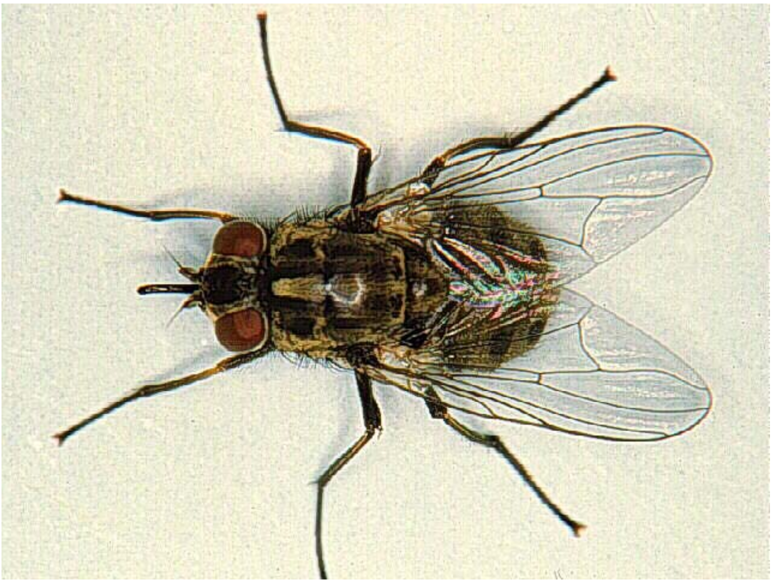
STABLE FLY MANAGEMENT PROJECT



Report on the

Agriculture Western Australia initiative in co-operation with the Health Department of Western Australia as well as key Local Government and Agricultural Industries

to

Reduce stable fly breeding associated with intensive agricultural production to levels that do not disrupt rural industries and the community

Report to Monty House MLA

Minister for Primary Industry; Fisheries

August 1998

REPORT:

STABLE FLY MANAGEMENT PROJECT

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1.0 Membership of the Stable Fly Management Steering Group

The Minister for Primary Industry and Fisheries, Monty House established the Stable Fly Management Steering Group in 1996 with representation from horticultural and livestock industries, Local Government, the Health Department of Western Australia, the Department of Environmental Protection and Agriculture Western Australia. The steering group was established to provide direction, coordinate inputs and ensure that the interests as well as the concerns of stakeholders were considered in the development of solutions to the stable fly problem.

Membership of the Stable Fly Management Steering Group is:

Colin Philpott	Chairman
Sally Grant	Councillor, Shire of Gingin
Wally Munyard	Health Manager, Shire of Gingin
Arnold Dammers (resigned)	Councillor, City of Wanneroo City
Mick Austin	Health Manager, City of Wanneroo
Maurice Danks	Councillor, Town of Kwinana
Peter McKenzie	Health Manager, Town of Kwinana
Bruce Roe	Livestock Industry
Nic Trandos	Horticultural Industry
Terry Packard	Poultry Industry
Owen Ashby	Manager Applied Environmental Health Section - Health Department of WA
Dave Peckitt	Senior Environmental Health Officer -Health Department of WA
Peter Hoar	Department of Environmental Protection
Bob Paulin	Agriculture WA, Project Manager
David Cook	Agriculture WA, Entomologist

2.0 Acknowledgments

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We are sure that list is not complete and apologise to anybody who may have been ommitted inadvertenly. We thank them for their help in this project, no matter how small the contribution.

3.0 Executive Summary

Background and the Problem

Although the stable fly (*Stomoxys calcitrans*) (Diptera: Muscidae) has been present in Western Australia since the early 1900's it has only emerged as a significant problem to livestock (cattle and horses) and humans since the late 1980's. Both the severity and extent of stable fly outbreaks have increased around metropolitan regions of Perth in recent years. In particular, the Gingin, Wanneroo, and Kwinana Local Government areas have been badly affected with outbreaks also being reported as far north as Northampton and along the Swan Coastal Plain as far south as Bunbury and Capel.

In affected areas, cattle marketing strategies are disrupted and levels of animal distress and weight loss frequently force stock to be agisted to non affected areas. Cattle often bunch together in an attempt to avoid being bitten by the fly. As a consequence, some animals suffer heat exhaustion, collapse and are trampled to death. The stable fly has increasingly disrupted human lifestyle, especially in rural and rural residential communities by restricting outside activities and seriously affecting domestic pets. In addition, recreational horse properties and the race horse industry have been similarly affected, with individual businesses being forced to either close or relocate.

In response to these problems, the Stable Fly Management Project was initiated by the Minister for Primary Industry and Fisheries in early 1996. This project was established to develop and implement management practices and other strategies that would control stable fly breeding associated with horticultural and agricultural practices, to levels that will no longer interfere with livestock industries and the community.

Key Findings

- The use of poultry manure in horticulture, principally vegetable, turf and strawberry production is the major source of stable fly breeding;
- With respect to poultry manure use in crop production, the application of 'Best Crop Production Practices for Managing Fly breeding and for Using Manure" will not reduce stable fly breeding to acceptable levels.
- Stable fly breeding associated with crop wastes, either remaining in the paddock, fed to livestock or buried in pits can be a significant but less frequent source of stable fly breeding. However widespread industry adoption of best practices will effectively control this source of stable fly breeding.
- Stable fly breeding can also be associated with livestock industries (usually with intensive animal production), which includes horses, dairy production, and cattle feedlotting. However the level of this breeding was relatively minor.
- Extremely high levels of house fly breeding were associated with poultry manure use, which has implications for human and livestock health. House fly breeding will be effectively dealt with by the practices that have been developed to manage stable fly breeding.

Recommendations

The Stable fly Management Steering Group therefore recommends:

> Banning the application of raw poultry manure to land for either crop production or any other purpose after December 31, 1999, or earlier. After that date, only poultry manure that has been treated to prevent it breeding flies can be applied to land in Western Australia.

> That in relation to horticultural and turf crop wastes, these industries be required to formally adopt the practices as defined in the "Best Crop Production Practices for Managing Fly breeding and for Using Manure" either by December 31, 1999 or earlier.

Implementation

Legislative backup to under pin the adoption of 'best practices' for managing crop wastes will therefore be needed and the existing penalties under the Fly Eradication Regulations of the Health Act (1911), will be increased, to provide a more effective deterrent.

The Stable Fly Management Project has identified the factors contributing to severe and consistent stable fly breeding. It is clear that the use of poultry manure in horticulture, and close proximity to livestock, (mainly cattle and horses), which are a source of blood for the stable fly, are involved. As a result of these findings, the poultry industry is now aware of the significance that the use of raw poultry manure in horticulture makes to stable fly as well as house fly breeding.

In order to control stable fly breeding associated with the use of poultry manure in horticulture, it will be necessary to either:

- treat all poultry manure prior to its use in crop production, so that it will not breed flies; or
- direct poultry manure to some other use such as either methane production, electricity generation, or stock feed production

Recognising the need to evaluate the economic viability of options for treatment, utilisation and disposal of poultry manure, Agriculture Western Australia's Economic Unit carried out a study and reported on processing as well as other options to the Stable Fly Management Steering Group in May 1998. This report identified that using poultry manure to produce compost is a possibility, because composts do not breed flies. However it was not seen as a short-term option, because it would be unlikely to utilise all the available poultry manure. Making compost only requires 15 to 20% of poultry manure by volume, which would increase the volume of poultry manure, if composted, at least four to five times. On current costing, the report indicated that compost could be around 50 to 60% more expensive than conditioned poultry litter. However, this may not be the case because the price differential will be determined by the cost of poultry litter relative to the wide range of other organic wastes that can be used in compost manufacture.

The report identified conditioning poultry litter as the most economically viable processing option for preventing stable fly breeding when it is used in horticulture. The report also commented briefly on other options for utilising poultry manure, such as electricity and methane generation, as well as ethanol and animal feed production. The report recommended that the poultry industry investigate these options in order to reduce its current exposure to being reliant on a single outlet for its waste.

Of the options investigated by the Stable Fly Management Project, for treating poultry manure (other than full composting), only conditioning has provided adequate reductions in fly breeding to warrant consideration. Conditioning involves subjecting poultry litter to a composting process, without the addition of other organic materials such as straw. Conditioning will apply only to poultry litter, which means that potentially, it can deal with around 85% of poultry manure production.

Initial trials in March 1998 indicated that poultry litter would require four weeks conditioning, however problems with variable levels of fly breeding were encountered in the conditioned litter. This could be a continuing problem if the conditioning process was to be defined and managed by a minimum processing time. Continued monitoring of conditioned poultry litter has indicated that levels of ammonium nitrogen can be used as an analytical standard to define when the litter has been conditioned to the point where it will not breed flies. A maximum ammonium nitrogen level has been included in the proposed guidelines for conditioning poultry litter that are appended to this report. These guidelines and the maximum ammonium nitrogen level need to be refined and developed by further research.

The establishment of licensed manure processing facilities will be central to the horticultural industry switching to the use of treated poultry manure. The current use of poultry manure, and hence conditioned poultry litter, is price sensitive and therefore costs associated with planning controls, including buffers or requirements to deal with odours, noise dust and environmental regulations, need to be minimised.

To facilitate change to using treated manure in horticulture, efforts need to be made to explain the benefits compared to the use of raw manure. These include:

- Reduced use of chemical fertilisers, the fertiliser value of poultry manure produced in Western Australia is conservatively estimated at $2 million

- Improvements to soils, including improved moisture retention and particularly if composts become widely used, reductions in pesticide and fumigant use.

The poultry industry needs to urgently undertake feasibility studies to evaluate all options, including conditioning poultry litter so that they can have a strategy(s) in place by the end of 1999, for the continued use and or disposal of their manure. To avoid further regulations, they will need to ensure that there is a commitment by all sectors of the industry to deliver their manure to licensed facilities for treatment or utilisation.

The egg producing sector of the poultry industry also need to recognise that their cage bird manure is not suited to conditioning, because it lacks the level of carbon that poultry litter contains. With the recommended banning of manure application to land from the end of 1999, they will need to develop other processing or disposal options. Their manure is already favoured for making mushroom compost. Compost manufacture would seem to be an immediate processing option because carbon will be supplied from a range of other materials. Pelletising is another possibility provided the finished pellets can be demonstrated to not breed flies.

During the next 12 months, trials need to be directed to determine conclusively if the conditioning process will prevent fly breeding and to evaluate its performance compared to raw poultry litter in vegetable, turf and strawberry production. There is also a need to investigate the stability of conditioned litter, with respect to its fly breeding potential following a reasonable storage period, which has not been investigated to date.

The Stable Fly Management Steering Group will regularly review progress and evaluate research undertaken by industry and make further recommendations as deemed necessary to the Minister.

4.0 Terminology and Definitions

Reference is made to a number of industries, processes and agricultural/horticultural practices throughout this report. The following definition of terms used is provided for clarity in reading this document.

Biosolids treated human sewage.

Broiler chicken meat bird.

Broiler industry refers to chicken meat industry.

Cage bird manure manure from egg production.

