] would be ~875 properties, as ~575 properties would be considered within an acceptable disease management timeframe. Nevertheless, good disease management practice requires that Confirmed Properties are managed to a suitable resolution more quickly.

Casing of the (reported) 300 Urgent and High risk properties was completed by 17th May; furthermore, an additional 443 Urgent and High risk properties were completed by 31st May 2019; the latter included properties identified as part of the backlog and properties identified since April 12th.

Quantitatively, the majority of the properties in the 'backlog' (>70%) are from source farms that became Confirmed Properties (CP) since January 1st 2019; >25% of the properties to be cased are from source farms that were identified as Infected Properties (i.e., also CP) 5 to 14 months ago. Qualitatively, farmers, veterinarians, and Response field personnel claim that they reported to the National Control Centre (NCC) a failure of the Response to contact farms of interest from last spring, but believe their concerns were not given due consideration. In interviewing personnel in the Disease Management and Intelligence team, the Tracing and Surveillance team members were unsurprised that there was a considerable number of properties awaiting Casing because of their own workloads between January and March. There were regular team meetings; but, these do not appear to have been a forum to discuss workloads and anticipate resource needs.

[1] Through the review, we established that there were ~1,450 properties in the disease management queue on the 12th April 2019: ~800 Medium-Low and ~650 Urgent-High risk properties.
[2] i.e., the ~1,450 properties in the disease management queue as of the 12th April 2019.

The workload building in the disease management queue was, largely, unanticipated. Prior to May 2018, the Intelligence team manually produced reports that outlined the number of properties in the different parts of the Disease Management queue; when the epidemiologists in Wallaceville left the Response, this reporting appears to have ceased. The failure to continue these reports is a key reason for a failure to detect this backlog earlier.

There are longer-term implications of the backlog. Senior epidemiologists have estimated that there will be 30 to 40 Confirmed Places in the backlog, based on the historical transmission of disease between farms. This will lead to a considerable workload for Field Operations teams subsequent to clearing the backlog. However, because of the makeup of the source properties (65% beef, 28% dairy, and 7% dairy support) and because the Estimated Dissemination Rate of the disease is considerably lower on beef farms than dairy, we can hypothesise that this is in a much less concerning situation than if the majority of movements had been traced off dairy farms. The Response team have done considerable planning to enable resourcing this increase in operational work.

I recommend that a full planning session is undertaken during the next month to define tasks to be completed and inter-dependencies of tasks, and workflow scheduling be undertaken to predict the resource needs of the directorate into the future. As part of this, divesting some responsibility for Operations to regional centres and engaging stakeholders, such as Response Government Industry Agreement partners, DairyNZ and Beef+Lamb New Zealand, and stakeholders, like DCANZ, New Zealand Veterinary Association, and Federated Farmers, should also be considered; this will help ensure that future Response efforts meet the aim of eradication with the smallest possible social footprint. Finally, full NAIT compliance is a cornerstone of New Zealand's ability to manage disease incursions. Current compliance remains inadequate and anything that can be done to encourage farmers to comply with requirements will greatly accelerate the efforts in tracing, property prioritisation, and, ultimately, disease eradication.

BACKGROUND

On 21 July 2017, samples collected from a dairy herd in South Canterbury tested positive for *Mycoplasma bovis* (*M. bovis*), a bacterium that causes disease in cattle. Although not a trade risk, *M. bovis* is an economically significant pathogen and the animal welfare and disease management implications of it are, potentially, severe. While widespread internationally, *M. bovis* had not, previously, been detected in New Zealand. The disease had established itself in New Zealand more than 18 months before the suspected 'Origin Farm' was identified and the Response team worked hard to close the time from infection of a property to detection and movement control. After careful consideration, on 28th May 2018, a decision to eradicate *M. bovis* from New Zealand was announced by the New Zealand Government; this decision was taken collectively by Government and the dairy and beef industries.

Disease eradication is a complex and specialised scientific and technical field. Simplistically, successful eradication is based on preventing the spread of disease from one property to another. Critically, this involves identifying farms at risk of infection and placing movement controls more quickly than the disease can move between properties. In the case of *M. bovis*, spread between properties is almost exclusively a result of movement of infected animals; animals become infected through either contact with other infected animals or through the consumption of milk from an infected cow. Once infected and shedding the bacteria, the disease can move very rapidly within a farm (i.e., it is highly infectious). Both *M. bovis* and the New Zealand livestock farming industries offer unique challenges to an eradication effort.

Mycoplasma bovis is a bacteria that can infect a host without causing immediate clinical signs; the length of the latency period between infection and expression of clinical signs is variable and, unpredictable. This means that the primary mode of detecting a disease by observation of clinical signs is ineffective. Furthermore, the bacteria can, in effect, hide from the immune system, meaning that currently available diagnostic tests are not very sensitive for detecting the presence of the bacteria; this also means that the absence of a positive test may not reflect an absence of infection. In fact, because of our systems of farming, within herd prevalence on grazing beef properties can be very low, making even effective tests less effective. In addition, screening tools (e.g., bulk milk surveillance) may not detect the presence of the disease in a herd within the year of infection (because the infected animals are not lactating or because prevalence in the lactating herd is low). This means that national screening surveillance and observation of clinical signs cannot be relied on as a replacement for adequate tracing activity, where such tracing is incomplete. Tracing risk movements from known infected properties quickly and placing movement controls on properties at a high risk of having been infected faster than the likelihood of the disease spreading to a subsequent property is, therefore, the primary aim of an effective disease management system. The efficiency of this aspect of disease management would be greatly improved if industry NAIT compliance was increased.

New Zealand farming industries, and, in particular, dairy, however, offer unique challenges. New Zealand has a long-standing 'semi-nomadic' approach to farming, wherein young farmers gradually accumulate wealth in live-stock of their own while working on someone else's property (Sharemilking). This approach is a foundation stone of the New Zealand dairy sector, with many farmers today having followed that career pathway. But, it also means large movements of stock nationally around the 1st of June each year.

