Ministry of Agriculture and Forestry
Te Manatu Ahuwhenua, Ngaherehere

POST WEANING MULTISYSTEMIC WASTING SYNDROME

RESPONSE OPTIONS ANALYSIS

7 NOVEMBER 2003

Ministry of Agriculture and Forestry
National Centre for Disease Investigation
MAF Operations
Upper Hutt
New Zealand

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1 EXECUTIVE SUMMARY

On 4 September 2003 a suspect case of post-weaning multisystemic wasting syndrome (PMWS) was notified to MAF. On 8 October 2003 sufficient evidence had been obtained from the MAF lead investigation for the Technical Advisory Group to confirm the diagnosis of PMWS in New Zealand.

MAF Biosecurity requested development of a response options analysis as an aid to decision-making during the biosecurity incursion process. MAF NCDI was requested to perform the analysis.

The major assumption underpinning the MAF process is that the occurrence of PMWS in a New Zealand pig herd represents an incursion of New Zealand's biosecurity by an unwanted organism. The aetiology of PMWS remains controversial. The MAF Technical Advisory Group has considered this issue and concluded that there is presently insufficient evidence to conclusively demonstrate the validity of either of the two conflicting aetiological hypotheses. The first is that either a virulent strain or strains of porcine circovirus type 2 (PCV2) or another unrecognised agent causes PMWS, and that the recognition of PMWS in New Zealand reflects an introduction of such an agent. The second is that all strains of PCV2 are pathogenic, but the disease PMWS only occurs when infection coincides with the presence of other co-factors (both infectious and non-infectious).

It is important to note that PCV2 is endemic in both the North and South Islands of New Zealand. The entire validity of the MAF biosecurity response (investigation, initial phase response, response options analysis, and economic impact assessment) is predicated on the validity of the first aetiological hypothesis. MAF's policies would consider the process unnecessary if PMWS was caused by an endemic agent.

Eradication of PMWS is considered only briefly. The conclusion is that the current state of knowledge regarding PMWS aetiology, epidemiology and diagnosis make eradication not technically feasible.

Containment options are considered. The objective is to slow the spread of PMWS in New Zealand, thereby mitigating disease impacts. Management of case farms by retaining movement control or by depopulation and decontamination are considered as alternative options. Other non-mutually exclusive options for containment include protection of zones, in particular the South Island, through movement controls on risk goods, and protection of strategically important establishments, through measures such as improvement to farm biosecurity and use of buffer zones. The value of the containment options in slowing spread of PMWS is considered with respect to the conflicting aetiological hypotheses.

Surveillance options are considered. The objective is to understand the spatial and temporal distribution of cases in New Zealand. Importantly, it must be understood that the investigation of farms linked by movement of risk goods to the case farm does not provide a comprehensive understanding of present distribution of PMWS in New Zealand. If endemic PCV2 is the cause of PMWS, the methods used to date have not attempted to determine the distribution of PCV2 in New Zealand. Previous (limited) studies suggest it is endemic in both the North and South Islands. If a recently introduced agent is the cause of

PMWS, investigation methods lack sensitivity and specificity. The hypothesised entry pathway is through imports of pig semen. Back tracing along this pathway has found no evidence of PMWS. Pigs and semen likely to have been exposed to the introduced agent have probably been distributed widely in the industry. The apparent lack of other cases in the industry can be taken as indicating evidence against the introduced agent hypothesis, lack of sensitivity of detection methods, or the importance of co-factors in disease manifestation (regardless of necessary causes).

In light of these difficulties, enhanced passive surveillance run prospectively presents the most efficient means of understanding distribution of PMWS in New Zealand. This understanding could be enhanced through application of longitudinal survey methods, by establishing a cohort of farms to be closely observed over time. This is further discussed in the research section.

Diagnostic capability to support PMWS diagnosis is discussed. Confirmatory test methods include immunohistochemistry (IHC) and in-situ hybridisation (ISH). These are immuno-staining methods that rely on histo-pathological specimens and experts. MAF concludes that IVABS, Massey University, is best placed to develop these methods to provide a specialist diagnostic service to industry. MAF and/or the pig industry could provide assistance to Massey for set up costs. Ongoing provision of the service could be on a cost recovery basis, depending on who submits the samples. The cost of testing is therefore built into the surveillance and survey costings.

Research proposals are also considered. A genotyping study and a pathotyping study for PCV2 are proposed. The objectives are to understand the origin and relationship (genetic and pathological) of New Zealand PCV2 isolate to overseas isolates. An epidemiological study has been proposed with the objective to determine whether PMWS behaves as a propagating epidemic in New Zealand, which would provide supporting evidence for causal theories that require introduction of a novel agent. This issues has been the subject of much uncertainty internationally, during development of New Zealand import health policy, and during the investigation and response to the occurrence of PMWS here.

Table 1 presents a summary of the options and estimates of associated costs.

Table 1. Summary of options and ballpark estimates of associated costs

Option	Cost
2. Eradication	Not considered
3. Containment	
3.1 Case farms	
3.1.2. Maintain under movement control	$139,000 MAF costs, plus marginal production losses to affected farmers: $-5-35,000 for a 100 sow finishing enterprise.
3.1.3. Depopulate and decontaminate	$135,000 MAF costs, including compensation, plus marginal production losses to affected farmers: $44-174,000 for a 100 sow finishing enterprise.
3.2. Zone protection of South Island	$60,000 for year 1, thereafter $20,000 annually
3.3. Compartment protection of nucleus farms	$10,000 for development of guidelines. $160,000 per farm worst case.
3.4. Risk management for imported semen stocks	Tracing imported semen $10,000. Destruction of stocks and compensation: $50-200,000
4. Surveillance	
4.1. Enhanced passive surveillance	$15,000 set up. Case farm investigation @$1,000 per farm (estimate 30 farms per year: $30,000)
4.2. Diagnostic capability	In-situ hybridisation at Massey Univeristy: $82,000
5. Research	
5.1. Genotyping study	$35,000
5.2. Pathotyping study	$50-75,000
5.3. Epidemiological study	$53,200

2 ERADICATION

The following preconditions and criteria for successful eradication campaigns have been recognised:

- There should be a control measure completely effective in breaking transmission, simple in application and relatively inexpensive
- The disease should have epidemiological features allowing timely and effective case detection and surveillance in the advanced stage of the program
- The disease must be of recognized national or international socio-economic importance
- There should be a specific reason for eradication rather than control of the disease
- Resources: finance, administration, manpower, veterinary or medical services, budgets, contingencies, political stability
    - semi-autonomous organization relatively unbound by bureaucratic procedures
    - training programs for staff - adequate remuneration - performance standards and adequate coverage
- Socio-ecological conditions - population movements, migration, cultural sensitivities

(From P.Yekutiel, *Eradication of Infectious Diseases - A critical study*. In: Contributions to Epidemiology and Biostatistics, 1980, S.Karger.)

The current state of knowledge for PMWS indicates major constraints associated with the first two criteria.

This fact was recognised by the PMWS Technical Advisory Group during the second meeting on 23 October 2003. The TAG specified that an eradication option need not be presented.

3 CONTAINMENT

3.1 Case farm management

3.1.1 Summary

At the time of writing there was only one place with confirmed PMWS. Options for containment of infection on this place are identified and analysed. The effectiveness of the methods depends largely on the cause of PMWS on the index farm.

Four ***causal hypotheses*** are:

- Hypothesis A - PMWS on the index farm was caused by endemic PCV-2 due to the presence of initiating factors and viral cofactors. The disease is sustained by sustaining husbandry factors and high PCV-2 contamination.
- Hypothesis B - PMWS on the index farm was caused by a non-endemic strain of PCV-2 introduced by boars or gilts derived from imported semen, in combination with husbandry and endemic viral co-factors .
- Hypothesis C - PMWS on the index farm was caused by a non-endemic viral cofactor introduced by boars or gilts derived from imported semen, in combination with endemic PCV-2, other endemic viral cofactors, and the husbandry.
- Hypothesis D – PMWS on the index farm was caused by a unique mutation of endemic PCV-2 in combination with husbandry and endemic viral co-factors.

At this stage of the investigation it is not possible to assign probabilities to these hypotheses.

There are three ***containment options*** for the index case and other subsequent cases:

- Containment by Restricted Place Notices in accordance with section 130, Biosecurity Act, 1993.
- Containment by depopulation in accordance with section 109 of the Biosecurity Act
- No MAF or industry control measures.

Table 2 shows effectiveness of containment methods on the factors, co-factors and consequences of each causal hypothesis with reference to known status of the affected farm and other farms. From the table it is possible to demonstrate that none of the control methods completely deal with all the factors, co-factors or consequences associated with any of the hypothesised causes, however they may reduce the extent to which they impact pig producers.