Compost the product as defined in the Australian Standards AS 4455-1997 being "material resulting from the controlled microbial transformation of organic materials under aerobic and thermophilic conditions.

Conditioned litter poultry litter that has been through a composting process without the addition of any other organic materials that are normally associated with making compost.

Crop waste unharvested crop that remains in the paddock or that remains after marketing is complete. It may also refer to crop waste remaining after reject/unmarketable crop is fed to livestock.

Growers refers to people involved with horticultural and agricultural production.

Horticulture production of fresh food and plants that are consumed (apart from cooking) or utilised without further processing.

Horticultural industry principally the vegetable, turf and strawberry industries as well as the fruit, viticultural and floricultural industries.

Livestock industry animal industries, principally the cattle, horse and pig industries.

Milled manure poultry manure that has been delumped by either screening or some form of physical processing to remove or break up lumps.

Poultry all forms of farm birds including *Gallus* species (chickens, waterfowl, ducks, game birds including turkeys, ostriches and emus).

Poultry growers refers to people involved with chicken meat, eggs and breeding poultry production.

Poultry industry principally the broiler and egg producers as well as poultry breeders, waterfowl,
ducks and game birds including turkey, ostrich and emu production.

Poultry litter untreated (raw) poultry manure from both the broiler, breeding and egg producing industries, which contains around 30% sawdust or some other bedding material (eg. chopped straw, shredded paper) by volume.

Poultry manure includes all forms of untreated (raw) poultry manure generated by the poultry industry.

Standard error variability about the mean.

Thermophilic Refers to the first stage of the composting process when microbial activity is generating large amounts of heat, it is the stage when natural sterilisation occurs.

Trashed crop **r**efers to **crop waste** that has been thoroughly slashed/broken up and then incorporated into the soil.

Treated manure manure which has been treated to prevent fly breeding when it is used in either crop production or any other land use application.

5.0 Background

5.1 The Pest

The stable fly, *Stomoxys calcitrans* (Diptera: Muscidae) has been present in Western Australia since the early 1900's and reports of it seriously affecting horses in the Wanneroo area date back to the 1930's. However, it was not until the late 1980's that this fly emerged as a significant problem for livestock, particularly cattle and horses, as well as a nuisance to people.

The stable fly is similar in size and appearance to the house fly, but can be recognised by its rigid proboscis with which it inflicts a painful bite as it punctures the skin to obtain a blood meal. This fly actively feeds on most short haired animals and humans, with cattle and horses being the most preferred host. The female requires blood to lay eggs, hence she feeds several times per day and produces up to 1,000 eggs in her lifetime. Stable fly eggs are layed into rotting organic matter or manures containing organic matter. Females can produce around 800 eggs in their lifetime under optimal conditions (25-30°C).

The life cycle of the stable fly is highly temperature dependent (as with all insects). The fly life cycle consists of eggs, larvae (maggots), pupae (dormant phase in the soil) and adults. Larval developmental times range from >60 days at 15°C to <12 days at 30°C. Larval and pupal survival is optimal at cooler temperatures around 20°C and lowest at temperatures in excess of 35°C. Extreme temperatures (>35°C) have a deleterious impact on survival of all life stages, especially when moisture is scarce.

The complete life cycle of the fly (ie., from egg to adult) can be as short as 15 days in summer, and as long as 90 days in winter temperatures. The stable fly is capable of building up numbers rapidly and as few as 20 to 25 flies per animal are capable of significantly reducing livestock growth and performance.

Stable fly problems are generally associated with areas where horticulture occurs in close proximity to livestock production.

5.2 The Impact of Stable Fly

In recent years, both the severity and extent of stable fly outbreaks have increased around metropolitan regions of Perth and particularly in the Gingin, Wanneroo, Kwinana and Serpentine Local Government areas. Outbreaks have also been reported as far north as Northampton and occur along the Swan coastal plain as far south as Bunbury and Capel.

In affected areas, cattle marketing strategies are disrupted and levels of animal distress and weight loss frequently force stock to be agisted to non affected areas. Cattle will often group together in an attempt to ward off the fly and consequently, some animals suffer heat exhaustion, collapse and are trampled to death. The stable fly has increasingly disrupted human lifestyle, especially in rural and rural residential communities by restricting outside activities and seriously affecting domestic pets. In addition, recreational horse properties and the race horse industry have been similarly affected, with individual businesses being forced to either close or relocate.

The stable fly has therefore become a significant problem for a number of Local Government Authorities, which have a responsibility to respond to complaints and enforce the Fly Eradication Regulations of the Health Act. These regulations allow for fines of up to $1000 for breeding flies and have provisions to enable the recovery of costs associated with addressing fly breeding problems.

5.3 Key Involved Industries

Horticulture and principally vegetable, strawberry and turf production use most of the poultry industry's 275,000 cubic metres of annual manure production. Vegetable production, which is by far the largest user has been widely blamed as the cause of the stable fly problem.

The poultry industry comprises meat, egg and breeding bird production. The broiler industry produced over 33 million bird in 1996/97 and this industry is expanding at 4% per year. The cage bird industry has 900,000 bird in production and around 90% of these industries are centred around the Perth metropolitan region. Total manure production is estimated to be around 275,000 cubic metres of which 85% comes from the broiler industry. Most of this poultry litter is used by horticultural industries and most of the cage bird manure has been pelletised, however with the recent closure of a processing plant, this manure is also being increasingly used in horticulture.

Vegetable production has remained relatively static around Perth at approximately 2,700 hectares per annum. Poultry manure is a valuable fertiliser, having a nutrient value in excess of $2 million (in and around the Perth metropolitan area) and being a soil conditioner for the production of a wide range of crops on the coarse sandy soils around Perth.

The cattle industry around the metropolitan region is small compared to the States total industry, however it is an important part of rural income generation in several Local Government areas. The stable fly therefore has significantly affected the rural economy.

The horse industries are diverse in nature and while the value of the thoroughbred/racing industry is undisputed, the recreational sectors that are centred around the metropolitan region, also make important contributions to regional economies.

6.0 Stable Fly Management Project Development

During the 1990's, several committees were formed to address the stable fly problem. In late 1995, and with recognition that a number of important rural industries, namely the poultry, cattle, horse and horticultural industries were being seriously affected by the stable fly problem, it was agreed that Agriculture Western Australia should take the lead role in developing strategies to solve this problem.

Following this, the Minister for Primary Industry, Mr Monty House, initiated a Stable Fly Management Project which commenced in early 1996. The project was initiated to develop 'best practices' and other strategies that would reduce stable fly breeding associated with agricultural and particularly horticultural practices, to acceptable levels. Following consultation with the main stakeholder representatives, namely agricultural and horticultural industries, Local Government, the Health Department of Western Australia and Agriculture Western Australia, the Minister formed the stable fly Management Steering Group to provide direction and to coordinate inputs from these stakeholders.

The Stable Fly Management Project was established with funding to June 1998 to:

- provide co-ordination and liaison between government, Local Government and industry.
- undertake investigations and research that would identify sources and develop controls for stable fly breeding.
- develop and ensure the adoption of best production practices that would reduce stable fly breeding to levels that were acceptable to the community.

6.1 Co-ordination and Liaison

The major stakeholders in the Stable Fly Program are government agencies (Agriculture Western Australia, Health Department of Western Australia and Department of Environmental Protection), Local Government (principally Shire of Gingin, City of Wanneroo and the Town of Kwinana) and rural industries (horticulture, poultry, and livestock industries).

The Stable Fly Management Steering Group was established to ensure that the needs and interest in these key stakeholders were considered and that their inputs were strategically co-ordinated towards addressing the stable fly problem.

Further working groups were also established to maximise industry input and involvement with the project and to assist with the development and adoption of Best Management Practices and other strategies for managing the stable fly problem.

6.1.1 Stable Fly Management Steering Group

The Stable Fly Management Steering Group was established following consultation with key government agencies, Local Government and industry groups. Under independent chairmanship of Mr Colin Philpott, it was jointly supported by Agriculture Western Australia and the Health Department of Western Australia, and held its first meeting in October 1996. With a three year term, this Steering group's role was to:

- review progress and ensure that the necessary research and investigation projects were well coordinated, and that they addressed the issues and needs of all parties;
- identify responsibilities and seek commitment of resources from participating parties to achieve control of stable fly;
- guide the development of strategies to solve the stable fly problem that centre on management practices in the first instance and if necessary, develop the framework for legislation;
- keep the Ministers for Primary Industry and Health and other relevant agencies fully informed; and
- keep stakeholders and the wider community informed.

The steering group comprised a representative from each of the horticultural, poultry and livestock industries, Agriculture Western Australia, Health Department of Western Australia, Shire of Gingin, City of Wanneroo and the Town of Kwinana. More recently, the Department of Environmental Protection has also been represented.

Information and minutes are regularly circulated to a wider number of concerned industries, groups, government agencies and Local Governments than are represented on the steering group. An extensive range of individual industries, Local Governments and other government agencies are kept informed of project developments. This contact list is provided in Appendix 1, Stable Fly Management Steering Group objectives, Terms of Reference, member responsibilities and membership.

The relationship between the Stable Fly Management Steering Group and various working groups is outlined in Appendix 2 Stable Fly Management Project Structure. These working groups include:

6.1.2 Crop Industries Stable Fly Management Working Group

The first of these working groups, initially called the Horticultural Industry Stable Fly Management Group was formed in December 1995 to develop and promote the adoption of best practices for the management of fly breeding. This group was responsible for finalising the "Best Vegetable Production Practices for Managing Stable Fly Breeding and for Using Poultry Manure" that were released to industry in February/March 1996.

The document was subsequently amended to include all forms of horticulture and turf production. The current version (March 1997) is titled "Best Crop Production Practices for Managing Fly Breeding and for Using Manure".

This working party has continued to make inputs to the project, which will complete the final version once the implementation of the recommendations contained in this report are finalised.

6.1.3.Livestock Industry Stable Fly Management Working Group

The next working group formed was the Livestock Industry Fly Management Working Group. With representatives from the cattle, dairy, recreational and racing horse and pig industries, it met in April 1997 to review the first draft "Best Management Practices for Managing Livestock Manure and Wastes to Reduce Fly Breeding".

These best practices have not been finalised which reflects the relatively minor contribution that these industries make to the stable fly problem.

6.1.4 Poultry Industry Stable Fly Management Working Group

The Poultry Industry Stable Fly Management Working Group first met in late May 1997. With representation from all sectors of the poultry industry including the broiler and egg producers, poultry processors, and the manure transporters, this group recognised that:

- poultry manure was a major contributor to the stable fly problem when used in crop production and that
- the application of best crop production practice still resulted in unacceptable levels of stable fly breeding.

From this recognition, greater ownership for finding a solution to the stable fly problem emerged. This was a major development and through this working group the poultry industry has committed to implementing manure processing in conjunction with the development of appropriate regulatory powers.

6.1.5 Stable Fly Legislation Working Group

The Stable Fly Legislation Working Group has been recently convened by the Health Department of Western Australia with representation from the Department of Environmental Protection, Agriculture Western Australia and Local Government. It met for the first time in June 1998.