Furthermore, New Zealand dairy farmers were amongst the first to realise the financial advantages of business specialisation, focussing their efforts on the production of milk on the contiguous land base around the milking shed, while leasing land or contracting others to rear replacement stock away from the 'milking platform' from between 12 and 20 weeks of age. This practice has led to the development of a 'contract rearing' industry, wherein groups of animals from different properties are, often, co-mingled and grazed together for more than a year; even if not deliberately co-mingled, the risk of animals 'straying' between herds is elevated in this environment.

An extension of this process for mature animals was developed in the South Island to accommodate the longer and colder winters compared with the North Island; during the late-autumn and winter, whole herds of dairy cows are relocated to properties that have been contracted to grow winter feed crops, allowing the 'milking platform' to re-grow sufficient pasture to sustain cows following calving. Although herds are generally kept separate on these wintering platforms, the risk of animals from different herds mixing for a period of time is increased. In addition to these movements, the dairy sector is both a supplier of stock to the beef sector and a supplier of waste milk to people that raise calves for supply to the dairy sector.

Notwithstanding these unique challenges, the basic premise for eradicating this disease in New Zealand is the same as described previously: identify infected properties (i.e., regular surveillance) or properties likely to be infected through animal movements (i.e., tracing from known or suspect properties) as soon as possible after the infection risk event, and prevent movement of animals from these properties to other properties.

THIS REPORT

On April 12th 2019, the Director-General of the Ministry for Primary Industries was advised by the Head of Biosecurity New Zealand of a 'backlog' of properties in the disease management queue. Industry partners had been briefed and, in a communication prepared on the 8th April, it was reported that 666 properties were in the backlog.

At a *M. bovis* Governance meeting on the 15th April, Response reported that the 'backlog' was larger than this and that there were 1,100 properties in the backlog, 300 of which were Urgent/High Risk and 800 of which were Medium/Low risk. A remediation plan was put in place that involved Casing all 1,100 properties before the 17th May and placing movement controls on appropriate properties before moving day on June 1st.

On 15th April, the Director-General asked me to:

- investigate the origin of the 'backlog' and a timeline of discovery and response escalation;
- review the plan for remediation and provide assurance that the plan was sufficient;
- determine the effect of the 'backlog' on the wider response programme;
- recommend measures and reporting that would ensure such a 'backlog' is not repeated;
- ascertain the long-term volume of forward casing and notifications; and
- predict what volume of casing and notification would be reasonable for resourcing into the future.

The request from the Director-General provided me with full access to all relevant staff, contractors, and documents.

Throughout my review, I worked closely with *M. bovis* directorate staff to ensure that they were aware of my findings and were able to redress any issues and improve processes quickly. I must acknowledge that staff were very helpful and truly engaged in rectifying any problems impeding progress.

ORIGIN OF THE 'BACKLOG' AND TIMELINE OF ESCALATION

We used two approaches to estimate the scale of the 'backlog' and the timeline of events that led to the 'backlog' and the subsequent escalation of the problem:

1. We interviewed staff and asked them to provide their recollection of events and any communications they sent or received regarding the backlog; and
2. We interrogated the Response database to ascertain a timeline of when the properties came to be of interest to MPI in the disease eradication efforts.

Interviews

The existence and scale of a greater than 'business as usual' number of properties in the disease management queue was 'discovered' during the first week of April. However:

- farmers, veterinarians, and MPI field staff and contractors claimed that they were alerting the National Control Centre since spring that farmers that had received animals from Confirmed Places had not yet been contacted (i.e., had not been Cased). They believed their concerns were not given due consideration and were not surprised by the announcement of a 'backlog';

- the Tracing team were, also, not surprised by the presence of a 'backlog', as they felt they had a very large workload through late January and February, which would result in down-stream work for Surveillance and Casing;
- the Surveillance team, during interview, also acknowledged more properties coming through the Case Evaluation meeting (NOD meeting) in late February and March and, so, in retrospect, were not surprised by the existence of a 'backlog'.

However, all were surprised by the size of the 'backlog'. The news of an increased workload in the early parts of the disease management queue in late January and February was not provided to the Casing team, who already had a 'backlog' of approximately 200 properties, with an additional 400 low risk neighbouring properties (i.e., Contiguous Properties) yet to be cased; this 'backlog', known to Casing, was discussed during March and additional resources were being assigned to help overcome it.

Document review

Between the 3rd April and the 8th April, the Disease Management and Intelligence team collated their work plans. An initial estimate of 666 properties was deduced from 14 Confirmed Properties; but, there was an additional 53 farms in the 'backlog' that had, at that time, not been prioritised (i.e., still required Tracing or were yet to go to a Case Evaluation Meeting). The presence of additional farms was clearly communicated to the Manager Disease Management and Intelligence.

A paper was prepared (8th April) for a meeting (9th April) between the Head of Biosecurity NZ, Director *M. bov*is Programme Directorate, Manager Disease Management and Intelligence, the CEO of DairyNZ, and the Chairman of the DairyNZ Board. The CEO of Beef+Lamb New Zealand was not in attendance. In this paper, it was stated that:

- a significant 'backlog' of Low and Medium Casing calls has accumulated over the past three months;
- there are currently 666 casing calls to be made of which 96 are urgent priority.

Database interrogation

On May 6th we determined that the correct number of 'backlog' properties requiring Casing collated on April 12th was ~1,450 (Figure 1), not 1,100 as had been presented to Governance. More than 300

of the ~1,450 had been removed from the 'Surge' list and staff had been instructed to move them into a 'Business As Usual' (BAU) Casing list. All of these properties had been prioritised as High risk in the Case Evaluation meeting (NOD meeting). Further analysis of the list to remove duplicate risk events and property identifications resulted in a final list of 309 properties that had been transferred from 'Surge' to BAU, despite being a part of the April 12th collated list. A breakdown of the 309 High risk properties into Business Type is presented in Table 1.

Table 1. Breakdown of the 309 properties that were removed from the original list before presentation of numbers to Governance on 15th April.