Table 3 illustrates costs to MAF and owners of affected farms under containment by depopulation, using movement control via Restricted Place Notice, or with no action. The example used is an affected place with 100 sows. Costs to MAF of containment by Restricted Place Notice or depopulation are similar. The least cost to the farmer was the depopulation option. Assumptions used in these estimates include:

- PMWS does not reoccur on the place after depopulation.
- Restricted Place measures were applied for one year. During this time the driveway and conveyances entering and leaving the place require decontamination. A restricted place manager would oversee this movements and decontamination. Replacement of sows would be prevented, possibly reducing litter sizes by 10%, requiring compensation for loss of income associated with this restriction.

- Depopulation occurs over a three month period and is followed by decontamination of the place. No allowance was made for any fallow period or repopulating other than the cost of stock. Compensation[1] is paid for the marginal losses associated with slaughter of sows and boars. The capital value of sows and boars per sow was estimated at $280.
- Pig production economic parameters were based on the following margin per sow (pers.comm. Chris Ward MAF Policy), excluding indirect costs, for varying levels of weaner production:

100% weaner production	$1518
90% weaner production	$1,079
80% weaner production	$639
70% weaner production	$216
60% weaner production	-$224

- The effect of PMWS was considered at 10%, 20% and 30% weaner deaths.

[1] Where MAF uses powers for the restriction or destruction of an unwanted organism, provisions is made in section 162a of The Act for compensation.

(1) Where-
(a) Powers under the Act are exercised for the purpose of the management or eradication of any organism; and
(b) The exercise of those powers causes verifiable loss as a result of -
(i) The damage to or destruction of a person's property; or
(ii) Restrictions, imposed in accordance with Part VI or Part VII, on the movement or disposal of a person's goods, -
That person is entitled to compensation for that loss.

It should be noted that the compensation is not made for the effect of the unwanted organism, but rather for the loss associated with the use of powers.

Table 2. Table showing the effectiveness of movement control, depopulation and zone controls on the agents cofactors and consequences of three causal hypotheses for PMWS with reference to what is known about the status of the affected farm and other farms .

Causal hypotheses		Factors, co-factors and consequences	Affected farm status	Other farm status	Restricted Place Notice contains?	Depopulation contains?	Zone policy contains?
A	Agent	Endemic PCV-2	y	y	n	n	n
	Co-factors	Initiating factors	y/n	?	n	n	n
		Sustaining factors	y	y/n	n	n	n
	Consequence	High levels of endemic PCV-2 on farm	y	n	y	y	y
		Endemic PCV-2 in product	y	?	n	n	n
		High levels of endemic PCV-2 in live pigs	y	?	y	y	y
B	Agent	PCV-2 in imported semen	y?	y?	n	n	n
		Non endemic PCV-2 strain on farm	y?	y?	y	y	y
	Co-factors	Initiating factors	y/n	?	n	n	n
		Sustaining factors	y	y/n	n	n	n
	Consequence	High levels of non-endemic PCV-2 on farm	y?	n?	y	y	y
		Non-endemic PCV_2 in infected farm product	y?	y?	n	n	n
		High levels of non-endemic PCV-2 in live pigs	y?	n?	y	y	y
C	Agent	Non endemic viral cofactors in imported semen	y?	y?	n	n	n
		Non endemic viral cofactors on farm	y?	y?	y	y	y
	Co-factors	Initiating factors	y/n	?	n	n	n
		Sustaining factors	y	y/n	n	n	n
	Consequence	High levels of endemic PCV-2 in pigs	y	n	y	y	y
		Endemic PCV-2 in product	y	y	n	n	n
		Non endemic co-factor in product	y?	y?	n	n	n
		Non-endemic co-factor in live pigs	y?	?	y	y	y
D	Agent	Unique genetic variant of PCV-2 on farm	?	n	y	y	y
	Co-factors	Initiating factors	y/n	?	n	n	n
		Sustaining factors	y	y/n	n	n	n
	Consequence	High levels of unique variant PCV-2 in pigs	y?	n	y	y	y
		Variant PCV-2 in product	y?	n	n	n	n
		Overseas market access requirements*			n	n	n

Key to Table 2

Hypothesis A -That PMWS was caused by endemic PCV-2 and has occurred due to the presence of initiating husbandry factors and possibly viral cofactors. That the disease is sustained by the presence of sustaining husbandry factors or high PCV-2 contamination

Hypothesis B - That PMWS was caused by a non-endemic strain of PCV-2 and has occurred through the introduction of imported semen and the husbandry factors on the farm.

Hypothesis C - That PMWS was caused by a non-endemic viral cofactor in combination with endemic PCV-2, other endemic cofactors and the husbandry factors on the farm.

Hypothesis D – That PMWS arose from a unique mutation of endemic PCV-2

Initiating factors - Factors that initiate PMWS may not be required to sustain it as levels of contamination of PCV-2 increase. Initiating factors could be exposure of naïve animals to PCV-2, husbandry factors, the introduction of a new co-factor etc.

Sustaining factors - PMWS may be self-sustaining despite changes in management practice due to high levels of contamination, or the presence of endemic viral co-factors.

Overseas market access requirements – There are no requirements identified in relation to causes A, B,or C, however in the case of a unique variant of PCV-2, there may be requirements that no product from places under official control be exported, in which case the Restricted Place and depopulation policies would require modification to ensure local destruction or local consumption of product.

Table 3. Table of costs to MAF and to the owner of an affected place with 100 sows under containment by depopulation and Restricted Place Notice or with no action.

		Depopulation	Restricted Place Notice	No action
MAF costs				
Decontamination costs		$50,000	$40,000	$0
Inspectors costs		$15,000	$40,000	$0
MAF management costs		$15,000	$15,000	$0
Compensation				
Capital		$28,012	0	$0
Loss of income (10% mortality)		$26,972	43,944	$0
Total MAF Costs		**$134,984**	**$138,944**	$0
Pig production margin	**$ per sow**	**3 month loss**		
Normal weaner production	$1,518	$37,958	$151,832	
90% weaner production	$1,079	$26,972	$107,888	
80% weaner production	$639	$15,975	$63,900	
70% weaner production	$216	$5,397	$21,590	
60% weaner production	-$224	-$5,600	-$22,400	
Farmer loss of income				
Normal weaner production		$37,958		
90% weaner production		$26,972	$43,944	$43,944
80% weaner production		$15,975	$87,932	$87,932
70% weaner production		$5,398	$130,242	$130,242
60% weaner production		-$5,600	$174,232	

Assumptions and parameters of Table 3 were:

1 The analysis concerns a 100 sow finishing operation.

2 The Restricted Place Notice:
- Applied for a period of 12 months
- Involved decontamination of driveway and conveyances costs of $40,000
- Involved inspection costs of $40,000
- Involved MAF management costs of $15,000
- Prevented replacement gilts costing the equivalent of 10% weaner deaths
- Required compensation for loss of income associated with movement restrictions.

3 Depopulation, decontamination and repopulating:
- Occurred over a 3 month period
- Involved decontamination costs of $50,000
- Involved inspection costs of $15,000
- Involved MAF management costs of $15,000
- Required compensation is for capital value of sows and for loss of income associated with disruption of business.
- Did not require a fallow period of incur repopulating costs other than stock.

4 Pig production economic parameters were based on the following margin per sow (excluding indirect costs) for these levels of weaner production

100% weaner production	$1518
90% weaner production	$1,079
80% weaner production	$639
70% weaner deaths due to PMWS	$216
60% weaner production	-$224

5 Effect of PMWS is considered at 10%, 20% and 30% weaner deaths

6 Capital value of sows and boars per sow was estimated at $280

3.1.2 Movement Control

Objective

Apply movement control through the use of Restricted Place Notices in order to:

- Contain the affected place until such time as the aetiology and national prevalence and distribution of PMWS has been established and policy of infected places is reformulated.
- Contain the disease until depopulation and decontamination are undertaken.

Restricted Place Notices are used to contain infectious unwanted organisms. Their use implies causal hypotheses B C or D, or a desire to limit exposure of other herds to high doses of endemic PCV-2 associated with under hypothesis A. The restrictions and conditions would be ineffective in preventing exposure to other farms in the case of B and C as the means of infection of the index case implies that other places have been and are being exposed to the same exotic agent.

As there is no resolution of the health status of a place with PMWS a Restricted Place Notice could only be seen as delaying the spread of disease.

Measures required

i. Specify risk goods

Infection is assumed to occur by sexual, oral or respiratory routes. PCV-2 is present in most excretions with high excretion in respiratory and faecal excretions and semen. Transmission mechanisms between farms would be with the regular introduction of sows, and the introduction of boars or infected semen. Some transmission may occur if pigs are exposed to and ingest infected material such as pig products, manure or feed.