The Working Group was established to identify a legislative framework from existing regulatory instruments, to assist the successful implementation of the Stable Fly Management Project's initiatives and recommendations.

The Group identified three main areas which needed to be addressed by regulation:

- The need to provide clear guidelines for the establishment of manure processing facilities
- Regulation of the industries producing, transporting and treating raw poultry manure
- The need to increase the penalties under the Fly Eradication Regulations of the Health Act (1911)

6.2 Surveys and Studies

Surveys have been an important element of the Stable Fly Management Project providing valuable information on the nature and extent of the stable fly problem, direction to the research and additional communication with rural communities. Apart from the poultry manure use surveys, they were coordinated and the reports were prepared by the Health Department of Western Australia. The list of reports prepared are provided in Appendix 3.

6.2.1 Surveys of Poultry Manure Use

A postal survey of vegetable growers use of poultry manure was fortuitously carried out in 1995. It provided information on the use and importance of poultry manure that shaped communication and assisted with the development of best management practices. A modified survey was sent to wider range of growers in 1998 and although changes were made from the original questionnaire, a number of key questions were retained

In summary, the surveys indicated that growers are now better informed about the stable fly problem and while the number of growers using manure has not declined, they are using less. Further, the percentage of growers believing that they could not grow their crop without manure has dropped from 77% in 1995 to 56% in 1998 and the number who believed that poultry manure does not cause fly breeding has also dropped from 41% to 21%.

Response rates to a number of key questions are provided in Table 1. and other conclusions included:

- The number of growers who believe that they are reliant on the use of poultry manure decreased and there was an increasing number who indicated that it would need to be replaced with cover cropping or some other form of organic soil amendment. This possibly indicates increasing awareness of the need to manage the quality of there soil.
- Reluctance to invest in manure storage facilities continues to be reported which reflects the belief that manure heaps do not contribute significantly to the overall fly problem.
- Asked whether they would pay more for manure that was treated to prevent fly breeding when used in crop production, most indicated that they would not pay more than an additional $4 per cubic metre.
- It would appear that growers have an increased understanding of the problems associated with using poultry manure and an apparent reduction in complaints reported by growers may reflect this change in attitude and approach to its use.

In conclusion, most vegetable growers continue to use poultry manure quoting improved soil moisture as well as nutrient holding ability, improved growing conditions and better crop quality as the reasons for doing so (see Table 1 below).

Table 1: Comparison of vegetable grower responses to survey of poultry manure use in 1995 and 1997.

Question	1995	1998
% vegetable growers using poultry manure	70	74
% vegetable growers dependent on using poultry manure	75	56
% growers who have reduced their manure usage	14	36
% growers using less than $50m^3$ of poultry manure/ha/year	70	84
% growers believing poultry manure does not breed flies	41	21

6.2.2 Regional Rural Surveys

During the course of the Stable fly project, two large community surveys were carried out in Gingin (March 1996) and Wanneroo (February 1997). The surveys were initiated by the Health Department of Western Australia and involved officers from the Health Department, Local Government, Agriculture Western Australia and environmental health students from Curtin University. Survey reports, listed in Appendix 3 were submitted to the Stable Fly Management Steering Group.

Both Wanneroo and Gingin had been experiencing problems with Stable fly, particularly over summer months. The problem had been seriously affecting the cattle industry in Gingin.

The purpose of the surveys was to raise community awareness of the stable fly problem and identify more clearly, where stable flies and other nuisance flies were breeding in the environment. The surveys involved inspecting a large cross section of properties, but focusing primarily on rural and semi rural areas. Details were recorded on an inspection report form. Where any fly breeding was found, samples of fly larvae were collected for identification.

NOTE: *Whilst it was known from previous research, that significant fly breeding was occurring at market gardens, (ie: associated with the use of poultry manure), it was not known to what extent other sources of breeding were contributing to the overall problem.*

Gingin Survey - Key Findings

- Unfortunately the weather conditions during the Gingin survey were much cooler than expected, hence fly activity was low. Nevertheless, the survey provided some useful information on potential and actual sources of breeding (although not exclusive to stable fly). During the survey some 200 properties were visited in rural and special rural areas. Although there had been a history of complaints about stable fly in areas such as Woodridge, at the time of the survey most people indicated that the situation was tolerable due to the cooler weather.
- A large number of 'potential' breeding sites (111) were identified in rural and rural residential areas of Gingin. However in terms of actual fly breeding, only 19 sources were found. Most of these breeding sites were associated with the storage or use of poultry manure and rotting vegetable waste, at market gardens. Other sources were in an isolated overflowing effluent treatment pond at a piggery, livestock dung on rural properties and an uncovered pile of organic refuse. The highest number of stable flies emerged from samples of vegetable waste that were mixed with poultry manure at a market garden.
- Very little if any breeding was found in residential / rural residential areas.

Wanneroo - Key Findings

- The Wanneroo survey was carried out in a similar manner to the Gingin one, but in warmer weather conditions (February). A total of 424 properties were visited, covering a cross section of rural activities, rural residential and residential areas. Problems with stable fly in Wanneroo were generally found to be confined to certain 'hot spot' areas. The hot spots were in areas where market garden, horse stables and residences were in close proximity.
- The findings of this survey again, identified a high number of potential breeding sites (231). However in terms of actual fly breeding, (76) sites were identified. Most of these (56), were again associated with market

gardens. The main sources of breeding at market gardens were in poultry manure (wet heaps or applied to the soil) and in rotting vegetable matter. Poultry manure was responsible for 59% of all stable fly breeding. Other significant but isolated sources of stable fly breeding were; horse stable manure, use of poultry manure at turf farms, livestock dung, an uncovered heap of organic refuse and a piggery effluent treatment pond.

- Residential properties were not found to be contributing to fly breeding.

  The survey highlighted the need to better educate market gardeners on the correct practises they needed to adopt to minimise fly breeding. This related to use of manures, disposal of vegetable waste and other preventative measures. The survey also highlighted the need for industry and government agencies to examine possible ways of treating poultry manure so that it is less attractive to fly breeding.

- A common problem associated with the storage of poultry manures, was that many heaps of manure were uncovered and located within the range of sprinklers.

6.2.3 Poultry Industry Surveys

To gain a greater understanding of the poultry industry, surveys were carried out of broiler farms and of the manure transporters.

Broiler farm survey

In November 1996, the Health Department of WA in conjunction with Local Government, carried out a survey of poultry (meat bird) farms. This exercise was an extension of the community surveys in Gingin and Wanneroo. The purpose of the exercise was to identify if and the extent to which fly breeding was occurring at poultry farms.

Note: There had been some evidence during the community surveys, of manure delivered to market gardens from broiler farms, already fly ‘struck’.

The survey mainly focused on broiler farms which supply most of the manure to market gardens, but also included breeder and turkey farms. A total of 35 farms were visited.

Key Findings

- Overall, the poultry farms visited were found to be quite well managed and growers were aware of their responsibilities to comply with standards set by industry.
- Fly breeding was not an issue which growers had a great awareness of. Most growers simply did not believe that fly breeding occurred at their farms. The findings of the survey did not substantiate this and fly breeding of varying degrees, was found to be occurring at 19 or 50% of the farms visited. The breeding was predominantly house fly.
- Most of the breeding was in residues of manure outside sheds (resulting from final clean and wash out operations), in drainage channels, uncovered heaps of manure and spilt feed outside sheds.
- Management outside the sheds at a number of farms needed to be improved. At some farms it was noted that manure residues from the final clean out of sheds were not being removed quickly enough, if at all.
- The method of disposal of wash out water (containing manure residues) from most sheds, eg. directly onto the ground, was found to be contributing to fly breeding. It was a recommendation of the report on the survey, that all sheds should have design features to properly contain and dispose of waste water.
- Fly breeding inside sheds was isolated, but where it was found (at 4 farms), it was in patches of wet manure. It was mainly found where birds had been removed.
- Whilst most of the manure inside sheds was quite dry, wet patches were common, particularly under drinkers and as a result of use of misters/foggers.
- There were some situations where faulty drinkers and/or misting equipment was contributing to excessive dampness of manure.

Manure Cartage Contractors Survey

As a follow up to the broiler farm survey, a survey was carried out by the Health Department of Western Australia in August 1997, to assess practises being employed to remove manure(litter) from poultry sheds and how it was handled from the farm to end users. Part of the survey was to observe the condition of manure being removed from sheds.

The survey of seven contractors was conducted during removal of manure from farms. A standard questionnaire was developed in conjunction with Agriculture Western Australia and used to record relevant information.

Key Findings

- It was found that all contractors removed waste manure from poultry sheds in a prompt and efficient manner.
- All contractors carried out the manure removal process in much the same way, using similar vehicles and equipment. However, it was found that the use of a sealed conveyor system as used by one contractor, had advantages where was a likelihood of dust problems affecting adjoining properties
- Most of the manure removed from sheds contained a large percentage of lumps in it. Only one contractor was able to break up lumps (using a front end loader) with any degree of success.
- Damp areas of manure was quite common and varied from shed to shed and farm to farm. Most contractors advised that damp manure was worse in summer when misters were used to cool birds. There was insufficient time to observe batches of manure for evidence of fly breeding.
- All contractors advised that they did not check for fly breeding when removing manure or prior to transporting it. The consensus opinion was that contractors did not believe it to be their responsibility.
- A criticism made by most contractors was that there was inadequate sealed area outside poultry sheds to allow them to effectively clean up any spilt manure. This matter was passed on to the Broiler Growers Association who did not see this as a problem.
- All contractors covered manure on vehicles prior to leaving farms.
- Contractors indicated that they only stockpiled manure on their properties when there was no other alternative eg.,. over supply or no market for the manure.
- Contractors advised that they had no say over where loads of manure were deposited on a property, stating that this was up to the buyer.

6.2.4 Stable Fly Population Monitoring

Across the Shires of Gingin, Wanneroo and Kwinana, fluctuations in the relative size of the stable fly populations were measured using white cylinder traps (see methodology). The white surface of these traps is highly attractive to stable flies, particularly post-feeding, when they look for a cool, vertical perch to rest and ingest their bloodmeal. Once the stable flies land on these traps, they become stuck in the non-drying glue.

Details of trap design, trapping layouts and results are provided in Appendix 4, Regional Trap Monitoring of Stable fly Populations.

Key Findings

- The trapping results indicate that there are localised outbreaks of stable fly. These outbreaks are predominantly located near horse and livestock properties surrounded by market gardens.
- Stable fly activity and rates of development (egg, larvae, pupae) are all temperature dependent, hence warmer temperatures increase fly activity, larval development and generation time.
- Peak abundance of stable flies occurred across each shire during the summer and autumn months.
- In general, the winter and early to mid spring months had very low numbers of stable fly, however, brief outbreaks were still evident.
- Although there was considerable variation between weekly trap counts, there was evidence of several

population peaks and then a decline, which indicates periods of favourable conditions (ie., moisture and warm temperatures).