Source farm	Expected NOD	Expected Active Surveillance	Total
Dairy	8	75	83
Beef	35	176	211
Dry	7	8	15
Total	50	259	309

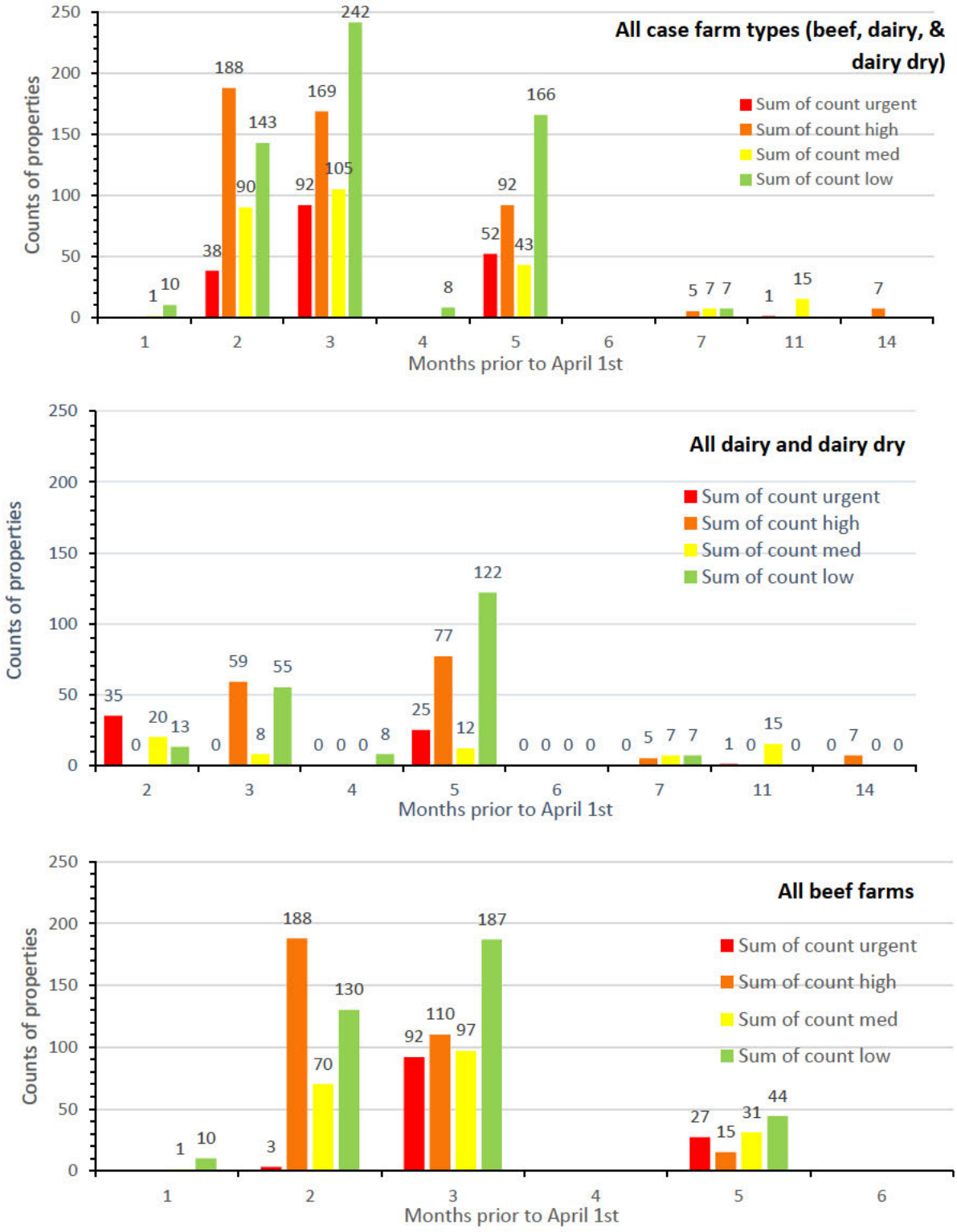


Figure 1. Counts of uncased farms by risk category and grouped by number of months that have elapsed since the service of the RP on the property from which the movements were traced (either forwards or backwards). For origin farms that had NODs to C&D, the issue date of that NOD was used to calculate the interval. Month categories should be interpreted as uncased farms in month 1 (on the x axis) could have had their notice issued at any time from 1 to 30 days prior to April 1st.

True size of the backlog

In this report the term 'backlog' has been used to refer to all of the properties requiring casing, as of 12th April 2019. We have used this definition to be consistent with what has been presented to Governance. Some of the properties that have been captured within this, however, are from Confirmed Properties that were identified an acceptable level of time before the 'backlog' was quantified.

Epidemiological experts that we interviewed during our review have stressed that to delimit the disease, time from identification of a Confirmed Property to placing movement controls on associated risk event properties must be no longer than 1 month for Urgent/High risk properties and <4 months for Medium/Low risk properties. If we use these categories to separate the properties in the Disease Management queue into those still within an Acceptable Timeframe ('Routine') and those that should have been previously acted upon (i.e., 'Backlog'; Table 2; Figure 2);

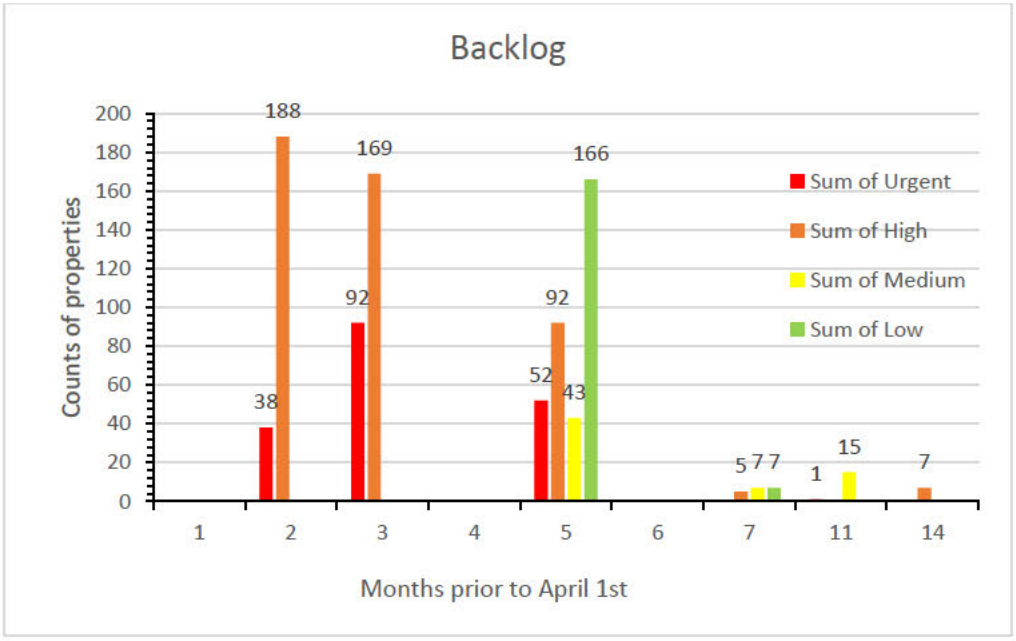
- the 'backlog' is made up of 882 risk events (644 Urgent-High and 238 Medium-Low);
- 599 risk events (all Medium-Low) were within an acceptable timeframe relative to the identification of the source property and the risk category assigned at the Case Evaluation meeting (Table 2).