The relative risk of disease transmission with movement of various conveyors is not quantified. It is assumed that they fall in the following risk categories:

- High-risk conveyors - live pigs, dead pigs, porcine genetic material,
- Medium risk conveyors - pig products, conveyances and pig manure.
- Low-risk conveyors - other animals; pig equipment; animal feed.
- Nil or near nil risk conveyors - people and other species of animal.

Infected places are likely to have a high degree of environmental contamination, as PCV-2 is very stable. PCV-2 can resist 60ºC for 30 minutes and survive in a range of pH from 3 to 9. PCV-2 can be inactivated by cleaning and disinfection with Virkon at 1:100 dilution.

PMWS has been present on the index place since mid-late 2002. As the index place sends pigs only to slaughter, investigation has provided no empirical data on the risk posed to other pig farms by the movements of conveyors from infected places. The finishing operation on the index place has not apparently spread PMWS in that period.

ii. Specify restrictions and conditions

Restrictions and conditions can be placed on the removal of high, medium and low risk conveyors and on the conveyances used to move them. Removal of conveyors can be permitted provided that the conveyor or conveyance does not subsequently come into contact with other pigs, or in such cases the conveyor and conveyance have been treated (cleaned and decontaminated) to inactivate PCV-2.

Permission could be given to remove:

- Pigs directly to slaughter (not via a saleyard) at an approved abattoir under the supervision of an inspector or authorised person., on condition that all the pigs are slaughtered, vehicles are cleaned and disinfected before and after use, and product is managed in accordance with overseas market access requirements. Allowing pigs to go to slaughter does not mitigate the risk of oral infection of pigs consuming garbage that contains infected pig product derived from infected places. This risk is not quantified. To mitigate this risk treatment condition on product would be required after slaughter.
- Medium and low risk conveyors on condition of treatment to inactivate PMWS agents or a demonstrated nil risk of contact with other pigs, and under the supervision of an inspector or authorised person.

Restrictions and conditions can be placed on the introduction of conveyors and conveyances to the infected place. Where the fate of the infected herd may be depopulation it is not desirable to allow pigs to be introduced. Conveyances should be thoroughly cleaned before entering the place to make decontamination after use feasible.

Benefits

i. Owner of an infected place

There are no benefits to the place under Restricted Place Notices as the disease can only be eliminated by depopulation. Compensation does not cover the cost of the disease, but rather verifiable losses associated with the restrictions.

ii. Other pig producers

Industry may be protected from the impact of the disease at the farm level by the prevention or retardation of disease spread. Containment may slow the spread of the disease by preventing dispersal sales and placing conditions on routine movements. A short-term benefit may be to contain the disease on known infected places until the aetiology, prevalence and distribution of PMWS is known, at which point a decision to stamp out the disease or do nothing could be made. However, surveillance for the disease is of low sensitivity and its true distribution may never be known.

If hypothesis A is the cause then restrictions in this situation may prevent exposure to large amounts of endemic PCV-2 virus rather than the PCV-2 *per se* and may prevent the clinical expression of disease in other herds.

iii. Exporters of pig products

There are no identifiable trade benefits from a Restricted Place containment policy.

iv. The public

In that there are no identifiable human health risk associated with PMWS, there are no identifiable benefits to the public. The public is unlikely to feel protected by a policy that does not control the use of product from infected places.

v. Animal welfare

There are no animal welfare benefits from containment by Restricted Place Notice, as the disease will still occur.

Risks/constraints

i. Disincentives to reporting

Containment is not ethical unless there are means of obtaining revocation of the Notice, such means would be:

- A planned review of policy at a given time, when more is known about the national prevalence and distribution of PMWS and policy for infected places can be reformulated.
- The option of depopulation, decontamination and repopulation.

If there is no reasonable exit strategy for restricted places, the policy could result in non-reporting of disease.

ii. Disruption to management

Containment by Restricted Place Notice would require breeding farms to implement a major change in the farming operation to finishing only. On these farms the economic impact of a slaughter only policy may be greater than depopulation, decontamination and repopulation. Only short-term containment to allow time for decision making is feasible.

iii. Compliance

Owner compliance with the provisions of the notice is assumed. If compliance can not be assumed gate control would be required.

Cost

Table 3 examines the costs of each containment measure.

3.1.3 Depopulation and decontamination

Objective

Reduce infection pressure by depopulation and decontamination of case farms.

Measures required

i. Depopulation

Immediate removal to slaughter of breeding animals. Slaughter of young stock after finishing.

ii. Decontamination

Infected places are likely to have a high degree of environmental contamination. Decontamination involves the disposal of dirt, feed, manure, and items that can't adequately be decontaminated. All surfaces must be cleaned and subsequently disinfected. All disinfectant must be removed by washing, and all equipment reinstated to its form place and condition.

Appendix I provides further detail of methods.

Benefits

i. Owner of an infected place

Depopulation is economically the best solution for the owner, if the assumptions associated with Table II are valid and the disease does not reoccur.

ii. Other pig producers

Depopulation does reduce the potential infection pressure (by dispersal sale) from the index place under all hypotheses.

iii. Exporters of pig products

There are no identified benefits under hypothesis A B or C, because infection should be assumed to already be widespread in the New Zealand pig industry. Depopulation may be beneficial for exporters under hypothesis D.

iv. The public

Depopulation has no identifiable benefit to the public.

v. Animal welfare

Depopulation does prevent the ongoing disease syndrome and may be seen to have some ascetic and welfare benefits.

Risks and constraints

i. Infection may already be widespread

If infection with the causal agent of PMWS is already widespread in the New Zealand pig population, depopulation results in only an incremental reduction in infection pressure. The proportional value of the incremental reduction cannot be quantified.

ii. Consumer perceptions

Consumer perceptions of pigs and pig meat products may be negatively affected by publicity regarding slaughter of pigs from infected farms. Domestic and international markets may be affected by these perceptions.

Cost

Table 3 examines the costs of each containment measure.

3.1.4 No containment action

A case for taking no action could be made under hypothesis A B and C. In the case of A, the agent is ubiquitous and management factors should be the focus of any measures. In regard to B and C, the presumptive method of entry is through semen importation. The ongoing importation of semen and its wide dissemination through the pig industry could lead to the conclusion that any imported agent is already widely distributed.

Appendix I Depopulation and decontamination processes

(adapted from AusVetPlan)

DEPOPULATION

All breeding ceases and the adult stock be slaughtered, young stock can be grown out.
The carcases of pigs that died or were killed are to be processed or destroyed under official supervision;
semen, ova and embryos of pigs collected from the holding during the period between the probable introduction of disease into the holding and the taking of official measures shall be traced and destroyed under official supervision in such a way as to avoid the risk of spread of classical swine fever virus;
all substances and waste likely to be contaminated, such as feeding-stuff, must be subjected to a treatment; all single-use materials which may be contaminated, in particular those used for slaughter operations, should be destroyed; these rules shall be applied in accordance with the instructions of the official veterinarian;
after the pigs have been disposed of, the buildings used for housing the pigs, the vehicles used for transporting them or their carcases and the equipment, bedding, manure and slurry likely to be contaminated shall be cleaned and disinfected or treated

Slaughter
Should slaughter of animals be required on an infected place. The method of slaughter will be complaint with the relevant code of recommendations and minimum standards for the emergency slaughter of farm livestock. These documents may be found listed on the MAF animal welfare group website at:
http://www.maf.govt.nz/biosecurity/animal-welfare/codes/emergency-slaughter/emergency-slaughter.pdf.

DECONTAMINATION

Preliminary disinfection
Preliminary disinfection of the roadway for entrance an exit and overflows of animal effluent is required to rapidly reduce the amount and distribution of the infective agent on the infected place up to the time of the completion of slaughter and disposal when thorough disinfection can be undertaken.

Clean-up process
Removal of all manure, dirt and debris and contaminated articles that cannot be disinfected is required. The surfaces of all buildings, pens, fittings and equipment must be exposed ready for the first disinfection. This is the most important phase in the decontamination procedure because the presence of organic material reduces the effectiveness of disinfectant. Encrusted dung, dirt and grease shield the underlying permanent surfaces from the effect of the disinfectant. The easiest method of disposal of solid and semi-solid faecal material is burial.

All old insulation material (polystyrene, fibreglass and press boards) is removed for burial or burning unless they have sound impervious surfaces which can be effectively decontaminated. All unsound, rotten and underrun wooden fittings and flooring and other

structures which cannot be effectively disinfected should be removed for burning or burial. All fixtures and fittings should be dismantled and stacked for cleaning and disinfection. All delicate electronic equipment must be protected for later specialist treatment.

Earthen floors in buildings may need to be broken up and soaked in disinfectant. Concretions and encrustations of material on permanent surfaces are removed. Particular attention should be paid to corners and wall/floor junctions. The surfaces are then washed down using a high pressure system and plain water. All permanent surfaces must be free of visible contamination. All feedstuff considered contaminated must be removed and buried after valuation. Feeding and water troughs are emptied and cleaned out.