6.3 Communication Strategies

Throughout the project, extensive use has been made of the press and particularly local community newspapers, as well as radio to inform the widest possible audience of the activities and events associated with the Stable Fly Management Project. Both Agriculture Western Australia and the Health Department of Western Australia have issued general press releases to the media and extensive use has also been made of postal mail outs to specific industry groups. In addition to these activities, the following items have been released:

6.3.1 The Biter

A quarterly newsletter (called "*The Biter*") was produced to provide growers (horticultural and livestock) and members of the community with a concise and simple explanation of research findings from the stable fly project. Three issues of this newsletter were produced between May 1997 and February 1998. Large numbers of each issue were provided to the Health Department of WA and shires with a stable fly problem for their dissemination to concerned residents. In addition, any growers involved with trial work were sent a copy. All issues of *The Biter* are on Internet via the Agriculture WA web page. Select Pest Updates on the Entomology Homepage.

6.3.2 Fly Brochure

Both Agriculture WA and the Health Department of WA produced a 6 page colour brochure titled "Fly Breeding Associated with Horticulture and Livestock". This brochure provided:

- Large pictures of nuisance flies commonly associated with manures and rotting vegetable matter (ie., stable fly, house fly, lesser house fly, false stable fly)
- Fly life cycle, with pictures of all life history stages and actual average size drawings of eggs-larvae-pupae
- Pictures of situations/sites where fly breeding is most commonly found in association with livestock and horticultural production
- A simple guide for authorised officers, growers and landowners to use to assess the severity of fly breeding on their own property
- Point form advice on what to do if fly breeding is found, both for small areas and large areas typically associated with crop production. Both cultural and chemical treatment options are provided.
- Pictures on the impact of fly breeding on humans and livestock
- Sources of further information on use of manures and fly breeding

6.3.3 Fly Pamphlet

The Health Department of WA produced a 2 page, fold out pamphlet on the stable fly. This pamphlet indicated common stable fly breeding sites, manure management options, how to reduce fly breeding in general with household and green wastes, simple facts about the stable fly, and registered fly control products.

6.3.4 Journal of Agriculture

A four page article was produced in the Journal of Agriculture, Western Australia, Volume 38 (2): 58-61. Titled "*Stable Flies on the Swan Coastal Plain*", this article outlined the research into identifying and quantifying stable fly breeding sites across horticultural and livestock industries.

6.3.5 Grower and community Meetings

Meetings have been held annually with horticultural industries to discuss 'best practice' development and to outline progress with the Stable Fly Management Project. Meetings have also been held with community groups in stable fly affected areas to inform people about the project and its progress towards developing solutions to the stable fly problem. In all cases, personnel from Local Government, Agriculture Western Australia, Health Department of Western Australia and representatives from industry associations have been involved.

6.3.6 Environmental Health Officers Workshops

Regular workshops and meetings have been held with Local Government Environmental Health Officers to:

- keep them informed with Stable Fly Management Project progress;
- inform them about the stable fly problem and the development of best practices
- assist with developing an educational component to their regulatory role;
- develop a uniform approach to assessing both fly breeding severity and to decide on when to instigate legal proceedings.

7.0 Investigation and Development of Industry Practices

The major objective of the Stable Fly Management Project has been to improve existing practices and develop new ones so that stable fly breeding levels are controlled at levels that no longer interfere with livestock industries and the community.

The approach taken recognised that the stable fly problem was complex and that solutions would take time to develop and implement. Over the two and a half years since the Stable Fly Management project commenced, a wide range of initiatives have been undertaken and without exception, contributed to the development of strategies to address the stable fly problem.

Over this time it has also become increasingly obvious that the stable fly problem in Western Australia is uniquely different to problems with this pest overseas and that it is not a serious problem elsewhere in Australia despite, the existence of areas with similar mixes of rural activities and practices. Investigations have lead to the conclusion that in Western Australia, the stable fly problem is uniquely associated with horticultural crop production and the application of raw poultry manure on coarse sandy soils. Optimal stable fly and house fly breeding conditions in manures and decomposing crop waste are provided by multiple, daily waterings. These irrigation strategies are demanded on these soils over extended periods from at least October to May and provide almost continuously moist conditions at the soil surface.

7.1 Entomology Research

A major element of the development of management practices and strategies for managing the stable fly problem has been based around extensive entomological program that has involved both field and laboratory work.

7.1.1 Sources of Stable Fly Breeding

Using a combination of emergence trap, emergence tub and grab sample data, a range of potential fly breeding resources found associated with both horticulture and livestock production were monitored. In horticulture, preplant and sideband applications of raw poultry manure were covered with a minimum of 10 emergence traps at least 7 days after the manure had been applied. This enabled flies to oviposit (lay eggs) on the manure and begin larval development. The emergence cages were left on the ground until adult fly emergence had been completed. This took from several weeks to months depending upon the time of the year, as the rate of fly development is highly temperature dependent.

Table 2 (on the following page) shows the average numbers of stable fly and house fly emerging from a square metre of breeding material. This data has been compiled from both emergence trap and emergence tub data.

To understand the relative importance of each breeding source as a contributor to the stable fly population, their total area must be taken into account. For example, 200,000 stable flies (and 300,000 house flies) are capable of being produced on average from every hectare of preplant application of poultry manure. Approximately 42,000 stable flies (and 330,000 house flies) can be produced on average from every hectare of sideband application of poultry manure.

Conversely, from livestock production, an average of 80-100 stable flies per hectare can be produced from horse and cattle dung (assuming 2 animals/ha, 64 L (cow) and 40L (horse) of dung produced per day and viable for fly breeding for 5 days). Heaps of poultry manure can produce relatively high numbers of stable flies, if wet either on delivery or by sprinklers/rain. They are not an important source of fly breeding when delivered dry and kept dry.

Table 2. Average numbers of stable fly and house fly emerging from a square metre of breeding material (emergence trap and emergence tub data) in order of severity.

Breeding Source	Stable fly	House fly
Trashed crop wastes	150	40
Vegetable waste fed out to livestock	46	873
Poultry manure – preplant application	25	35
Poultry manure – sideband application	21	164
Spilled grain feed (wet)	19	0
Poultry manure heaps	13	42
Spilled grain feed (wet)	19	0
Lawn clippings	5	1
Horse manure	2	1
Cattle dung	1	51
Silage	0	0
Wetlands material	0	0
Pig manure effluent	0	4
Composted poultry manure	0	0

Key Findings

- Applications of poultry manure to horticultural crops either as preplant or sideband produce on average 200,000 and 42,000 stable flies per hectare respectively.
- In addition, preplant and sideband applications of raw poultry manure to horticultural crops each produce on average 300,000 house flies per hectare.
- Rotting crop wastes, either left in the ground, or fed out to livestock can produce very high numbers of stable flies (150 per m^2 of rotting material).
- Horse manure and cattle dung produce an average of 100 stable flies per hectare (assuming a stocking rate of 2 animals/ha)
- Heaps of poultry manure can produce an average of 50 stable flies per $10m^3$, if either delivered wet or allowed to get wet on site.

Fly Breeding in Poultry Manure Heaps

Tunnel houses made of fine, white mesh were erected over poultry manure heaps to determine fly breeding levels in poultry manure heaps on grower properties. Providing poultry manure was delivered dry and the heaps were located away from the range of sprinklers, very little fly breeding was found, however in situations where the manure was delivered wet, the heaps provided a significant source of fly breeding. The results from this work are provided in Appendix 5.

Key Findings

- There is evidence that raw poultry manure is being delivered to growers already struck with flies (mainly house flies and also stable flies).
- Large numbers of house flies and to a lesser degree stable flies are capable of developing in manure

heaps after delivery if they become wet.

Fly Breeding in Livestock Manures and Manure-Based Products

Fresh manure/dung was collected from cattle, horses, poultry broiler sheds and poultry egg-layer sheds. The broiler shed litter consisted of poultry manure and jarrah sawdust mixed together, whereas egg-layer manure approaches 100% poultry manure (with some rotting carcass, eggs and feathers). The cattle and horses from which dung was collected had not been treated with anti-parasitic drugs during at least the previous 10 weeks. Residues of these drugs are excreted in the animal's faeces, which are lethal to fly larvae for up to 10 weeks post-injection). Each manure type was thoroughly homogenised and exposed in the field for 48 hours as uniform 1 L pads (see Exposed Dung Pad Trial System, Appendix 6). The poultry manures had water added to make the dung up to between 40-70% moisture content. No water was added to either the cattle or horse dung.

Table 3. **Average numbers of house fly and stable fly emerging from 1 litre pads of various livestock manures and composted manure products.**

Resource	House fly	Stable fly
Poultry litter (40% m.c.)	<1	0
Poultry litter (50% m.c.)	7	0
Poultry litter (60% m.c.)	29	0
Poultry litter (70% m.c.)	786	0
Caged bird manure	247	<1
Horse manure	0	0
Cattle manure	0	0
Dynamic Lifter	14	0
Multigrow	38	<1
Compost (poultry manure)	<1	0
Compost (pig manure)	0	0
Nutrapel Plus	35	0
Biosolids	0	0
Landscape Mix	<1	0

m.c. = moisture content

Key Findings

- Raw poultry litter is a major source of house fly breeding when moist.
- Horse and cattle manure (under normal paddock regimes) are poor breeding sites for house flies and stable flies.
- Moisture content (m.c.) of poultry litter has a major impact on fly breeding, and needs to be >60% m.c. for optimal fly breeding to occur.
- The results confirm that composted manures do not breed flies.
- The extremely low levels of stable fly breeding in the poultry litter are probably due to the manure only being exposed for 48 hours (see next section).

7.1.2 Processing Poultry Manure

The failure of 'best practices' to adequately reduce fly breeding associated with the use of poultry manure in horticultural production resulted in the evaluation of manure processing options

Milled Litter

Numerous observations confirm that fly larvae are breeding in large clumps of poultry manure that are exposed at the soil surface. Fly larvae were found in the large clumps of manure more so than in fine, powdery manure that is thinly spread and mixed in with the soil. On average, over 3 times more larvae are found in large clumps of poultry manure compared with fine manure mixed in with the soil. For this reason, trials were completed comparing clumpy poultry litter with litter that had been put through a 50 mm mesh screen (milled) in both sideband applications (two trials) and preplant applications (two trials). In the sideband application, counts were made of fly larvae at 3 and 6 days after manure application. Three methods of sampling were used, in each plot. (a) Fly larvae were counted in eight of the largest manure clumps visible in each plot(12 replicates); (b) fly larvae were counted in 4 x 30 cm strips chosen at random in each plot; and (c) adult fly emergence was measured using one square metre emergence traps (10 per treatment).

Table 4. Average % reduction in the numbers of either fly larvae or adult flies developing in milled poultry litter relative to raw, lumpy manure when assessed at 3 and 6 days post-application. The average number of flies emerging per square metre of manure are included.