Table 2. Categorisation of 'Risk Events'[1] in the disease management queue into a 'Backlog' or a 'Routine' category (i.e., within an acceptable timeframe from identification of Confirmed Property)[2].

	Months to address risk	Backlog	Routine
Urgent	1	183	0
High	1	461	0
Medium	4	65	196
Low	4	173	403
Total		882	599

[1]Note: these are risk events and not properties. Some properties will have multiple risk events.

[2]The categorisation does not factor in the time taken to apply a movement control. If the time between casing and the serving of a movement control is included (approximately two weeks), some of Medium and Low properties in the Routine column could move to the 'Backlog' column.



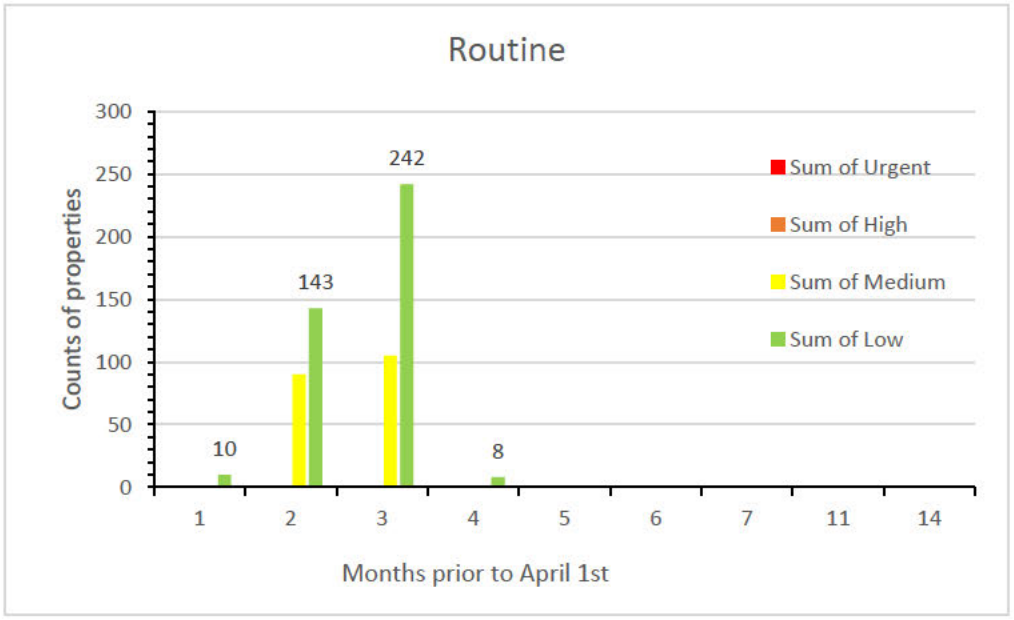


Figure 2. Counts of uncased 'risk events' in the disease management queue that should be categorised as 'Backlog' (n= 882) and Routine (i.e., within an acceptable timeframe for disease management; n= 599). Note: these are risk events and not properties. Some properties will have multiple risk events.

REASONS FOR THE 'BACKLOG'

Reported reasons

In the presentation to Governance (April 15th), the 'backlog' was described as "an acute, critical casing workload issue, developed over the last 6 weeks" that resulted from "a significant increase in Confirmed Properties" in the November to February period and an associated increase in Tracing Output, "Increased 'non-core' Casing work", "workload forecast but not to true volume", and an "Absence of Workflow tools", which hid the volume of the backlog. Although there is some validity to the reasons given, we don't believe them to reflect the state completely.

1. The 'backlog' did not develop over the preceding 6 weeks. Only 30% of the Cases in the 'backlog' originated from source farms identified after the 1st February (10 weeks before the governance meeting) and 395 of the 1,481 (>25%) of the source farms were Confirmed Positive before 1st November 2018 (29% of Urgent farms, 23% of High farms, 25% of Medium farms, and 30% of Low farms).
   During interviews with field staff, regional contractors, and the NZ Veterinary Association (NZVA), none were surprised that a considerable 'backlog' was developing, although the scale of the 'backlog' was, to most, a surprise. During my interviews, farmers, field staff and veterinarians reported that they had alerted NCC to a failure somewhere in the process that ensures farmers associated with Confirmed Properties are contacted by MPI. They all believed that their concerns were not given due consideration.
   The belief that a 'backlog' was developing from last spring, at least, is consistent with the data presented in Figure 1, which provides a graphical timeline of when source farms for the current 'backlog' were identified; >25% of farms in the 'backlog' were from source farms identified in 2018.
   a. Within MPI, the Tracing team had anticipated a very large workflow for Casing in January-February 2019; similarly, the Surveillance team acknowledged that their workload increased greatly in late February-early March, as Traced properties came through the Case Evaluation (NOD) meetings. However, there was no process for collating the number of properties in each phase of the disease management pipeline and the Casing team was not advised of the upcoming surge in numbers.
   b. Compounding this further, it was claimed that Casing would only be provided with a new NOD list (i.e., the list generated at the Case Evaluation meeting) when they were close to completing current tasks. In other words, the Casing team, through no fault of their own, were unaware of the impending workload.