First full disinfection
The aim of the first disinfection is to inactivate the disease agent using physical and chemical agents. This process must be carried out in a systematic fashion to ensure that areas which have been disinfected are *not* recontaminated by people or machinery. A recommended order of cleaning is: roof – wall – floor, and this should be adopted in each building. When the disinfection of each building or area is completed it should be cordoned off with marking tape. Once an area is dry it will not be obvious where the disinfected area starts and finishes.

First inspection
The aim of the first inspection is to ensure that all tasks which were detailed on the property assessment have been performed. Important aspects to be checked are that:
all contaminated woodwork not able to be cleansed and disinfected has been completelydisposed of;
all fixtures and fittings have been dismantled where appropriate so that no organic material is left behind them;
there are no observable encrustations on any exposed surface;
all contaminated feedstuff has been destroyed, and remaining material made safe;
all grossly contaminated sites (slaughter and disposal) have been effectively cleaned and disinfected;
all fluid that has been disinfected has been released into drains or septic tank;
the conditions of quarantine, especially at exit/entry points, and warning notices are being maintained.

Preparation for second disinfection
There can be a potential residue of contamination particularly under old cracked concrete and under rundown buildings. Areas of underrun or loose concrete should be examined carefully and a cost assessment made whether they are to be re-rendered, repaired or the area destroyed. Earthen pathways and walls of animal houses which are constructed of porous brickwork or ‘breeze block’ should be similarly inspected and assessed. If repair/re-rendering work is done, a written agreement with the owner on the work to be done must be obtained before any work is commenced.

Second full disinfection
The work detailed must be finished or in such an advanced stage of progress that it will not hinder the second disinfection process. The second disinfection is a repeat of the first and can be started approximately 14 days after the first disinfection, depending on the disease agent involved and provided no rendering work needs to be done.

Final inspection
This inspection is carried out in the same way as the first inspection. The premises must be meticulously inspected preferably by an experienced officer not previously involved in an earlier inspection. If there are any doubts, then work must be repeated. All equipment and personnel are finally disinfected at the decontamination site before removal. If the final inspection is satisfactory, reconstruction work can be carried out and the premises made re-habitable for stock. The premises are left empty for a prescribed time before restocking with sentinel animals, depending on the specific disease strategy.

Restocking sentinel animals (if required)
Sentinel animals may be allowed back into the premises at a time determined in accordance with the relevant disease strategy. They must come from a disease-free area of the country. The sentinel animals will be housed in those areas that had the highest degree of contamination. The vehicle and driver will be disinfected when leaving the receiving property. This is because the driver may have further contact with other animals and if there has been any breakdown in decontamination, the consequences would be serious. The animals will require regular clinical inspection. The officer doing the inspection must disinfect off the premises at each visit. If there is no sign of disease at the end of the sentinel period, the premises are declared free of disease and quarantine lifted, depending upon any local disease control measures in force at the time.

CONVEYANCE DECONTAMINATION

Contaminated cars, livestock, animal feed or product haulage vehicles with their drivers carry a disease dissemination risk. No vehicles leave the infected place without thorough decontamination. Vehicles can be divided into four broad categories, those that:

- do not need cleaning and disinfection;
- need the wheels cleaned only;
- need the outside cleaned only; and
- need both outside and inside cleaned.

Cars
Any rubber floor mats on the driver's side should be removed for scrubbing with disinfectant. The dash board, steering wheel, handbrake, gearstick and driver's seat should be wiped liberally with appropriate disinfectant. If the boot *is considered contaminate*d, the contents must be removed and the interior of the boot wiped with disinfectant. The contents of the boot must be treated similarly before being replaced. The wheels, wheel arches and undercarriage of the car should be sprayed with disinfectant — NOT plain water. The vehicle wheel arches, wheels and bodywork should be sprayed with a non-paint corrosive disinfectant. Plain water is not to be used with power hoses because the process will release contaminated aerosols of the pathogen. A mixture of disinfectant and water should always be used with power hoses. Cleaning heavily contaminated vehicles would only be done on the infected rural IP as most cleaning processes, including power hoses, spread the infectious agent. Cleaning using disinfectant/soap and water with *brushing* to dislodge encrusted dirt and organic matter is preferable to washing with strong water streams. Caustic soda should not be used on paintwork.

Livestock vehicles
All solid debris should be removed from trailers and the like. The vehicle is then soaked in disinfectant using a detergent, and scrubbed down to bare metal or wood. When the crate

structure of the trailer has been decontaminated, the crate should be lifted free from the body, the undersides of the stock crates and where the crate was sited on the trailer, decontaminated. The vehicle must be closely inspected to identify if there is a double layer. If this is so, the top layer of metal tread plate or wood must be removed to reach areas where contaminated material could be trapped. Any metal flooring which appears solid must be weight tested to ensure welding is not cracked and that there is no rubbish under the flooring. Some trailers may carry extra equipment under the body — this must be treated. The outside dual wheels and spare wheels must be removed to ensure:

- adequate decontamination of wheel hubs; and
- to inspect the spare wheel hangers which can be of hollow construction and therefore could hold contaminated material.

The driver's cabin and, where fitted, the sleeping compartment must be thoroughly cleaned and decontaminated. Enquiries should be made of the driver as to what clothing and boots s/he was wearing when in contact with suspect stock. These articles must be identified, decontaminated and arrangements made for dry cleaning where applicable. All animal faecal matter and bedding must be removed. All water, feedstuff and litter carried in the vehicles must be disinfected and burnt or buried. All fixtures and fittings must be dismantled to ensure that infected material has been removed. All surfaces must be cleaned down to metal and then disinfected. Any wooden surfaces must be cleaned and disinfected where appropriate or valued before removal and destruction. The wheels, wheel arches, bodywork and undercarriage must be cleaned of detritus and disinfected. The drivers cabin and sleeping compartments also need to be cleaned and disinfected. It is common practice for specialised vehicles to be self-contained with water, food and litter supplies for the animals. If the vehicle is known to have carried diseased or suspect stock, then every effort should be made to identify the area of disposal of these materials if they have been removed before departmental officers have identified the vehicle as being contaminated. Once identified, these materials must be disinfected and disposed of by burial or burning.. For any vehicle known to have carried stock susceptible to the disease organism, the principles of vehicle and trailer decontamination are the same.

Animal feed delivery vehicles

The path of the vehicle through the place must be traced and the degree of contamination of vehicle and driver ascertained. When a suspect vehicle has been detained, decontamination will require removal of all encrusted material in wheel arches, wheels and the underside of the body, and depending on the degree of contamination of the driver, his or her clothing, boots and cabin. Residual food material in the vehicle must be sprayed with disinfectant and removed for disposal. The inside of the bulk trailer must be decontaminated with approved disinfectant. Wherever practical, animal feed should be delivered to the outer limits of the property and then transferred to the animals without the vehicle or driver of the delivery vehicle becoming contaminated.

3.2 Zone protection

Objective

Protect the South Island from PMWS.

Measures required

i. Statutory support

Declaration of a Controlled Area under section 131 of the Biosecurity Act. The Controlled Area would be the North Island. High risk movements (pigs, pig semen) from inside the Controlled Area to outside would be prohibited, except by permission from the controlling authority.

ii. Industry support

Zone protection would only work with the full support and endorsement from the major stakeholders. The Pig Industry Board and the New Zealand Pig Breeders Society represent most New Zealand pig farmers. These agencies would need to promote the measure to farmers and request assistance in monitoring compliance.

iii. Transport operators

Transport companies (road, rail and shipping) would be made aware of the prohibition on movements. Implementing restrictions and monitoring compliance of live pig transports would be relatively straighforward. Transport of frozen or cooled semen might be more difficult to monitor.

iv. Compliance monitoring

Dedicated staff with appropriate authority are not considered necessary. MAF or other staff with appointments under the Biosecurity Act could make periodic compliance checks such as audit of freight company records.

v. Risk management for permitted movements

Measures consistent with those applied to import pigs and/or pig semen from countries where PMWS occurs could be applied to allow movements from North Island to South Island. The Controlling Authority would be required to issue movement permits and to monitor compliance with the required measures.

It should be noted that the appropriate level of protection from PMWS during importation of pig semen has been under consideration by MAF since prior to the recognition of PMWS in New Zealand. The matter has caused some controversy and opposing views have been expressed. The measures applied to imports into New Zealand and to the South Island would need to be consistent.

vi. Time period

The measures would remain in force until PMWS was confirmed in the South Island. Enhanced passive surveillance and suspect case investigation would be required.

Benefits

i. Protection from PMWS

The primary purpose of the measure is to protect the South Island from PMWS, thereby preventing the economic losses associated with the disease.