Manure Application	Fly Larvae	Adult Flies	Adult Fly Emergence
Sideband	55	58	301
Preplant	95	44	280

Key Findings

- Removing large lumps from poultry litter reduced the numbers of fly larvae by an average of 55% in sideband applications and 95% in preplant applications.
- Adult fly emergence was reduced in sideband and preplant applications of milled poultry manure by an average of 58% and 44% respectively.
- Although milled manure reduced the numbers of adult flies developing relative to raw, lumpy manure, the numbers of flies emerging were unacceptably high (approx. 300 flies/m^2).

Conditioned Poultry Litter

Poultry litter conditioning involves putting it through a composting process without the addition of other carbon rich materials such as straw. Conditioning involved daily turning and watering of a 300m^3 windrow of poultry manure using tractor mounted windrow turner. This equipment used in this process was identical to that used when making full compost. The manure was heavily watered during the first 3-5 days of the process, and no additional material was added to the raw poultry manure.

At varying intervals after conditioning of the manure had commenced, samples were taken from the windrow (one shovel at each of 4 equidistant locations on each side of the windrow and thoroughly homogenised) prior to exposure in the field for assessment of fly breeding. Small subsamples were sent to the WA Chemistry Centre for chemical analysis (pH, % moisture content, %nitrogen (dry weight) (dw), %ammonium (dw), %nitrate (dw), %potassium (dw) and % phosphorus (dw).

The conditioning process was then modified to incorporate the manure being turned either once per day (±extra watering) or turned twice per day (±extra watering) in an effort to speed up the conditioning process. This commenced in March 1998 where the manure was conditioned up to 3½ weeks. This manure was exposed to flies using both the Exposed Dung Pad Trial System and replicate 1m strips of manure within and adjacent to existing crops so that they received normal watering regimes.

Samples collected from the first batch of conditioned manure (0-6½ weeks) were exposed in the field to flies on both horticultural and livestock properties using the Exposed Dung Pad Trial System (5 trials). In each of these trials, manure conditioned for more than 3 weeks reduced fly breeding by 90-100%. After more than 5 weeks conditioning, there was virtually no fly breeding evident.

Table 5. Mean numbers of adult flies developing from 1L pads (n=10) of conditioned poultry litter exposed for 48 hours, and the % reduction in fly breeding relative to raw poultry litter. Results presented are the summary of five trials.

Weeks Conditioned	Total	% Reduction
0	526	-
1	130	60
1½	17	71
2	40	74
2½	12	80
3	20	95
3½	26	98
4	2	96
4½	4	93
5	0	100
5½	1	98
6	0	100
6½	0	100

Subsequent trials using 2 separate batches of poultry manure conditioned out to 4 weeks and exposed in replicate 1m strips within and adjacent to existing vegetable crops produced more variable results (see Figures 1 and 2 below).

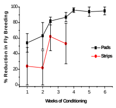


Figure 1. Percent reduction in fly breeding (mean±standard error) in poultry manure conditioned from 1-4 weeks with daily turning.

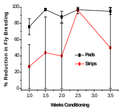


Figure 2. Percent reduction in fly breeding (mean±standard error) in poultry manure conditioned from 1-4 weeks with twice daily turning.

Chemical Analysis of Conditioned Poultry Manure

Samples of conditioned poultry litter used in the first series of Exposed Dung Pad Trial System exposed on horticultural and livestock properties were analysed for pH, % moisture content, % total nitrogen, %ammonium, %nitrate, and % phosphorus on a dry weight basis (dw).

Table 6. Chemical analysis of samples of poultry litter conditioned for 0-5 weeks and exposed as 1L pads on horticultural and livestock properties to assess fly breeding.

Sample	**pH (ar)**	**H_2O %ar**	**N %dw**	**$NH4^+$ %dw**	**$NO3^-$ %dw**	**P %dw**
Raw litter	8.60	77.6	2.14	0.36	0.18	1.38
1 week cond.	8.60	74.6	2.32	0.39	0.16	1.50
2 week cond.	8.90	37.9	2.22	0.34	0.06	1.61
3 week cond.	8.80	46.5	2.32	0.26	0.07	1.89
4 week cond.	8.80	40.7	2.01	0.02	0.07	1.89
5 week cond.	8.10	31.3	2.23	0.03	0.06	2.08

ar= as received; dw= dry weight.

A further 28 samples of poultry manure conditioned from 0-4 weeks from 3 separate batches were analysed for the above listed parameters. The following figures (3 and 4) demonstrate the importance of ammonium concentration as an indicator of the completion of the conditioning process in terms of fly breeding. As ammonium levels in conditioned litter fall below 0.15% dry weight, there is negligible fly breeding (Figure 3). When averaged across different litter batches, the levels of ammonium in the litter decline over time from the commencement of conditioning (Figure 4).

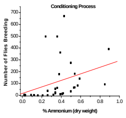


Figure 3. The relationship between the numbers of flies breeding in conditioned poultry manure and ammonium levels.

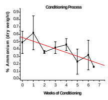


Figure 4. Ammonium levels (mean±standard error) in poultry litter conditioned for up to 6½ weeks.

In the time available from the commencement of the conditioning trials in March 1998, only limited investigations could be carried out. Initial work set out to establish the period of conditioning required to prevent fly breeding, however the trial results generated in the time available had the following limitations and concerns:

- Not enough data was generated for greater than 4 week conditioned poultry litter
- Enormous variability in both the levels of fly breeding and the fly species composition between trial sites
- Variability between different manure batches (feed regime, seasonality, litter base) was not tested.
- Trials to investigate fly breeding in conditioned poultry litter after medium to long-term storage were not carried out. There was some concern that fly breeding which occurred in stored conditioned poultry litter was the result of changes in microbial status that lead to a resumption of fly breeding rather than to inadequate conditioning.
- Application of 3½ week conditioned poultry litter as a surface dressing alongside raw poultry litter on a turf farm only reduced adult fly emergence by 8%.

Key Findings

- Poultry litter conditioned for 3-4 weeks appears to provide a second window of opportunity for fly breeding. Although the level of fly breeding in this material was significantly reduced relative to raw poultry manure (50-80%) there was considerable variation and a significant fly risk
- Delays in wetting poultry litter to around 60% moisture content need to be accounted for by extending the conditioning period accordingly
- The period of conditioning required is likely to vary with seasonal conditions, poultry litter quality and process management that may extend this period to beyond 6 weeks
- Fly breeding was virtually negligible in conditioned poultry litter with ammonium levels below 0.15% (dry weight)

- Measurement of ammonium nitrogen concentration is potentially a more reliable parameter for determining the completion of the conditioning process, than is the length of time conditioning. See Appendix 7,

Proposed Guidelines for Conditioning Poultry Litter

- Storage of conditioned manure for any length of time may result in a resumption of fly breeding
- ***There is a need to conduct work to evaluate the conditioning process over much longer time periods with different poultry litters and in different seasons. Work is also needed to assess the impact of storage on the fly breeding potential of conditioned manure***

7.1.3 Crop Waste Management

Throughout the stable fly project, samples of fly larvae found breeding in rotting crop waste have been collected from a range of situations. Stable flies were recovered in almost every situation (see Table 7 below). On 60% of the situations, greater than 90% of flies bred from the rotting vegetable matter were stable flies (Table 7).

Table 7. Numbers of stable flies (SF) and house flies (HF) bred from rotting crop waste.

		Fly Numbers		
Crop Type	**Location**	**SF**	**HF**	**SF/m^2**
Carrots*	Gingin	71	0	20
Carrots	Gingin	112	4	100
Carrots*	Gingin	1	0	1
Carrots*	Gingin	70	0	10
Carrots	Wanneroo	34	30	15
Carrots*	Baldivis	749	4,245	200
Carrots	West Gingin	1	144	1
Carrot tops	West Gingin	33	0	600
Carrots/Onions*	Kwinana	1	121	1
Celery	Mandogalup	272	0	800
Celery	Myalup	139	0	600
Onions	Wanneroo,	11	0	25
Trashed corn	Wanneroo	53	179	300
Lawn clippings	Wanneroo	17	0	5
Lawn clippings	Mandogalup	2	6	1
Lawn clippings	Gingin	18	0	2
Lawn clippings	Bullsbrook	42	241	100
Broccoli	Kwinana	0	0	0
Cauliflower	West Gingin	52	0	400
Cauliflower	West Gingin	20	0	150
Mean				**166**

*=fed out to livestock

Crop waste case study - Myalup

A severe stable fly problem occurred on a large vegetable growing property at Myalup (50 km north of Bunbury) where they were using only artificial fertilisers. A large celery crop on the south side of the property had been abandoned after some initial harvesting, 3-4 weeks earlier. There was large amounts of harvest waste and whole plants had fallen into piles on the ground. With constant irrigation, this plant material rapidly decomposed and became rotten and slimy near the soil surface. Large numbers of stable fly larvae were found in this material.

A range of cultural and chemical options with the rotting celery (of different ages) were investigated to identify the best options(s) for controlling stable flies. This involved rotary hoeing, disc ploughing and insecticide application. Emergence traps were placed over several combinations of hoe/disc/pesticide. When the crop waste was hoed in to the ground as soon as possible after harvest and additional disc ploughing employed, fly emergence was minimal. Pesticide application reduced fly breeding even further. If the crop wastes were left to rot exposed to flies for greater than 1-2 weeks, then repeated hoe/disc treatments had little impact on reducing fly breeding.

Key Findings

- Rotting vegetable matter (crop waste, excess harvest) from several crop types can breed substantial numbers of stable flies, averaging over 150 flies/m^2 of rotting material.
- Harvested crop waste (especially carrots) fed out to livestock allows stable flies and house flies to breed in both the rotting residue of carrots, dung and urine trampled together, as well as the cattle dung that is excreted containing carrot residue.
- When crop waste is rotary hoed into the ground as soon as possible after harvest and additional disc ploughing employed, stable fly emergence was minimal. Pesticide application reduced fly breeding further, but not to any great extent.
- Once decomposition of crop waste gets under way, repeated rotary hoe/disc treatments with or without pesticide application has little impact on reducing stable fly emergence.

7.1.4 Chemical Additives to Poultry Litter

Several possible chemical additives are reported in the literature to prevent or significantly reduce stable fly breeding in a range of breeding resources. Calcium cyanamide (CaCN) reduces nitrification (ammonia/nitrogen loss) from livestock manures and has been demonstrated to reduce stable fly breeding (Chamberlain,WF & Matter, JJ (1986) *Journal of Economic Entomology*, **79**: 1573-1576). Similarly, it has been suggested that stable flies breed in acidic materials such as rotting straw or lawn clippings, whereas house flies prefer a more alkaline environment (Brues, CT (1946) *Insect Dietary*. Harvard University Press. Harvard. pp. 466). Addition of lime to poultry litter should produce a more alkaline environment, which may either minimise or prevent stable fly breeding. Sodium bisulphate ($Na_4(SO_4)_2$) is a dry acid that has been used to control flies in horse barns (Sweeney *et al.* (1996). *AVJR* **57:** 1795-1798). Sodium bisulphate reduces ammonia production and suppresses bacterial growth. Both calcium cyanamide and sodium bisulphate either inhibit microbial growth or combine with and neutralise the released ammonia, which is highly attractive to flies such as stable and house fly.