2. Although the 'absence of workflow tools' does make understanding the workloads in the different parts of the disease management pipeline more difficult, prior to the Response moving from Wallaceville to Pastoral House, regular Intelligence (monthly) and Situation (weekly to fortnightly) reports were produced outlining the number of properties in the disease management pipeline: Traced, but not Cased; Cased, but not Tasked; R1 tasked; R1 scheduled; R1 sampled; R1 complete – pending negative; Surveillance complete – negative; Under investigation; IP/Pending positive; and Total.
   These situational reports appear to have ceased when the Senior Epidemiologist from Wallaceville left the Intelligence team manager role. Therefore, although it is true that the lack of a fit-for-purpose workflow tool made understanding the number of properties in the different parts of the disease management pipeline at any one time difficult, when an experienced epidemiologist was in the role of Intelligence Manager and understood the

importance of this information, a regular report was produced to provide this visibility[3].

3. Additional surveillance work was undertaken in spring, including bulk milk testing and a calf survey. While 'non-core', these activities were planned in mid-2018 and the additional workload should have been anticipated and resourced.

Non-reported reasons

In the course of the review, I arrived at the conclusion that there are at least three reasons for why a 'backlog' could occur:

1. Process inadequacy;
2. Directorate structure and team resourcing;
3. A lack of Disease Management and epidemiological experience of the Team Leader for Disease Management and Intelligence.

The coincidence of all three was sufficient to result in an event of this magnitude.

Process inadequacy

Disease management system is not fit-for-purpose

The Disease Management Database System was designed for small scale responses and is not fit-for-purpose for a response of this size or duration. The Animal Response Database (ARDB) is a web-based database with geospatial characteristics that record the Tracing, Casing, and Disease Management information, including laboratory summaries. It was built under enormous time pressure at the beginning of the response and, so, is limited in its capacity. In particular, it cannot deal with the fact that:

- farming in NZ is highly connected (the likelihood of multiple risk events on each property is very high); and
- these networks change over time.

Because of these limitations, there is no 'line of sight' to track farms through the process and, so, staff are unable to automatically see how a farm is progressing from Confirmed Property to limiting forward spread. Furthermore, the Response team must match multiple farm identifiers from different incomplete data sources. Over time, these difficulties are compounding because the database cannot manage repeated interactions with individual farmers. These problems are recognised by the senior managers in the directorate and a new database management system (Project Tiaki) will be available in the next few months to improve these processes.

Workflow planning is undertaken manually

Because of the nature of the disease management pipeline, work specialties are divided into teams (i.e., Tracing, Surveillance, and Casing), through which properties pass in a, somewhat, logical manner (see Appendix 2). However, there is no automatic view/dashboard of how many properties are in any one part of the system at any time. This makes resource planning a manual task for team leaders and management. The manual nature of the process involves the passing of lists of completed tasks to the next team in the process.

[3]A complete report outlining the number of properties in each part of the pipeline was produced under urgency during the 11th and 12th April for this purpose. The production of this report was not at the direction of the Disease Management and Intelligence Manager.

Although, neither the team leader for Surveillance nor Casing knew, there appears to have been an understanding in some parts of their teams that Surveillance would not pass any lists to Casing until the Casing team had almost completed the list they were currently working on. This resulted in a 'backlog' of properties between Surveillance and Casing that was not visible to either team leader.

Team meetings did not address workflow issues

It appears that, although there were regular team meetings in Disease Management and Intelligence, these meetings did not assess workloads and, therefore, did not facilitate resource planning.

Summary

A lack of a fit-for-purpose software for workflow planning led to the maintenance of workflow lists within distinct groups, of which other teams in the disease management pipeline did not have visibility. Poor communication of within-group workloads at team meetings likely contributed to this. The systems do not facilitate easy access to summary data of response statistics and, so, unless someone values those statistics and applies resources to extract the data for analysis, the workflow of the disease management team will not be obvious.

Directorate structure and team resourcing

The structure of the directorate has, potentially, contributed to the current problem. For example:

- There was no L5 manager for Disease management;
- Tracing and Casing teams gather the majority of Intelligence (data/information) for the programme and, yet, they do not report to Intelligence;
- Surveillance appears to have two distinct functions: engagement with Operational Epidemiology and an Operations tasking role; yet, the entire team sits within Disease Management;
- Technical advice in Disease Management is not sufficiently senior to input into crucial decisions;
- There does not appear to be a discrete role that oversees the internal operations of the directorate; this is a different role to the Controller, who ensures coordination of the directorate's outward activities.

This has been acknowledged and a new structure has been proposed and important changes progressively implemented throughout the course of my review.

A lack of Disease Management and epidemiological experience of the Team Leader for Disease Management and Intelligence

In the past, the Manager of Disease Management and Intelligence in a large animal disease response has been filled by an experienced veterinary epidemiologist because a large amount of technical expertise is required to undertake this position. Disease management experts interviewed during my investigation and asked for their opinion on the origin of the 'backlog' identified that the appointment of a veterinarian with no prior Response experience and no qualification or experience in epidemiology to the role of Disease Management and Intelligence Manager was probably a contributing factor.

The position has considerable responsibility, both upwards in communicating to management and downwards to the teams. The person in this role must provide direction and course correction for

Disease Management and Intelligence activities. Day to day running is highly technical and needs constant monitoring against changing requirements from above, messaging from the field, and staff capability and capacity. To track this, when the Response was based at Wallaceville, intelligence reports and surveillance reports included counts of queued properties in each step of the process. Response staff reported that this function was planned to be done by the Intelligence team when it was created in the directorate; there is no evidence that this was tasked by management.

Effect of the 'backlog' on the wider programme

Disease propagation risk from movement of animals carrying disease increases with time, as does the total number of movements. Quantifying the impact of the delay in casing properties and issuing movement controls on the long-term outcomes of the programme is difficult as actual numbers cannot be deduced with certainty. Nevertheless, if we consider historical conversions, we expect there will be between 30 and 40 Confirmed Properties identified in the 'backlog'.