The ability of the measure to meet this objective is uncertain. See the discussion under Risks/Constraints below.

ii. Minimal disruption to slaughter pig and pig meat domestic trade flows

Pigs produced in the north of the South Island are slaughtered at meat processing plants in Wanganui and Levin, crossing by ferry two to three times weekly. There is no movement of live pigs from the North Island farms to meat processing plants in the South Island.

Most pig meat products produced in the South Island are destined for North Island markets, primarily Auckland.

Slaughterhouse capacity in the South Island is sufficient to process all pigs produced on the South Island, including those shipped for slaughter in the North Island (although this trade would not be impacted by the proposed measure).

iii. Protection of export markets

A very small amount of pig meat products are currently exported to Singapore and Tahiti. Exported goods are containerised and shipped from Lyttleton or Timaru. Very occasionally live pigs are exported from the South Island to Tahiti.

Neither market currently requires certification for PMWS.

Australia does impose import risk management with respect to PMWS. Any industry aspiration to export pigs, semen and pig meat products to Australia could be protected by zonal movement control.

iv. Tried and true

Movement controls at Cook Strait were imposed to protect the South Island from Aujeszky's disease from the mid-1980's until confirmation of eradication in 1995. These measures supported an export market for pigs and pig meat products to Australia, a trade that has since been discontinued.

Risks/constraints

i. **Genetic isolation of the South Island**

Replacement boars and gilts cross from the North Island to South Island every week as replacement stock for breeding units. There is also the movement of semen in both directions from nucleus farms to multiplier farms and to commercial breeding and finishing farms.

By prohibiting genetic material crossing the Cook Strait there will be a slowdown of genetic improvement in pigs. There are nucleus breeding herds in the South Island but few currently import genetic material. Lengthy zone protection of the SI will see an increase of genetic material being imported by nucleus farms in the SI to restore genetic capability.

ii. Loss of markets for North Island breeders

The natural corollary to the above is that farmers/companies that presently sell pigs and semen from North Island to South Island would lose customers. Compensation under the Biosecurity Act for these losses would be required until alternative markets were found.

iii. Failure to prevent PMWS occurrence

PMWS could occur in the South Island as a result of the following mechanisms:

- Activation of endemic PCV2. PCV2 positive serology has been recorded in South Island pigs. If PMWS is caused by endemic PCV2, zonal movement controls provide no protection from risk.

- Spread of PMWS prior to imposition of movement controls. Current belief is the PMWS has been present on case farms in New Zealand since mid-2002. Since that time there has been no regulatory controls managing the risk of spread. PMWS could already have spread to the South Island. No surveillance to demonstrate freedom has taken place.

- Failure of risk management. Exact transmission mechanisms for PMWS are not currently known. Undefined local spread mechanisms appear important in spreading the disease. Pig effluent could be a risk item, and unregulated movements of contaminated vehicles, equipment and people could lead to a failure of risk management. The risk of airborne or bird-associated spread has not been established.

Costs

The following cost estimate was based on the current establishment of a Controlled Area for Varroa destructor protecting the South Island from incursion of this apiculture pest.

Promulgation of the Controlled Area Notice through publications in the Government Gazette and all major and regional newspapers: $20,000

Public awareness campaign

- signs at Ferry Terminals $10,000
- provision of information to pig farmers and other industry stakeholders $10,000

Auditing pig and transport company compliance $10,000 annually

Enhanced passive surveillance and suspect case investigation $10,000 annually

Total cost:

- Year 1 $60,000
- Thereafter, annually $20,000

3.3 Compartment protection

The objective

Identify strategically important establishments for the pig industry, in particular distributors of boars, gilts and semen (imported or locally collected). Ensure protection of this strategically important compartment through education and promotion of best practice for biosecurity on pig farms. In this way, prevent massive dispersal of PMWS throughout the New Zealand industry associated with distribution of pigs and semen from an infected supplier.

The measures required

i. Identify the pig farms to comprise the compartment

There are currently 11 "nucleus farms" supplying pigs and semen to other pig farms in New Zealand (Table 1).

ii. Develop industry guidelines for biosecurity best practice

Nucleus farms already tend to apply high levels of farm biosecurity, but there is some inconsistency in measures and facilities in support of farm biosecurity throughout the New Zealand industry.

MAF visited four of the 11 nucleus farms during the PMWS investigation. Biosecurity practises differed between farms. The highest level of biosecurity encountered (i.e. New Zealand best practice) included the following measures:

- A 24-hour stand down period is required for any visitor. No direct or indirect contact with pigs is permitted two days prior to the visit.
- Vehicles are parked 25 meters from the buildings at a clearly marked visitor's car park.
- Visitors and employees are required to shower on arrival and when leaving. Protective clothing, hats and boots are provided to wear on the farm.
- Employees are not allowed to keep pigs at home.
- Footbaths filled with an approved disinfectant must be used when entering a building.
- Transportation trucks can only enter the farm through a monitored barrier.
- Trucks are not allowed close to the buildings and the loading and unloading of pigs happens 25 meters from the nearest building.

The North American pig industry implemented major changes to farm biosecurity practices during the 1990's as a result of PRRS. An investigation of international best practice could be undertaken by an industry expert.

The goal from both investigation of New Zealand and international best practice should be to develop a realistic and achievable guidelines for New Zealand nucleus farms.

iii. **Promote the guidelines and monitor compliance**

PIB and Pig Veterinary Society would be expected to play an important role in promotion of the industry biosecurity guideline. Audits of compliance could be undertaken with the primary education and advice objectives.

iv. **Consider use of buffer zones**

Pig free buffer zones are implemented by some companies in some countries. New Zealand endorses the concept by making a 3km pig free buffer zone surrounding pig semen collection centres a requirement of within import health standards. This measure is specifically directed against PRRS.

Implementation in New Zealand could be achieved through either:
- A statutory mechanism, such as use of a Controlled Area notice under section 131 of the Biosecurity Act; or
- Voluntary or commercial compliance agreements with neighbours; or
- Purchase of land in buffer zones.

Benefits

i. Industry protection

Implementation of high levels of farm biosecurity for nucleus farms in New Zealand would support commercial and industry disease control measures for a range of pathogens, both endemic and exotic. Protection of nucleus farms protects the industry as a whole.

ii. **Market opportunities**

Improved farm biosecurity has the potential to create market opportunities for exports. Previous visiting trade delegations have emphasised the importance of such measures in opening up markets for exports of New Zealand pig meat products.

Risks/constraints

i. **Costs to industry**

Major upgrade of facilities would be required at some farms. Implementation of the measures have both start-up and ongoing costs. Costs would be borne by individual farms, and are likely to be the major barrier to implementation of biosecurity measures, despite most farmers agreeing that they are desirable.

ii. **Dispersal risks arising outside the compartment**

The distribution of genetic material is not limited to commercial nucleus establishments. Rare pig-breed breeders and other enthusiasts might actively import and/or distribute genetic material, creating dispersal opportunities.

Costs

i. Development of guidelines

Government and/or industry support for development of the guidelines $10,000

ii. Implementation of the guidelines

Per farm costs will vary considerably depending on current facilities and practices. Start up costs from a zero base are estimated as follows:

Vehicle car park:		$10,000
Shower complex:		$20,000
Annual cost of purchase, replacing and washing protective clothing		$5,000
Fencing:	up to	$100,000
Monitored gate		$10,000
Disinfectant and vermin control	per year	$2,000
Truck disinfection station/ford/mats		$10,000
Surveillance	per year	$5,000
Annual auditing		$1,000
Total per farm		$161,000

Table 4. Eleven nucleus farms forming the strategic compartment.

	Name of Company	Agribase no.	Location	No of pigs	Semen Importer	Island
1	Pig Improvement Company (PIC)	WK03544	Maramarua	3600	Yes/Jan.2003	North
2	PIC	FR01254	Tasman Park	3610	Yes/Jan.2003	North
3	PIC	SE04406	Bradford	3100	Yes/July 2003	South
4	PIC	SE04408	Burnalan	4600	Yes/July 2003	South
5	Waikato Breeding Company	WK01392	Taupiri	1335	no	North
6	Waratah Farms	OT00472	Otorohanga	7314	Yes/June 2003	North
7	Canbay Pig Development co.		Christchurch		Yes /March 2003	South
8	Willaden Farm	SE01016	Christchurch	1000	Yes/Nov.1998	South
9	Jeff Cooley		Levin		Yes/ Feb. 2003	North
10	Pork Corp NZ Ltd	WI04166	Christchurch		Yes/June 2003	South
11	CS & KJ Kay	MN01970	Fielding		no	North

II

3.4 Risk management for imported semen

Objective

Manage the historical risk associated with the presumed pathway of entry of PMWS through identification of imported stocks of semen, testing stocks for PCV2, and destruction of contaminated stocks. Implement controls on imports of semen providing an appropriate level of protection.