To test the impact of each of these chemicals on fly breeding, trials were completed at Wanneroo and Gingin using the Exposed Dung Pad Trial System (see Appendix 6) to assess the impact of adding various levels of both calcium cyanamide and lime on stable fly development. In addition, 2 trials were completed at Wanneroo, where 3 rates of lime and 3 rates of CaCN were put out over 400m^2 plots of preplant applications of poultry litter. Adult fly emergence from each treatment plot was monitored using emergence cages. Finally, a trial at Mandogalup examined the addition of sodium bisulphate to poultry litter on adult fly development.

Calcium Cyanamide and Lime

Using the Exposed Dung Pad Trial System , there was a clear dose response in the numbers of house fly developing from poultry litter with increasing levels of calcium cyanamide (CaCN). At levels greater than 5g CaCN per kg of poultry litter, there was a 100% reduction in fly breeding in two separate trials. Similarly, addition of 5g lime per kg of poultry litter reduced house fly numbers by more than 90%.

Two trials assessed the addition of 100, 200 and 400kg/ha of either CaCN or lime to preplant applications of poultry litter. The CaCN and lime were applied by marshal spreader over the preplant manure application and immediately watered by overhead irrigation prior to incorporation of the litter into the soil. Five emergence cages were placed over each treatment plot until adult fly emergence was complete. In the first trial (March '98), the data collected was incomplete as some traps were damaged, however, the CaCN and lime applications reduced stable fly emergence by an average of 46% and 54% respectively. However, there was not a clear dose-response between levels of CaCN and reductions in stable fly emergence. The CaCN In the second trial (April '98), all 5 replicate traps from each treatment were collected, however, stable fly numbers across all treatment groups were very low as the trial was carried out in May, when stable fly populations had declined dramatically.

Sodium Bisulphate

Although the data is not presented here, all treatment levels of sodium bisulphate (1g/kg - 40g/kg) had no impact on fly breeding, with several thousand flies being produced in every treatment group.

Key Findings

- The addition of more than 5g CaCN per kg of poultry manure resulted in a 100% reduction in fly breeding using the Exposed Dung Pad Trial System.
- Similarly, the addition of more than 5g of lime per kg of poultry manure resulted in a significant reduction in fly breeding.
- Addition of sodium bisulphate to poultry manure did not result in any reduction in fly breeding.
- Addition of either CaCN or lime to preplant applications of poultry manure reduced adult fly emergence by an approx 50%, but without a clear dose-response and an acceptable reduction in fly breeding.
- There is clear evidence that addition of calcium cyanamide can have a significant impact on fly breeding, however its addition to raw poultry litter on a large scale would create considerable occupational health and safety concerns because of its nature and this product is no longer commercially available in Western Australia.

7.1.5 Insecticide Evaluation

Early in the project's development, vegetable growers reported that they were able to control fly larvae with a range of insecticides that they were using for general insect control. This suggested a possible avenue for controlling fly breeding, particularly when poultry litter was side banded. The results from trials and assessments of grower applications are provided in Appendix 8. Information on insecticides registered for use against flies in Western Australia is also provided in Appendix 9. The key findings from this evaluation were:

Key Findings

- There was no reduction in adult fly development when fly larvae were treated with either trichlorfon, dichlorvos or fipronil
- Of the insecticides registered for use against fly larvae in manure and waste products, only triflumuron and diazinon had any significant effect.
- Even when applied at the recommended rate, grower applications of insecticides registered for use against fly larvae have little impact (average of 27±10% larval mortality).
- Insecticides are unable to significantly impact on fly larvae, due to the larvae avoiding chemical contact when in and under large clumps of poultry manure.

7.1.6 Stable Fly Control on Cattle

A total of 150 cattle from 6 properties located in the Shire of Gingin were used to conduct 2 trials (Trial 1 and Trial 2) to compare the repellency effects of Optimizer® (active ingredient 200g/kg diazinon) and Python® (active ingredient 100g/kg zeta- cypermethrin and 200g/kg piperonyl butoxide) eartags against stable fly on cattle.. Three properties were located in the Gingin Brook area and 3 from a region 10 km north of the Gingin townsite. At each location 25 cattle were used in each treatment (Optimizer eartags (Treatment 1), Python eartags (Treatment 2) and no eartags (untreated). Cattle used in all treatments were female and male castrates. Eartags were inserted via an applicator into both ears of all cattle used in the trials. Farmers inserted the eartags as per the instructions on the label.

Fly Counts

Counts were made between 10.00am-12.00pm, daily for the first week and then weekly for another 13 weeks with the last counts at day 101. The number of stable flies on one side of cattle (N = 10) within a 2 minute period on each day were counted by an observer using binoculars.

Statistical analysis of the results from the first trial, using least significant differences, showed that the number of stable flies on cattle treated with Python were significantly less than the number of stable flies on the untreated cattle ($P < 0.05$).

In the second trial, there was a significant difference between all treatments ($P < 0.05$) with the number of stable flies on cattle treated with Python being significantly less than the number of stable flies on both the untreated and Optimizer treated cattle ($P < 0.05$). There was no difference in stable fly numbers observed on cattle treated with Optimizer and untreated cattle (see Table 8 below).

In both trials the variance was significantly different between treatments ($P < 0.001$) and demonstrated that on days when stable flies were at high densities, Python treated cattle were less affected. Optimizer had a reduced effect.

Table 8. Numbers (mean±standard error) of stable flies counted on cattle treated with either Python or Optimizer ear tags.

	Untreated	Python	Optimizer
Trial 1	7.2±1.3	4.4±0.7	5.8±0.8
Trial 2	14.5±2.5	4.9±0.9	10.8±1.6

Key Findings

- The number of stable flies on cattle treated with Python ear tags were significantly less than on untreated cattle
- There was no difference in stable fly numbers on either untreated cattle or cattle treated with Optimizer
- When stable flies were at high densities, Python treated cattle were significantly less effected than either Optimizer treated or untreated cattle.
- The Python ear tags were able to reduce stable fly numbers down to a level there were no obvious signs of distress in the cattle.
- The Python ear tags could be expected to keep stable fly numbers down for up to 12 weeks in the field.

7.1.7 Sequence of Fly Species Breeding in Ageing Poultry Litter

Poultry litter was exposed successively to flies every 2 days as it aged after a surface dressing application. Plastic boxes (35cm x 30cm) surrounded the surface dressing applications and fine mesh lids prevented fly oviposition (egg-laying) on the litter. The boxes covering the litter received a watering regime typical for a vegetable crop. Every 2 days (up to 2 weeks), 6 replicate boxes (randomly chosen) had the fine mesh lids removed to allow flies the opportunity to lay eggs on the litter. Forty-eight hours later, the infested litter was returned to the laboratory and all fly larvae reared to adult flies for counting and species identification. Figure 5 on the following page shows the relative numbers of house fly and stable fly breeding in poultry litter of different ages.

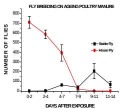


Figure 5. Mean numbers (±standard error) of stable flies and house flies breeding in poultry litter aged from 0-14 days after application onto the soil.

Key Findings

- House flies breed predominantly in fresh poultry litter up to 4-7 days after being applied to the soil
- Stable flies prefer to breed in poultry litter that has aged for at least 4-7 days after being applied to the soil.

7.2 Best Practice Development

Central to the achievement of the Stable fly Management Projects objective is the development and implementation of best management practices that are able to address stable fly breeding associated with horticultural and livestock industry practices.

The principal of best practice management of stable fly breeding associated horticultural/agricultural production was to be based on three steps:

- identify existing and develop new practices that prevent or manage breeding within acceptable levels;
- inform growers about best practices and how to apply them;
- apply appropriate regulations in a consistent, coordinated manner to encourage rapid adoption of ‘best practices’.

7.2.1 Horticultural Best Practices

Priority was placed on developing best practices for the use of poultry manure in vegetable production and the initial version titled ‘Best Horticultural Practices for Managing Fly Breeding and for the Storage and Use of

Poultry Manure' was presented to industry at three regional meetings in late February, early March 1996. This document also dealt with strawberry production.

They were based on aspects of a 'Draft Environmental Code of Practice for the Use of Poultry Litter in the Horticultural industry', that had been prepared by the Department of Environmental Protection and they were developed to:

- deal with other sources of stable fly breeding, such as rotting crop wastes;
- incorporate best industry practice that was identified in the 'Survey of Poultry Manure Usage in Vegetable Production' which had been completed earlier in 1995;
- further refined them in conjunction with the Horticultural Industries Stable Fly Management Working Group that was formed in late 1995;
- release them to industry at regional meetings held in Gingin, Wanneroo and Kwinana ;
- involve Local Government Environmental Health Officers

These 'best practices' have continued to be developed. The second version, 'Best Crop Production Practices for Managing Fly breeding and for Using Manure' were expanded to deal with other horticultural industries, including fruit and turf production and were released at a similar manner in early 1997

These 'best production practices' advise on:

- Storage of manure
- Use of manure;
- Managing crop wastes in the paddock;
- Disposal of harvested crop waste;
- Chemical control of fly breeding;
- Monitoring fly breeding;

A brief summary of the information provided in the Best Crop Production Practices for Managing Fly breeding and for Using Manure' is provided in Appendix 10.

7.2.2 Agricultural Best Practices

Livestock Best Practice

In most parts of the world, stable fly problems are usually associated with intensive animal industries and practices relating to manure and feed management. In Western Australia, stable fly breeding associated with animal and poultry industry production has not been identified as a significant contributor to the stable fly problem. Stable fly breeding has been found in the dairy industry and occurs in sectors of the horse industry when hygiene and management practices allow manure and or feed as well as other organic materials such as bedding to accumulate and decompose.

In the cattle industry, feedlotting is probably not sufficiently intense to create stable fly breeding situations although there have been notable outbreaks of stable fly at Northampton (80km north of Geraldton), Baldivis, Gingin and Wanneroo all in association with vegetables being fed out to livestock.

Stable fly breeding has also been associated with poorly managed waste settling ponds at piggeries near Perth.

Draft Livestock Production Practices for Managing Fly Breeding have been prepared but not finalised, reflecting their relatively minor contribution to the stable fly problem.

Poultry Industry Best Practice

In the Broiler industry, stable fly breeding occasionally occurs when manure is left around load-out areas, or escapes around the edge of poultry sheds. Feed spills that become wet as well as wet manure within sheds has also been found to breed stable fly. Shed washout effluent disposal systems can also breed stable fly. Stable fly breeding is not associated with the egg production facilities although other fly breeding (house fly and lesser house fly) can be significant if hygiene is not practiced.

The poultry industry was on the first agricultural industries to develop a voluntary code of practice. Although this code does not deal with manure management and disposal, it does set strong general management standards that contribute to the low levels of stable fly breeding associated with this industry. These codes are currently being updated and manure management and disposal will be included and it will reflect the findings and recommendations from the Stable Fly Management Project. These findings are summarised in the Report on Survey of Poultry Broiler Farms carried out in late 1996 that is referred to in the section on Regional surveys in this report.