It is important to understand that the 'backlog' (Table 3) is not a finite number of Traces or Cases, but an exponentially increasing workload. Although ~70% of properties are traced from Confirmed Places identified in early 2019, the magnitude of the 'backlog' and the age of some of the source properties' Restricted Place notices are concerning. The only way to control the spread of this disease is by detecting infection on a farm before routine movements disseminate disease; thus, any delays in following up the movement of trace animals increases the number of risk movements and the number of forward infections. The data presented in Figure 1 represent a 'backlog' that developed over a long period; for example, a large number of Urgent and High risk traces came from properties put under RP notice in October 2018 and there are a number of traces connected to properties served a RP notice 7 to 14 months before the quantification of the backlog. Good disease management requires rapid Tracing of Confirmed Properties to ascertain risk of forward spread and subsequent Casing and Movement Control or Surveillance.

Table 3. Count (proportion in parentheses) of source properties in the 'backlog' apportioned into business type and risk category.

	Urgent	High	Medium	Low	Totals
Beef	41 (22%)	343 (74%)	120 (46%)	464 (81%)	968 (65%)
Dairy	142 (78%)	77 (17%)	125 (48%)	63 (11%)	407 (28%)
Dry	0 (0%)	41 (9%)	16 (6%)	49 (8%)	106 (7%)
Totals	183	461	261	576	1481

The time between identifying a Confirmed Property[4] and placing movement controls on traces from that property is critical to reducing the dissemination rate of the disease. The current estimated median time from **infection to detection** of Confirmed Properties known to the programme is 10 months. A large number of the uncased farms in Figure 1 had Restricted Place notices placed on the

[4]Confirmed Property is a farm that has been confirmed positive for the presence of *Mycoplasma bovis*, has had a Restricted Place notice served, and either has been or will be scheduled for depopulation.

source farm more than 5 months ago. For these farms, the period from infection to limiting forward spread can be assumed to be greater than 16 months: 10 months (the historic median for infection to detection) plus 6 months (5 months from RP tasking to casing, and 1 month for casing and placement of controls). The historical median estimated dissemination rate (EDR) for dairy farms was 0.3 in 6 months (Table 4); this means that one farm would result in 2.2 Confirmed Properties, at ~16 months from infection to movement control. Epidemiological experts interviewed during our review have stressed that to delimit the disease, time from identification of a Confirmed Property to placing movement controls on associated risk event properties must be no longer than 1 (for High risk) to 4 (for Low risk) months.

A low EDR is expected in the current 'backlog' because:

1) 65% of the movements in the current 'backlog' are being traced off beef farms (Table 3);
2) dairy milking platforms, dairy support blocks and calf rearers present significantly more risk to disease propagation than beef farms;
3) animals on beef farms move primarily to other beef farms, and
4) the EDR for beef farms is, typically, much lower than for dairy farms and dairy support properties (Table 4).

The EDR for the different business types was estimated from data contained in the Animal Response Database and is presented in Table 4. We can, therefore, hypothesise that we are in a less concerning situation than if the majority of risk events were being traced off dairy farms. Spread from beef properties is very low, with the exception of 'traders' that accumulate cattle from different locations and co-locate them before trading subsequently to beef farmers.

Table 4. Estimated 6-monthly dissemination rate (EDR) for the different business types; beef farms have a much lower EDR than dairy farms. The large difference between mean and median highlights the risk of a 'super-spreader' (a highly connected farm that trades large volumes of cattle regularly).

	Count of farms	mean	median	min.	max.	range
Beef	30	0.04	0	0	0.6	0.6
Calf rearing	10	0.5	0	0	3	3
Milking	24	1.5	0.3	0	8	8
Dairy support	12	0.5	0.3	0	1.5	1.5
Total	76	0.65	0	0	8	8

However, it must be acknowledged that:

- we have very limited numbers of Confirmed Properties to calculate the historical EDR;
- dairy farms constitute the majority of Urgent properties in the backlog;
- single farms can be highly influential and are, at this point, not known. The presence of even a single 'super spreader' dairy farm in the 'backlog' could create a large amount of forward spread. For example, the maximum EDR in dairy in the Response was 8. This means that in 6 months, one 'super spreader' could infect 8 additional farms.

In conclusion, administrative delays must be removed and large volumes of Casing, Tracing, and Screening work (delimiting phase) completed within appropriate time frames to stop onward spread. The Technical Advisory Group reported that delimiting would be complete by mid-2020. Even if administrative delays are now removed, Tracing and Casing work could be extended if there

were calves that were not traced and left properties during 2018-19. These are not likely to be detected until such time as they calve and are found by bulk tank milk surveillance.

REMEDIAL ACTION PLAN

A plan was presented to address the Casing backlog, with the aim of casing all 'backlog' properties by 17th May (this date was set to allow two weeks for the subsequent tasking and serving of NODs to meet the 1st June deadline). Additional staff were brought into the Response to undertake the additional work. Staff must undergo significant training before they can commence Casing. These additional staff were initially intended to case only Low and Medium priority properties.

On April 30th, we established that the estimates used to calculate the number of properties that could be cased before the deadline was overly ambitious. Experienced Casing personnel can Case, on average, approximately 1 farm/day. MPI, therefore, adjusted the plan to facilitate casing all of the Urgent and High risk cases, as the first priority. All new staff of acceptable skill level were redeployed to work on the Urgent and High priority cases. The 309 High-risk properties identified during the course of this review will then be cased. Completion of the 800 Medium and Low risk cases became secondary in importance because of the much lower risk of disease spread, but will be completed after the Urgent and High Risk cases.

RESOURCING

To determine what level of personnel resourcing is required within the Disease Management team, a project plan for the next 6 months needs to be undertaken. However, there were an average of 9 Confirmed Cases/month for Tracing in January and February and these generated ~550 risk events each month for Casing. On the basis of these estimates, we estimate that the Response needs to resource:

- Tracing: 10 FTE (it takes one person approximately 1-2 weeks to Trace one Confirmed Property);
- Casing: 25 FTE (it takes one person approximately 1 day to Case one property resulting from the Trace;
- Epidemiology: 7 FTE (Two Principal Advisers (Strategic and Operational), three Senior Advisers (e.g. to manage national surveillance programmes, such as BTM surveillance), and two Advisers;
- Surveillance: 14 FTE (Surveillance undertake a range of roles, including generating boundaries of RPs, tasking out to the field, interpreting lab results, case evaluation, coordinating EDIR reports, etc).