Measures required

i. Identify imported stocks

New Zealand has import health standards allowing importation of semen from Australia, the United States of America (USA) and Norway. Importers can be identified through either import permits or biosecurity clearance records held by MAF.

All importers of pig semen are required, since 1999, to maintain records of imported stocks of semen and make these available to MAF for audit.

ii. Test imported stocks

Highly sensitive and specific polymerase chain reaction (PCR) tests are available for the detection of PCV2 at MAF NCDI. Testing is destructive. Decisions would have to be made as to the sampling unit for testing i.e. the collection, the boar, the imported batch and the semen collection centre could all be considered valid units, depending on the level of confidence required.

iii. Implement risk management for imports

Risk management options for imports of semen include the following measures:

- Prohibit the importation of all semen.
- Allow semen import from PMWS free countries, regions or farms.
- Allow semen imports from boars serologically negative for PCV2.
- Allow semen imports after negative PCT test for PCV2.

The choice of option depends on both the level of risk management achieved by the measure and the level of protection from risk considered appropriate by decision-makers and stakeholders. These matters were already under consideration by MAF prior to recognition of PMWS in New Zealand.

Benefits

i. Managing exposure risk

If imported semen has been the pathway of entry of PMWS in New Zealand, this measure protects the pig population from further exposure.

Risks/constraints

i. Exposure has already occurred

Much of the imported semen is likely to already have been inseminated into pigs in New Zealand. Most commercially farmed pigs in New Zealand are progeny of pigs bred with imported genetic material. Artificial insemination is prevalent in the industry and stocks probably have high turnover.

ii. Genetic isolation

Depending on the level of protection from risk deemed appropriate, changes to import health standards could restrict the importation of genetic material into the country. The result will be limitations to genetic improvement of New Zealand pigs.

iii. Wastage associated with testing delays

Fresh cooled semen needs to be inseminated within a certain time frame. PCR testing might compromises sperm survival rates, caused by time delays.

Costs

i. PCR testing

Testing cooled semen for PCV2 by PCR cost on average $150.00 per sample. A small fraction of the sample has to be sacrificed for the test. The remaining sample can be used for artificial insemination.

Testing frozen semen for PCV2 by PCR cost on average $150.00 per sample. The entire straw has to be sacrificed, which adds additional costs.

i. Tracing imported semen

Tracing of stored semen:	$10,000
Purchase and destruction of stored semen:	$50,000 to 200,000

4 SURVEILLANCE

4.1 Enhancing passive surveillance

Objectives

The objectives of enhancing passive surveillance would be:
- Heighten the awareness of PMWS within the animal health community.
- Allow detection of new or existing but unreported cases.
- Increase the sensitivity of the current level of passive surveillance

Measures required

i. Provide information to stakeholders

MAF and the Pork Industry Board have a role in education programmes for the pig farming sectors. The PIB website already has information. MAF have sent a direct mailer alerting all registered veterinarians in New Zealand to the recent diagnosis. The mailer also defined the risk groups and clinical signs.

Information targetting the various stakeholders groups should continue to be circulated, and opportunities created to present information and discuss PMWS surveillance at conferences and other meetings. The target audiences can be defined as:
- Pig farmers
- Veterinarians, especially pig veterinarians
- Pathologists.

ii. Define investigation triggers within existing system

Triggers could be defined for on-farm and at-slaughter software packages, such as weaner mortality or pneumonia lesions. A sudden reduction or marked fluctuation in numbers of grower pigs to slaughter by properties over time may also be a trigger warranting investigation.

Pharmaceutical and agricultural sales or sale records kept by representatives of Pharmaceutical companies provide an indirect means of quantifying disease occurrence eg pig respiratory vaccines. Increases in these products may act as a trigger.

iii. Suspect case investigation

A case definition and standardised investigation protocol has been developed and implemented within technical policies supporting the MAF-lead investigation. This information should be made available to industry veterinarians.

Benefits

i. Reliable prevalence data

Education materials will build on and enhance the existing surveillance system to increase the level of reporting. This represents an efficient and logical approach.

An increase in passive surveillance will
- allow a faster appreciation of geographical distribution.
- highlight regions within New Zealand, which may be disease free and where active surveillance could be explored.
- facilitate early initiation of any future remedial actions.
- detect any variations in the occurrence or expression of the disease.

Risks/constraints

i. Lack of specificity of investigation methods

Increased reporting will mean increased testing, and potentially increased false positive diagnoses.

ii. Negative market perceptions

These activities may promulgate the message that NZ has widespread PMWS. Some sectors may perceive risks associated with this approach, for instance potential negative trade implications.

Costs

Costs for suggested activities would include:

Development and distribution of promotional materials. A range of technical information formats targeting various sectors may be necessary. $10,000

Technical analysis establishing reporting triggers and the implementation of these within the industry sectors. $5,000

Suspect case investigation, including veterinary services, sampling of stock, and laboratory diagnostic work (histopathology only) per suspect case farm $1,000
@ 30 per year $30,000

4.2 Diagnostic capability

Objective

Provide PMWS confirmatory testing within New Zealand.

Confirmatory testing is required to fulfil the case definition for PMWS. The clinical and pathology criteria of the case definition have low specificity. Other porcine diseases can produce similar clinical signs eg Glassers, chronic pneumonia, ileitis, internal abscessation and higher bacteria/fungi/protozoa can cause granulomatous lesion in several tissues.

Measures required

i. Identify confirmatory test options

The options for confirmatory testing include:
- Immunohistochemistry (IHC).
- In situ hybridization (ISH)
- Quantitative PCR's

The tests currently recognised as 'best practice' for PMWS diagnosis are IHC and ISH.

Quantitative PCR would at best give a quantitative measure of viral load and add additional weight to a diagnosis of PMWS. It is a technique requiring real-time PCR.

ii. Select potential suppliers

ISH could in principal be developed at The Institute of Veterinary, Animal and Biomedical Sciences, Massey University. IVABS have a strong desire to develop this technology should the funding become available. Two broad methods are possible for development:
- Creation of a post-doctoral position to manage the project.
- Investigation of the technology at an overseas laboratory by an IVABS staff member.

Additionally there is a requirement to purchase the required equipment and reagents. Once development is completed the maintenance and operation of the test can be done by less qualified technical staff.

Real-time PCR technology is currently not available at NCDI, but purchase of hardware capability has been approved. Protocols for PMWS assays would require specific project work to develop. In accordance with established policy, NCDI would only supply a diagnostic service in the absence of a private sector supplier.

Benefits

i. Diagnostic self-sufficiency for PMWS

Increased diagnostic validation and robustness when fulfilling all parts of the defined case definition for PMWS. It is difficult to see how any surveillance undertaking could be pursued without the ready availability of this test.

ii. **Speed of diagnosis**.

Availability of the confirmatory testing service will remove delays associated with sending samples overseas.

iii. **Generic veterinary diagnositic capability enhancement**

The technology will be available to be applied for the diagnosis of other diseases. Both quantitative PCR and immuno-staining techniques have become important and widely used tools for animal disease diagnosis.

Risks/constraints

Time to development may be slow. Recruitment of qualified staff takes time.

Costs

Approval and funding for real time PCR hardware and software at MAF NCDI has already been granted by government. Project work could be incorporated into baselines.

With respect to in-situ hybridisation, estimates of costs for development are:

Machinery/equipment	$25 000
Initial set up reagents, disposables	$12 000
Plus overhead costs	
Cost of post-doctoral position	$45 000
Estimated Total	$82 000

5 RESEARCH

5.1 Genotyping of New Zealand Isolates of PCV2

Objective

The objective of this project is to obtain baseline data on the gene sequences of the New Zealand isolates of PCV2 isolated from healthy pig and pigs with clinical and pathological features of PMWS. Comparisons with overseas isolates may indicate genetic similarities, providing evidence for the source of New Zealand viruses.

Proposal

i. Obtain pure PCV2 isolates

Pure isolates of PCV2 are required for this project. The PCV2 isolates isolated in cell cultures should be free of any other bacteria or viruses of porcine and non-porcine origins. Careful re-sampling of pigs for PCV2 will be required. Samples should be collected from pigs showing signs suggestive of PMWS Alternatively, pigs from farms previously had disease problems suggestive of PMWS could be sampled.

Currently, only the abattoir-derived PCV2 will be suitable for this project. Pure PCV2 isolates will need to be obtained from PMWS-suspect pigs. Ideally, six isolates from each group of healthy and PMWS-suspect pigs will be required for genotyping analysis.