The significance of stable fly breeding associated with the current disposal of poultry manure in crop production has not been over looked. The formation of the Poultry Industries Stable Fly Management Working Group and their recommendation for engagement of a consultant to make recommendations for the treatment, utilisation and disposal of poultry manure indicates clearly, a recognition of their responsibility and role in solving the stable fly problem.

7.3 Legislation

The Stable Fly Legislative Working Group was established to identify a legislative framework from existing regulatory instruments to assist the successful implementation of the Stable Fly Management Project's initiatives and recommendations. This group has developed a framework of legislation based on the premise that for poultry manure to continue to be used in crop production in Western Australia , it will have to be processed or treated so that it will not breed flies. This framework includes other options as part of an overall strategy to control Stable fly and the group has considered the following issues.

7.3.1 Regulating manure transport

The Poultry Industry has given a commitment to apply self regulation and ensure that all poultry manure is removed from poultry farms by 'industry' authorised contractors and is delivered to a licensed processing plant. This is to be done through contractual arrangement between processors and poultry growers. Therefore it is not proposed to regulate the removal and transport of poultry manure. However in the event of individuals or sectors of the poultry industry failing to comply with industry self regulation, regulation will be introduced under the Offensive Trade Provisions of the Health Act (1911) or the Environmental Protection Act.

7.3.2 Establishment of Manure Treatment Works

Siting of manure treatment works have been difficult because of odours and fly problems. A manure treatment works is defined as an Offensive Trade (Manure Works) under the Health Act and would need to be licensed by the relevant local government accordingly. Part of the application process would require local government planning approval and this process often restricts their location to certain zones.

In an attempt to provide guidance on these issues to industries and local government planners, the Department of Environmental Protection has issued a discussion document on 'Guidelines for the storage, processing and recycling of organic wastes.

Premises where poultry manure is stored and processed with a production capacity of 1000 tonnes per year, is deemed to be a prescribed premises under the Environmental Protection Act. A proposal to establish a treatment facility would be subject to a formal assessment by the Department of Environmental Protection and require issue of a works approval and licence to operate. The Department of Environmental Protection will explore the possibility of regulatory instruments to set certain specifications for the finished product to ensure it is acceptable for land application. They have also undertaken to provide extra guidance on the issues relating to the development of manure treatment works.

The working group also recognised the need to address

- the need for buffer zones to minimise odour impacts and the
- need for regulatory controls on treatment facilities for odour, noise and dust.

7.3.3 Upgrading Penalties for Fly Breeding

It has been recognised for many years that the fines under the Fly Eradication Regulations are too low to act as a deterrent. Because of this, many Local Governments have been reluctant to initiate prosecutions. It is therefore proposed to seek an amendment to the Health Act to introduce a more appropriate level of fines. A further option to be investigated, is whether infringement notices could be introduced in addition to the primary penalties. A number of options to increase penalties have been considered by the working group and they include to:

- Remove the existing penalties under the Regulations and revert to using the general penalty provisions under the Health Act. This would be the easiest way to increase the penalties, in that it would not be necessary to amend the Health Act. However the difficulty with this option, is the need to justify a large increase in penalties from a current maximum of $1,000 under the Regulations to a maximum of $10,000. On considerations of equity across the community, this would be hard to justify.

- Introduce a more appropriate range of fines under the Regulations eg. from $750 to a maximum of $5000. This level of increase would be easier to justify, but would require amendment to the Health Act. Because fly eradication is not seen to be a 'pressing' public health issue, it may take some time for the necessary amendments to be introduced.

- Introduce a new range of penalties as exampled above and at the same time, introduce infringement notices over and above the primary penalties. The concept of infringement notices has considerable merit, in that it allows for 'on the spot fines' similar to a traffic or parking offence. This concept would also reduce the number of costly and time consuming legal proceedings in taking prosecutions and free up the time of Local Government Environmental Health Officers.

- Delete the existing penalties and introduce a split system ie., one for residential situations and a higher scale for commercial entities ie., market gardens. This could also incorporate the use of infringement notices. A split penalty arrangement may be seen to be the more preferred and equitable way of setting penalties under these Regulations.

The last three options would require amendments to the Health Act. For the reasons mentioned above, such amendments would be unlikely to receive a high priority on the Governments' legislative programme and would therefore be difficult to implement within a reasonable time frame.

Before pursuing any of the options, further advice would need to be sought from the Health Department's Legal Administration Branch.

7.3.4 Formalising Industry Best Practices

A further strategy is to review and update the Best Practice document which was developed by the Crop Industries Fly Management Working Group. The intention being to have the document formally accepted by relevant industry groups as the standard they agree to adopt. These Best Practices could then be used by Local Government Environmental Health Officers when enforcing the Fly Eradication Regulations.

7.4 Biological Control

The option of using biological control agents (BCA's) against stable fly was not pursued during the lifetime of this project, primarily because of the long term nature of such these solutions and secondarily because many of the agents are not available in Australia. Another difficulty with maintaining BCA's against stable fly in the horticultural industry is their high usage of a broad range of insecticides, that are likely to adversely impact on these agents. Although progress has been made overseas, the effective biological control systems tend to apply to intensive feedlot situations, where large numbers of animals are housed (in excess of one hundred thousand). The black dump fly *Hydrotaea aenescens* (formerly *Ophyra leucostoma*) is one example of a BCA that has been used since the early 1980's for fly control (mostly house fly) in swine and poultry houses. Black dump flies are sold commercially in the United States, Canada and Europe, and have been used predominantly in the midwestern United States. Parasites purchased from commercial insectaries for release in a particular geographic area, must be naturally adapted to that area if the parasites are to succeed. In addition, the process of brining in exotic insects through quarantine procedures in Australia and testing for host specificity before release costs in the order of $1 million per species.

Key Findings

- The option of using biological control agents against stable fly was not pursued because these are not available in Australia and are a long term option.

7.5 Development of Equipment

With the need to characterise the nature and extent of the stable fly problem as quickly as possible, there was an urgent need to develop traps and techniques that could be used in various field situations and that would require limited servicing as well as rapid assessment of fly numbers. Consequently a number of traps, devises and assessment techniques have been successfully developed including emergence cages and the Exposed Dung Pad Trial System. These are all detailed in Appendix 6.

8.0 Summary and conclusions

The Stable Fly Management Project has quantified sources of the stable fly breeding and particularly those associated with horticultural and livestock industries and has developed management practices and other strategies to address stable fly breeding.

However work remains to be done to ensure industry adoption of those practices and this is the challenge facing the Stable Fly Management Steering Group and the Stable Fly Management Project team over 1998/99.

Progress and findings of the Stable Fly Management Project are discussed under the following headings:

- Communication and community involvement.
- Sources of stable fly breeding.
- Investigation and development of Horticultural and Agricultural Practices.
- Best Practice Development.
- Legislation
- Biological Control.
- Alternative Uses of Poultry Manure

8.1 Communication and community involvement

The extensive communication program and the development of a number of working groups under the Stable Fly Management Steering Group has facilitated much of the progress achieved.

Outcomes:

- Clarified and quantified the sources of stable fly breeding and created an acceptance of the role played by the industries involved
- Provide the industries involved with opportunities to voice their concerns and requirements
- Collected and provided information to wider rural communities
- Developed and maintained effective communication with the principal industry groups, specifically horticulture and the poultry industry

8.2 Sources of Stable Fly Breeding.

Identifying and quantifying sources of stable fly breeding has been critically important to achieving the Stable Fly Management Project's objective. The results have enabled all stakeholders in the stable fly problem to develop a common, more consistent view of the importance that each plays in contributing to stable fly breeding.

Outcomes:

- The major cause of the stable fly problem is the use of poultry manure in crop production, principally in vegetable, turf and strawberry production
- Other sources of stable fly breeding are associated with the disposal of unharvested and unmarketable crop waste from mainly vegetable, but also from turf production, which have potential to cause significant, but less frequent outbreaks
- Vegetable wastes fed to livestock which can also provide a significant source of stable fly breeding
- Feeding, (including silage manufacture) and manure disposal in intensive animal production
- A wide range of activities including all forms of organic waste disposal, urban and rural gardens, poultry sheds (including domestic), piggery treatment ponds, biosolids and any site where organic materials can accumulate and break down
- Stable fly breeding has not been found in association with wetlands and with livestock manure in dry paddocks

8.2.1 Poultry Manure Use in Horticulture

The main features of current poultry manure use are that:

- Best crop production practices for the use of raw manures in crop production (*Best Crop Production Practices for Managing Fly breeding and for Using Manure - March 1997*) will not prevent significant stable fly breeding.
- Current prices of around $10/m^3 for poultry litter, compared to $16/m^3 some years ago reflects falling demand, presumably as growers respond to growing concern with fly breeding.
- Over 70% of growers continue to use poultry manure because of its fertiliser value (in the order of $170 per tonne cheaper than the equivalent cheapest artificial fertilisers (*Report on Options for the Disposal and Utilisation of Poultry Manure 1998*) and many believe that it provides additional benefits in terms of crop quality that are not provided by artificial fertilisers.
- The current lack of approved manure storage/distribution sites and possible capital investment requirements for such sites have potential to adversely impact on future poultry manure disposal in crop production.
- Most of the poultry manure produced in Western Australia is used on vegetable and to a lesser extent, turf and strawberry production around the metropolitan Perth region
- Poultry manure is also used on a range of tree and vine crops where it is mainly applied in late winter. While its contribution to stable fly breeding at this time is relatively small, it must be accepted that this use does contribute to the problem and that it can potentially encourage stable fly into areas where it has not previously existed.

The greatest use of poultry manure in vegetable production is associated with pre-plant soil incorporated applications. Despite incorporation reducing the amount of manure that flies can breed in, field sampling and emergence trap data confirms that this manure application is the largest source of fly breeding.

Surface post-plant application, common with a number of vegetable crops and turf production also breed large numbers of flies (Table 2) and is a more readily visible source of stable fly breeding.

Poultry manure heaps, probably because of their visibility, have been targeted as a significant source of the stable fly problem. Providing that they are located away from sprinklers and the manure is delivered dry, they represent a relatively minor source of stable fly breeding. However as regional surveys particularly in Wanneroo indicate, the reality is that many manure heaps are placed within the range of sprinklers and are therefore breeding large numbers of both stable fly and house fly.

A number of growers have installed hard stand storage areas and some cover their manure, although in most situations coverage is inadequate. However most growers continue to be reluctant to invest in manure storage facilities and they argue with some justification, that this is not the real cause of the problem. They also contend that covering large manure heaps is very difficult and not feasible

Outcomes:

Achieving the Stable fly Management Projects final objective, which is to reduce stable fly breeding to levels that no longer impact on rural industries and communities, cannot be achieved unless

- poultry manure is treated so that when used in horticulture, it will not breed flies or
- the poultry industry finds an alternative uses or means for disposing of this product

In addition to the stable fly problem, the possibility for some health concerns to be associated with the use of untreated poultry manure in fresh food production, have been raised. Testing has indicated that there is no risk and this is because most untreated poultry manure is applied prior to crop establishment or it is banded on the soil surface at an early stage of crop growth.