Outside of the Disease Management Team

- Field surveillance: 90 FTE (This estimate was generated by Planning on 30th April, in response to the Surge. It is based on delivering testing within 15 days after a farmer is notified they are entering the Programme and completing 2 rounds of testing by the 19th of July; and on the assumption that AsureQuality (AQ) sampling teams consist of 3 people per team, and, on average, can sample 1 property per day). If a more phased approach to casing the Medium-Low properties, with inter-dependent tasks appropriately timed, this FTE requirement will probably be less.
- Laboratory: Processing of test results currently occurs at Wallaceville and AQ. Wallaceville can process up to 4,000 ELISA tests per week, and 2,000 PCR tests per week. AQ currently

processes 10,000 ELISA samples, of lower risk, per week; this can be increased by contractual arrangement (potentially up to 40,000/week). To ensure that Urgent and High properties are sampled and processed in a timely manner, investigating alternative options should be considered, including the use of AgResearch's Hopkirk facility or the deactivation of samples, so that PCR and ELISA analyses can be undertaken by approved commercial labs, and potentially sending ELISAs from higher risk groups to AQ.

Note: these resources are 'Total' and inclusive of what would have been regarded as 'business-as-usual' work.

RECOMMENDATIONS

Standards for good disease management practice

In the course of the review, we interviewed several experienced disease management experts and epidemiologists on what they believe would be Best Practice disease management for an eradication programme like this; from this, we recommend that:

- There are only 2 property classifications (Urgent and Routine);
- For Urgent properties, Tracing and Casing must be completed and appropriate movement controls applied within one month of confirming the presence of infection on the source farm (i.e., Confirmed Property);
- For Routine properties, Tracing and Casing and at least the first round of surveillance should be tasked within 4 months of confirming the presence of infection on the source farm (i.e., Confirmed Property);

These standards for good disease management can be reported against and could be used to assess resourcing needs.

Disease management experts also believe that it should be possible to get greater granularity in casing prioritisation than currently occurs. This would allow the Response to prioritise the most Urgent cases that will likely need movement control ahead of Routine cases to a greater degree than currently occurs.

MPI should aim to place movement control on the high risk properties traced from a Confirmed Property in less than a month, while the lowest risk could be managed to ensure movement controls and/or testing, if necessary, are undertaken within 4 months. This would greatly slow the spread of disease.

The current system uses: 1) production type (Dairy, Dairy Dry, Beef); 2) the type of movement (Forward Trace or Backward Trace); and 3) physiological state to assign risk.

- Forwards movements off a property in the risk period are a greater risk than movements adjacent to the risk period;
- Backward traces when the source farm is not known can be prioritised higher than back traces where a feasible source is known;
- Prevalence is expected to vary by production type and animal physiological state. Prevalence on milking platforms, feedlots, and calf rearer operations is expected to be greater than pastoral grazing systems (dairy-dry and beef) that are under considerably less physiological stress.

MPI have gained greater knowledge of factors contributing to the risk of spread during the course of the Response; this, along with their knowledge of farming systems and the individuality of the risk posed could be used to help better prioritise risk events needing Casing. These disease- and system-level risk factors, in addition to those already used, could help reduce the risk of forward spread. For example:

- farms could be further prioritised by taking into account the count of animals moved. A movement of 100 animals has a greater chance of including an infected animal than a movement of 10 animals, particularly for beef properties;
- the farming production calendar could be incorporated to address periods where the risk of animal movements off farm is greatest in the different enterprises, and in the different regions (i.e., movements off farm vary by time of year, enterprise type, and region).

Development of such a model is part of the *M. bovis* Strategic Science plan; the procurement process for this is underway. Successful development of such a model will enable a better system of prioritising risk events for casing, shortening the period from detection to forward movement for the most 'at risk' properties, particularly those with the highest prevalence that move the most animals most frequently and, therefore, present the most significant risk.

Measures and reporting that should be put in place

A subset of measures identified to help with disease management are outlined in Table 5, which has been distilled from a longer list used by epidemiologists (Appendix 3); these would, if reported against monthly, facilitate an oversight of disease management for Response Management and Governance and prevent a re-occurrence of an unacceptable 'backlog'.

Ways to improve efficiency, thereby accelerating eradication and reduce expenses

Development of a six month project plan

A project plan, with all tasks, inter-dependencies, and resource requirements for the next 6 months should be developed in the next month and reported against.

Greater power should be provided to regional teams to make changes on affected farms (e.g., boundary re-adjustment, stock purchases).

Partnering with others

The technical and operational expertise, human resource, and other capability within milk companies (for dairy), GIA partner organisations, Federated Farmers, and NZVA is currently underutilised and could be of considerable benefit to the Response. Opportunities for greater connection with these organisations and others should be investigated and leveraged where practicable.

Table 5. Metrics proposed by disease management experts to facilitate an overview of disease management and operational performance.

Disease investigation process measures	
Tracing	Number Confirmed Properties (CP) with tracing not complete
	Proportion of incomplete tracing completed (%)
	Tracing capacity (CPs per person week)
	Number of Tracing personnel
Casing	Number of traced destinations not cased
	Casing capacity (herds per person/week)
	Number of Casing personnel
Screening	Number at-risk herds declared CPs
	Number at-risk herds surveillance complete
	Number at-risk herds surveillance underway
	Surveillance capacity (at-risk herds per quarter)
	Laboratory samples awaiting analysis;
Speed of control	Time from detection of CP to NOD for Urgent category properties (< 1 month)
	Time from detection of CP to testing for Routine category properties (<4 months)
Effectiveness of disease investigation	
	Tracing vs Bulk Milk (background surveillance)
Disease and Control measures	
	Cumulative Confirmed Properties
	Active Properties
	Cleared Properties
	Movement Control NODs (S122)
	Number of infected herds depopulated by herd type
	Incidence of all infected herds being depopulated by herd type
	Post-repopulation infections

CONCLUSIONS

In early April 2019, there was a 'backlog' in the disease management queue of the programme to eradicate *M. bovis*. In total, ~1,450 properties were in the queue on the 12th April; ~640 of these were Urgent-High risk properties that should have been Cased and appropriately managed earlier and ~135 were Medium-Low Risk properties that should also have been managed sooner under a recommended timeline for good disease management; ~600 were Medium-Low risk properties that were still within an acceptable timeframe for Casing and surveillance. Therefore, the total number of properties that should be considered as a 'backlog' is <900.