Initial work will focus on obtaining a suitable number of pure isolates from pigs exhibiting signs consistent with PMWS. Initially we will be attempting to obtain the required isolates from the currently identified infected properties. There is also a possibility these could be obtained from investigations of suspect cases, following the publicity associated with the most recent outcome. These isolates will then confirmed by in-house molecular and virology methods before being shipped to the collaborating laboratory.

ii. Sequence and compare the isolates

Characterisation at the collaborating laboratory will include sequencing and comparison with existing sequences. Analysis of closely related strains will include the degree of similarity, the clinical, pathological and epidemiological characteristics (if known) and any reports of control carried out from outbreaks associated with these strains. The analysis of this information would require the presence of an NCDI scientist at the laboratory for a period of weeks. The Department of Agriculture and Rural Development, Northern Ireland (Gordon Allan) or the Department of Veterinary Microbiology, University of Saskatchewan (John Ellis) are seen as possible collaborators.

Benefits

i. Establish the molecular epidemiology of New Zealand isolates

Provision of detailed information on the NZ PCV2 strain(s) present. This information will be useful in extrapolating a possible source of the infection and likely characteristics

(disease potential, epidemiological characteristics etc.) based on comparison with closely related strains overseas.

ii. Collaboration with overseas researchers

Establishment of collaborative relationship with PMWS and genotyping experts.

iii. Capability building

Expansion of skills and capability at NCDI, particularly in relation to PMWS pathogenicity, but also including generic bioinformatic skills.

iv. Publications

Published report in a peer reviewed journal clarifying New Zealand's PCV2 strains and their relationship with characterised overseas strains.

Risks/constraints

i. Participation of collaborators

There may be an inability of overseas collaborating laboratory to provide sufficient resources for the project to move forward at the required speed.

ii. Contamination of isolates

There may be an inability to obtain sufficient isolates of required purity for genotyping.

iii. Comparisons are uninformative

Comparison with overseas strains may be unproductive because of either:

- high levels of heterogeneity within the NZ PCV2 strains, or
- the NZ strains do not match any sequenced overseas strains.

Costs

Costing is based on the analysis of 12 isolates of PCV2 by MAF NCDI with the assistance of an experienced collaborating laboratory.

Personnel: salaries and overheads for existing staff absorbed to baselines	$0
Consummables for collection of isolates, culture and analysis at NCDI (Includes domestic travel for NCDI staff)	$15,000
Field work to obtain isolates, field data etc. absorbed to baselines	$0
Bench fees for contracting laboratory	$5,000
Travel and accommodation for a scientist to work in collaborating laboratory, 3-4 weeks	$15,000
Total cost:	$35,000

5.2 Pathotyping studies for New Zealand PCV2 isolates

Objective

Determine the "pathotype" of New Zealand PCV2 isolates through an experimental transmission study using standardised protocols and measurement allowing comparison of pathogenicity between isolates.

The questions to be answered by the study design are:

- Does PCV2 from cases of PMWS in New Zealand induce PMWS-like changes in pigs exposed within the experimental model?
- Does PCV2 from healthy pigs from farms in New Zealand with no suspicion of PMWS induce PMWS-like changes in pigs exposed within the experimental model?
- With respect to the pathology induced in pigs exposed within the experimental model, how do New Zealand isolates of PCV2 compare with each other? How do they compare with PCV2 isolates from a range of other scenarios (i.e. countries, clinical status of farms).

Proposal

The idea for this study came from an offer by Gordon Allan, Queen's University, Belfast. Dr Allan has an impressive bibliography of PMWS research.

MAF considers that any pathotyping study of New Zealand PCV2 isolates should use a minimum of two, but preferably three, isolates. The isolates would be:

- PCV2 isolated from a case farm from pigs that were exhibiting clinical signs of PMWS;
- PCV2 isolated from farms sampled without prior knowledge of PMWS status.

With respect to the former, attempts to obtain a pure PCV2 culture from the case farm have so far been unsuccessful due to overgrowth on second passage by a second virus suspected to be an enterovirus. Re-sampling has been scheduled.

With respect to the latter, two prior studies are potential sources of PCV2 isolates from farms not suspected to have PMWS. MAF currently holds several PCV2 isolates derived from abattoir sampling of pigs from three South Island farms [1]. Diatranz holds PCV2 isolates derived from currently unpublished studies conducted in two North Island farms (pers. comm. Olga Garkavenko to Roger Morris, relayed by Prof Morris to the PMWS Technical Advisory Group, 23 October). Ideally, an isolate derived from a North Island and a South Island farm would be used in the model. The presence of PCV2 in both islands of comparable pathogenicity to PMWS-associated isolates would significantly weaken the case for containment measures based on zone protection.

Questions that remain include:

- What is the exact method to be used in Dr Allen's model? No details of the exact method proposed have yet been provided, despite a request from MAF for a description of the model. Dr Allan has indicated that the model has not yet been published in a peer-reviewed journal. It uses colostrum-deprived pigs, suggesting derivation from earlier experimental transmission studies [2-4]. These studies used groups of 3-5 colostrum-deprived pigs inoculated at 3 weeks of age intra-nasally. Histology in

specified tissues is used to diagnose PMWS after pigs either become sick or upon conclusion of the study at around 35-42 days. NCDI assumes that a standardised system of scoring lesion severity to allow comparison between virus isolates has been developed.

The varying ability of previous experimental transmission studies[5-7] to produce disease and lesions have indicated that dose-rate, route of inoculation, age and immune status of the inoculated pigs all have a significant effect on the development of clinical disease and histological lesions.

- What isolates have been assessed using Dr Allen's model, and what level of variability between isolates has so far been found? That is, what comparisons will be able to be made if New Zealand isolates were subjected to the model? At the present time, MAF has no information on this matter. MAF believes that if no significant variation in pathogenicity between PCV2 isolates has so far been found, the rationale for the proposed study is weakened. An absence of variability in pathogenicity amongst overseas isolates is likely to also be reflected amongst New Zealand isolates.

- What is the view of the scientific community regarding pathotyping PCV2 isolates in general, and using Dr Allan's model specifically? Is the science sufficiently advanced such that appropriate inference can be made using the results of different trials? Can all the potential confounding co-factors affecting the severity of the manifested disease be controlled in an experimental setting in order to allow comparisons to be made? This point in particular seems relevant considering there is still a significant debate regarding whether all potential co-factors in PMWS are currently understood.

- What other pathotyping models are available? Dr Allen's proposal arose from a chance event, rather than as a result of research. Evaluation of the literature indicates experimental transmission studies using live pigs, with attempts to standardise, have been a fairly common method of investigating PMWS aetiology and pathogenesis (see first bullet point above). Further, it appears that models in other animals are now becoming available, such as genetically engineered mice[8].

- What is the cost per isolate? An estimate is made in the cost section below.

Dr Allan has indicated that he would not be able to perform this research this year, due to other commitments. Once started, the study would run for approximately two months, followed by a further month to process and analyse samples and report results. The conclusion is that even if MAF decided to pursue use of Dr Allen's model, results would not be available for approximately six months, and therefore be of no use to MAF during the biosecurity incursion decision-making process. This suggests that further time is available to research the issues noted above prior to making a decision as to whether to pursue pathotyping, and if so through which pathotyping model.

The method of research proposed is to use this paper as the basis for eliciting expert opinion, and to review the opinions received prior to moving to a request for proposals amongst a defined set of potential providers, in adherence to MAF's research tendering policies and practices.

Benefits

A pathotyping study comparing New Zealand PCV2 isolates, those associated and not associated with PMWS, is intuitively appealing because it directly evaluates the fit of PCV2 against policy criteria used to determine regulatory status as an unwanted organism i.e. ability to cause harm, and endemic or exotic status. These are important considerations during decision-making within the risk management frameworks related to both imports of risk goods into New Zealand and biosecurity incursions.

However, the issues discussed above indicate that the value of the additional information arising from the proposed study, relative to that which is already available to MAF through the scientific literature and from experts, is presently uncertain.

Risk/constraints

The major current constraint is a lack of information regarding the value likely to arise as a result of undertaking the study. The recommendation to undertake further research prior to commissioning a pathotyping study should address this risk.

Costs

No cost estimate is available from potential research providers. The following represents an attempt to estimate costs by analogy with previous contracted research.

A live pig transmission study contracted from an Australian laboratory as a result of a previous biosecurity incursion (*Brucella suis*) was quoted at $32,000. That study involves similar age pigs, with a treatment and control group of 10 pigs each. Sampling and laboratory diagnostics include weekly bleeding for serology, followed by slaughter, post-mortem and culture at the conclusion of the trial.

A pathotyping study for PMWS is assumed will involve groups of approximately 5 pigs per isolate plus a control group i.e. a similar number of pigs to the above study. However, experimental transmission studies for PMWS require SPF or other specially sourced pigs. Laboratory investigations will involve primarily histology and either immuno-histochemistry or in-situ hybridisation. The laboratory undertaking the work is unlikely to be one that MAF has a historical or strategic relationship with, and so MAF is likely to be charged full commercial rates. If the laboratory is in Europe or North America, the purchasing power of the New Zealand dollar will be lower than that for the *Brucella suis* study. Each of these factors are likely to increase costs.