We recommend that, in the future, properties should be classified into either Urgent or Routine on the basis of a more granulated approach to assessing risk of disease presence and risk of disease spread. Following classification, good disease management practice needs to ensure that the time taken from identification of a confirmed case to movement control or the completion of first round of surveillance was no more than 1 month for Urgent cases and less than 4 months for Routine cases.

APPENDIX 1 - METHODS

In the course of the review, I utilised experts in social and biophysical sciences, data and disease management, and veterinary epidemiology to help me address the Terms of Reference provided by the Director-General.

We interviewed 8 domestic and international disease management experts to determine what 'best-practice' disease management would look like for something similar to *M. bovis***.** Using MPI data from the Response to date, I was able to compare their recommendations with current Response performance.

We interviewed 31 staff and contractors working in and outside of the *M. bovis* directorate to gain an understanding of when the 'backlog' originated, and when the existence and size of the 'backlog' was communicated and to whom.

We interrogated the Response database to ascertain the size and origin of the 'backlog' and, also, to ascertain whether communication of the size of the 'backlog' had been accurate.

APPENDIX 2 - DISEASE MANAGEMENT PROCESS

The process of disease management for the *M. bovis* Response is presented in Figure 1. It is a complicated process that targets places (properties) linked to Confirmed Properties via movement of animals, other potentially infectious material, shared boundaries, and/or operational oversight, to determine the potential spread of *M. bovis* both onto and off of Confirmed Properties.

Activities include:

- Tracing of detectable cattle movements onto and off the Confirmed Property;
- Case evaluation meeting (commonly referred to as a NOD meeting), in which tracing information is evaluated and prioritised by epidemiologists; this information is then passed on to Casing;
- Casing, whereby contact is made with the farmer to confirm cattle movements and verify farm data and other detail as necessary; and
- Surveillance and sampling. The Surveillance team review casing information and determine what level of on-farm surveillance is required, including whether a Notice of Direction should be tasked to be served. The Surveillance team also reviews lab results, and determines whether any subsequent testing, changes to property surveillance status, or if serving of a Restricted Place notice is required.

This sequence is not always linear. New information can cause existing properties to be interpreted differently and may make specific risk events more important. In such instances, the property will be re-examined at the case evaluation meeting and additional tracing and casing work and, potentially, laboratory diagnostics may be required.

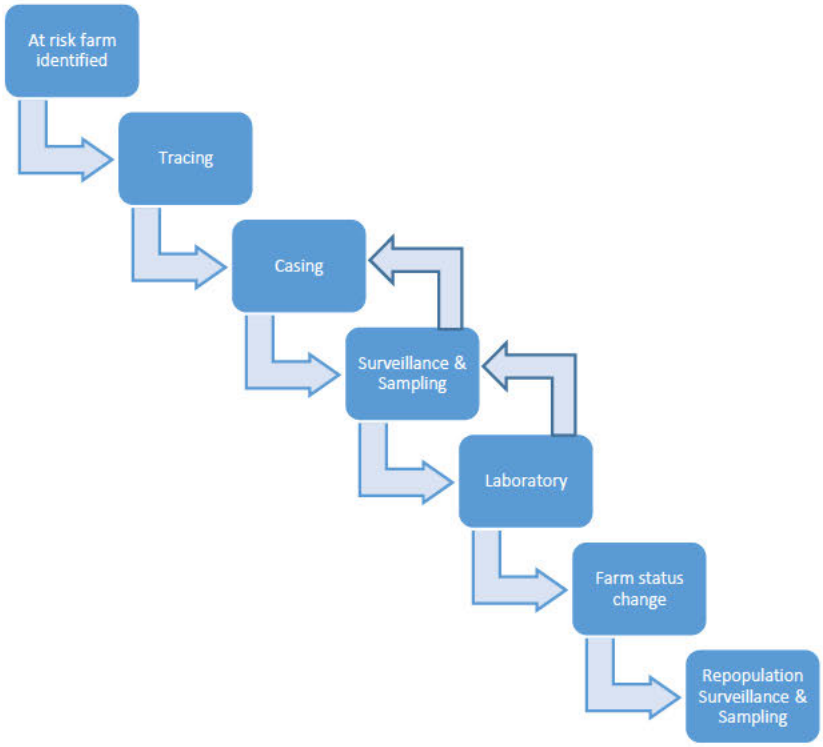


Figure 1. Overview of the disease management process

APPENDIX 3 – METRICS PROPOSED TO OVERSEE RESPONSE

Disease investigation process measures	
Tracing	Number of CPs with complete tracing
	Number CPs with tracing not complete
	Proportion of incomplete tracing completed
	Mean number of at risk herds per CP
	Proportion of movements traceable
	Estimated number of traced herds that will be set at-risk
	Proportion of risk movements that infect
	Tracing capacity CPs per person week
	Tracing personnel
Casing	Number of traced destinations not cased
	Casing capacity: herds per person/week
	Casing personnel
Screening	Report cases since start of programme
	Cumulative at-risk herds from movements
	Number at-risk herds declared CPs
	Number at-risk herds surveillance complete
	Number at-risk herds surveillance underway
	Surveillance capacity – at-risk herds per quarter
Speed of control	Infection to containment interval
	Containment to containment interval
	Infection to detection interval
	Detection to tracing complete interval
	Tracing complete to casing complete interval
	Casing complete to containment
	Detection to surveillance complete on all traces
Effectiveness of disease investigation	
	Known at-risk breakdowns vs unknown farm breakdowns
	Proportion of cases linked to the outbreak
	Number of properties infected after control
Disease and Control measures	
	Cumulative infected herds
	Estimated incidence since programme started
	Standing infected herds
	Period prevalence: 1 July 2018 to 1 June 2019
	Denominator: As at 30 June year preceding, the total number of herds by herd type
	Annual period prevalence, and number of infected herds at 30 June, by herd type
	Breakdown number, and likely cause of all new infected herds
	Number of infected herds being depopulated by herd type
	Number and rate of all infected herds depopulated by herd type
	Post-repopulation infections