A ball park estimate of costs is NZ$50-75,000.

References relating to experimental disease models

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Appendix 1 Information from Gordon Allen to Gary Horner on pathotyping studies, 3 November 2003

A Details of the method. ie number of pigs, used/isolate, how long do you keep them and how do you assess the pathogenicity?

We have transferred this model to sweden and denmark, but it is precise and you need good people.

1) Subjects
We use snatch farrowed pigs. The protocol for sf is precise (see appendix). These pigs are transferred to clean, but not sterile environment. Bottle fed and then put on solids/mlk as soon as possible

2) Inoculation
Inoculated with pcv2 isolate + ppv trigger.

3) Observation
Pigs held for up to 25 days pi.

4) Measurements
Survivors killed, autopsied and scored for viral load + histology.

B Have you found much variability between the strains you have pathotyped so far?

Very little - all kill pigs

C What will the likely cost per isolate pathotyped?

I havn't a clue, but as stated before, it will be difficult to fit you in to our schedule. If we can, it would have to be under a research contract agreement that would allow us to process the cash. We can do this through the university.

We would need to think about a litter/per isolate (if you include controls). The expensive bit is maintaining the animals.

If you let me know what you might want (in total) and what time frame then I can cost it.

Appendix 2. Rearing of colostrum-deprived piglets

Procedure in Farrowing Unit

Breeding stock Landrace/Large White

Only strong, good sized, piglets were chosen.

Wearing full PPE the piglets were delivered without coming in contact with known contaminated surfaces.

1. Cords were cut and tied (approx 10 cms)

2. Rubbed down with paper towel which helps to stimulate breathing.

3. Dunked in Novagen (iodophor) solution (holding mouth and nose closed)

4. Navel and cord soaked in tincture of iodine

5. Piglet placed in enclosed transport box under heat lamp and allowed to dry. The transport box contains sterilised (autoclaved dry straw as bedding).

6. After 5-10 mins the pigs were removed in the transport box to a less contaminated warm area where they were fed 20-30 ml. Volac calf volostrum (via syringe). This was followed by their first dose of antibiotic (in our case, Nuflor).

7. Groups of piglets were returned to the laboratory facilities within 2 hours.

Maintenance of piglets

Accommodation

The system which seems to work best for us is to house the piglets on the floor in a room which has HEPA filtered +ve pressure. As can be seen in the photographs this pen size suits about 20 newborns up to about 4 weeks old.

Prior to housing the animals the area is thoroughly cleaned and fumigated with Formaldehyde. The area is then set up with the equipment and consumables required for the period. Repeated fumigations with Formaldehyde are again carried out. Workers shower before entry to these areas and do not work with other pigs.

Feeding

Piglets given Volac calf Volostrum for first 48 hours. Initially by syringe but by the second or third feed most will take from a baby bottle. During the first 48 hours volostrum is also left in stainless steel dog bowls for 1 – 1.5 hours after each feed and then removed and cleaned and sterilised (wash in disinfectant) before using at the next feed. This gets the pigs

used to feeding from open dishes. A close watch is kept while they feed and those not drinking are fed with bottle/syringe.

In our experience, if one obtains good, strong well sized piglets the following feeding times can be followed:

1st feed at Farrowing Unit (shortly after birth)
2nd feed in Animal Room (2-3 hours later)
3rd feed in Animal Room (6 hours after birth)

Fed 4 hourly thereafter – last feed at 11 pm Day 1

For the next 3 days four feeds are given: 8am, 12 noon, 4 pm, 10 pm

After 48 hours milk substitute is used.

Volume given: 100 ml/pig/feed

Gradually increased by demand
Water also provided ad lib. Lectade plus is given when necessary to provide rehydration therapy.

NB We use bore-hole water which is bacteriologically negative.

A proprietory creep feed is given from about 10 days onwards.

All suspect diets are checked for porcine and viral content.

Milk Substitute

Acidified high fat sow milk replacer containing all milk products – min. 60% skimmed milk and balanced blend of animal and vegetable oils. Fortified with full range of vitamin/minerals and trace elements and probiotic.

De-tagging/de-teething done on days 2 & 3 respectively.

Bacteriology

Main problem is E. coli, many of which are untypeable. We give Nuflor for first three days and usually follow on with Baytril. Faecal swabs used to monitor and modify treatments.

Other problems encountered have been pericarditis, epicarditis, peritonitis, hepatitis, meningoencephalitis and septicaemia due to haemophilus.

5.3 Epidemiological Studies

Objective

To answer the question " Is the Post Weaning Multisystemic Wasting Syndrome (PMWS) behaving like a propagating epidemic"

There have been many debates over the aetiology of PMWS. Currently porcine circovirus 2 (PCV2) is considered as a necessary cause of PMWS. In order to understand more about the behaviour of PCV2 and appearance of PMWS in New Zealand it is proposed that a cohort of New Zealand pig farms is monitored in a longitudinal study. In order to understand this syndrome it is proposed that information be collected on risk factors, clinical observations, pig reproduction and mortality data , serology, post mortem and histological findings. It is intended that the selected cohort will submit pigs for slaughter to an abattoir that conducts PigCheck monitoring of carcasses so that any respiratory disease presence is monitored.

Proposal

Establish a cohort of twenty New Zealand farms. The cohort will be comprised of four biosecurity strata with five farms in each strata. A selection of pigs will be bled and tested serologically for PCV2 antibodies at the commencement of the study. The list of risk factors to be collected will be discussed with industry and epidemiology experts. A farm visit to each property will occur at six-month intervals for the purposes of:

- clinical monitoring of animals,
- collection of reproductive and mortality data
- collection of data in relation to the list of decided risk factors
- contact with NCDI to arrange post mortem and testing of any suspected affected animals

The six-month visits will run for a period of two years. In addition to farm visits, carcass data on pigs sent to slaughter will be collected for each farm for the duration of the study. Any suspected PMWS cases will be notified to NCDI and arrangements for euthanasia, post mortem and collection of samples for histology will be made. Immunohistochemistry may be used to confirm histological findings.

The data will be collated and analysed annually and a final report written for presentation to industry, pig farmers and veterinarians.

There are at least three anticipated interpretations of the data collected

- An introduced factor has resulted in a propagating epidemic of PMWS
- PMWS is / is not occurring throughout New Zealand as a result of management factors and not any single extrinsic factor considered in this study
- There is some form of interaction occurring between PCV2 and some other factor resulting in expression of disease on some properties and not others. The example of BVD virus causing a seemingly sporadic incidence of disease and variety of clinical syndromes in cattle depending on host status at the time of initial infection and manner in which animals are managed is a relevant case in point.

The twenty farms will be purposively selected for inclusion of the study and stratified into four biosecurity tiers by Massey University Epicentre researchers. Pig veterinarians as part of their normal biannual visits to these properties will monitor the three higher biosecurity tier strata. The fourth and lowest biosecurity tier will be visited purposively and monitored by Epicentre pig consultants twice annually as these farms do not regularly engage a consultant and passive surveillance is unlikely to be sufficiently sensitive to ensure these cases would be notified to MAF.

Benefits

Utilising the farmers existing pig consultants for monitoring the top three biosecurity tiers as part of their normal biannual visits is a win – win situation. It provides opportunity to reduce the costs of the project to MAF (in comparison to making special visits organised solely for research) and the farmers involved will receive assistance and advice from their regular pig consultant.

The information gained will provide information to all concerned about the degree of spread of PMWS within New Zealand, the relevance of certain risk factors in the New Zealand situation and contribute internationally to the literature on this syndrome.

Risks / constraints

There is a risk that the number of farms included in each of the tiers is too small to detect a propagating epidemic if it has only just begun. The options for mitigating this risk involve running the study over a longer period of time and/or increasing the number of farms under observation. Both of these suggestions are constrained by costs however.

Costs

Serology	Current ELISAs 20-25$ ea Test 50 pigs on each farm	20 farms x 25 pigs = 500 estimate $20 per sample $10 000 testing
Farm visits	Biannual visits to tiers 1-3 Biannual visits to tier 4	Estimate 250$ each visit 15 farms x 2 visits x 2 years $5 000 Estimate 1000$ each visit 5 farms x 2 visits x 2 years $20 000 Total visits = $ 25 000
Study design and planning	25 hours	NCDI / Epicentre time
Operational phase - NCDI	15 person days per year	NCDI time
Collation, analysis and report	50 hours	NCDI / Epicentre time
Histopathology if required	Pigs to be post mortemed in the event that veterinary consultant suspects PMWS	$160 per farm (average) $3200
Total	Ballpark Estimate	$53200