However there is a likelihood that in the future, the use of raw untreated poultry manure in the production of fresh food, will not be acceptable if HACCP (Hazard Analysis Critical Control Point) guidelines are introduced for the production of fresh food.

The use of conditioned or composted manures that comply with the Australian Standards for ‘Composts, Soil Conditioners and Mulches’ AS 4454‾1997, would address this requirement.

8.2.2Horticultural Crop wastes

Serious stable fly outbreaks occur with unharvested crop wastes, crop wastes being fed to livestock, and uncovered waste pits, however in terms of the overall problem, they tend to be isolated and infrequent.

Vegetable waste pits and small decomposing heaps of unmarketable produce will breed very large numbers of stable flies. Burying and covering daily, with at least 50 mm of soil will effectively control this problem. In future, the delivery of crop wastes to commercial composting operations, will become increasingly possible.

In the paddock, unharvested leafy vegetable crops such as celery, brassica crop and to a lesser extent, lettuce have greatest potential to breed stable flies. Unharvested carrots will also breed stable fly (see Table 7) while melon and cucurbit crops are not a stable fly and house fly problem and generally breed flies that are less common and not particularly troublesome.

Outcomes:

Stable fly breeding associated with crop wastes from horticulture can be managed to acceptable levels by the application of the following management practices:

- Slash and thoroughly incorporate crop waste within 3 to 4 days of harvest and in situations where considerable volumes of crop trash exist, such as when the crop has been incompletely harvested, apply a second cultivation within 7 to 8 days of harvest
- Ensure that crop waste fed to livestock is spread out thinly, so that very little is trampled into the soil
- Cover vegetable waste pits daily with at least 50 mm of soil

8.2.3 Livestock and Poultry Production

Stable fly breeding is not found in many animal manures (Tables 2 and 3), although breeding will occur when these manures are mixed with organic matter, such as straw, green feed and other feeds such as grains.

Animal industries, are minor sources of stable fly breeding, however in intensive situations, continuing vigilance and application of generally accepted hygiene/manure disposal practices must be maintained. If intensive feed lot cattle production increases, then attention to manure disposal/management will become increasingly important.

The poultry industry itself also needs to be vigilant because instances of careless shed clearing leading to a build-up of wet manure, spillage of feed and inadequate waste water management have led to fly breeding. The management of watering and cooling systems is critically important to maintaining dry poultry litter, which inturn is important for the productivity of both broiler and breeder sheds.

Inadequate management of piggery sludge ponds, and silage manufacturing can also lead to stable fly breeding.

Outcomes:

Stable fly breeding associated with animal and poultry production will be adequately controlled by the application of best practices. Because the failure to apply these best practices will directly impact on the health and welfare of the livestock, the involvement of the Stable Fly Management Project in their adoption is not considered to be warranted.

8.2.4 Other Stable Fly Breeding Sites

Our survey work has indicated that unless cattle manure is mixed with decaying vegetation, no stable fly breeding occurs in wetland areas. Similarly, animal manure deposited in paddocks is associated with bush fly (*Musca vetustissima*), rather than either stable fly or house fly breeding.

8.3 Investigation and Development of Industry Agricultural Practices

The principal intention of the Stable Fly Management Project was to investigate the management practices associated with the horticultural and agricultural industries that were contributing to the stable fly problem and then to identify how they could be changed to reduce this breeding to acceptable levels for the livestock industries and the community.

8.3.1 Insecticides to Control Fly Breeding

This was one of the first options investigated. Apart from a limited range of insecticides specifically registered for fly control (Appendix 9), there are a large number of insecticides registered for use on horticultural crops. Field trials and the Exposed Dung Pad Trial System indicate that only triflumuron and diazinon had any significant effect and that while individual growers may achieve good larvae kills occasionally, their overall effectiveness was very low, (less than 27% average larval mortality, Table 7).

Outcomes:

Even if insecticides were available that could adequately reduce fly breeding, this would not be an acceptable long term approach because:

- Both the stable and house fly have a demonstrated ability to rapidly develop resistance to insecticides
- Horticultural industries are seeking to reduce, not increase their use of insecticides

8.3.2 Poultry Manure Treatment Options

The need for poultry manure to be treated so that it would not breed flies when it is used in crop production and findings from previous field programs, resulted in a field evaluation program during 1997/98 to investigate the effectiveness of several treatment options, namely:

- hammer milled raw manure;
- Chemical additives including calcium cyanamide, sodium bisulphate and lime.
- conditioning poultry litter - composting the manure without the addition of other organic material such as straw.

Milled Poultry Litter

Investigations into possibilities for removing clumps from poultry manure prior to its land application for crop production came from repeated observations that fly larvae were invariably associated with clumps of poultry manure/litter. It was felt that clump free manure could be used in pre-plant situations because it would be readily distributed through the soil and would not provide clumps of poultry manure for egg laying.

Poultry litter was put through a hammer mill and screened to provide clump free poultry litter for trial purposes.

Outcomes:

- Removing clumps from poultry manure did not reduce fly breeding sufficiently to warrant consideration as a treatment option and there was the added concern that unless stored so that it was kept dry, the manure would loose its clump free condition

Chemical additives to poultry manure

Literature reviews indicated that the addition of calcium cyanamide and sodium bisulphate to poultry manure offered potential for preventing stable fly breeding. Lime, which would raise the manure's pH, was also included because of research articles suggesting that stable fly breeding may be reduced by increased pH (i.e., a more alkaline environment).

Calcium cyanamide was available as a nitrogen based fertiliser, however despite excellent results using the Exposed Dung Pad Trial System, the field evaluation was less effective, as were the addition of sodium bisulphate and lime.

Outcomes:

- Calcium cyanamide is no longer being sold in Western Australia and its nature would provide occupational health and safety concerns if it were to be used with poultry manure. Lime and sodium bisulphate were insufficiently effective to be considered

Conditioning poultry litter

Conditioning poultry litter involves applying the composting process to poultry litter without the addition of other organic matter.

The possibility for conditioning arose from information provided by Dr Harrie Hoitink from Ohio State University in the United States and initial semi-commercial trials suggested that fly breeding was reduced to very low levels after three to four weeks of conditioning (Table 5). Based on this, larger scale commercial conditioning started and was based on a four week turn around time between manure delivery and conditioned manure dispatch.

Agriculture Western Australia continued to field test these commercial batches of conditioned poultry litter and to have them analysed for nitrogen (total, ammonium and nitrate forms) as well as total phosphorus, pH and moisture content.

Results with the commercial product has been extremely variable and has generally bred considerable numbers of flies. Investigations showed that when large scale conditioning commenced, some changes occurred in the process management procedures. These changes and other factors that resulted in the poultry litter being insufficiently conditioned are that:

- the poultry litter was only turned daily - whereas in the initial trial batches, better conditioning results were obtained with twice daily turning;
- poultry litter was conditioned for 21 to 28 days from the time of delivery;
- poultry litter is difficult to wet so that without additional effort such as additional turning, wetting to 60% moisture content takes several days;
- commercial conditioning was initiated during cooling weather conditions which may also necessitate longer processing times;

These considerations clearly indicate that the manure was receiving no more than 3 weeks of conditioning, if the time is measured from when it is likely to have reached the required 60% moisture content.

The literature and analysis of ammonium nitrogen levels in conditioned manure indicate that fly breeding is related to ammonium nitrogen levels and that on present results, ammonium nitrogen levels below 0.1% on a dry weight basis will prevent fly breeding (Figure 3).

Consequently, and until further investigations indicate otherwise, poultry litter will be considered to be conditioned once its ammonium nitrogen content is 0.1% or less on a dry weight basis, in two consecutive and representative analysis that are taken five days apart. Proposed Guidelines for Conditioning Poultry litter are provided in Appendix 7.

There is also the possibility that conditioned manure will revert to a “fly breeding state” when it is stored.

Outcomes:

The conditioning process needs to be defined in terms of a measurable parameter that directly relates to its fly breeding capability. Our work to date strongly suggests that a maximum ammonium nitrogen level of 0.1% on a dry weight basis may provide this standard and it is suggested that this result will need to be repeated no less than five days later.

Conditioning is only suited to treating poultry litter which makes up around 85% of the total poultry manure production. This is because the other component of poultry manure, cage bird manure does not contain an organic bedding material which provides carbon for the composting process.

- Further work is needed to confirm that this ammonium nitrogen level requirement is adequate to ensure that the conditioned poultry litter will not breed flies;
- Work is needed to investigate the stability of conditioned poultry litter with respect to its fly breeding capability, when stored:

Work is needed to compare conditioned poultry litter’s performance with raw poultry litter on key crops in order to identify any management changes that may be needed.

Compost

Compost, made from 15 to 20 % by volume of poultry litter combined with usually straw or some other carbon rich organic waste such as greenwaste, crop waste, paper/ground wood waste is another option.

It was not investigated within the Stable Fly Management Project’s field work because it is known that it will not breed flies (providing composting has progressed to the end of the thermophilic phase) and that the use of composts in horticulture is being developed within a separate Agriculture Western Australia project. Compost is seen as another option for managing fly breeding associated with the use of poultry manure. However, composting would produce four to five times the volume of product because it only requires 15% to 20% of poultry manure by volume. Composting also requires a greater level of process management;

Compost has different properties compared to poultry manure and we suspect, conditioned poultry litter. Its real advantages are reduced fertiliser and pesticide requirements as well as improved soil condition. The achievement of these benefits requires repeat application of compost, whereas raw poultry manure provides much more immediate benefits, particularly in terms of nitrogen availability.

Costing treatment options

Recognising that treatment of poultry manure would increase its cost to growers, and that demand for poultry manure is very sensitive to price increases, the Poultry Industries Stable Fly Management Working Group recommended that a consultant be employed to consider options and make recommendations for the treatment, utilisation and/or disposal of poultry manure.

This was agreed to and a consultant team headed by Allan Herbert from Agriculture Western Australia's Economics unit delivered their Report on Options for the Disposal and Utilisation of Poultry Manure in late May, 1998.

In order to cost the various options, they developed the POULTMAN model, see Appendix 11.. Based on Excel spreadsheets, the model enables changes to any capital and operating costs to examined. It also calculates the relative nutrient value of manure treatment options in terms of purchasing those nutrients from the cheapest chemical fertilisers.

They identified conditioned manure as the best manure treatment option. Calculation based on the POULTMAN model suggested a price to growers of around $\$30/m^3$ and they calculated that Conditioned manure is competitive against artificial fertilisers, in terms of nutrient value at up to a price of $\$36/ m^3$ metre. They pointed out that because of its greater density, growers would apply conditioned manure at 50% of the raw manure rate so that its actual cost to growers would be around $\$15/m^3$. Using conditioned manure would therefore increase their manure application costs per hectare by around 50% compared to raw poultry manure.

The cost of compost was estimated to be around $\$50/m^3$ using the POULTMAN model or 50 to 60% more expensive than conditioned manure. However this may not be the case because the price difference will be determined by the cost of poultry manure relative to the wide range of other organic wastes that can be used in compost manufacture.

Outcomes:

- Conditioning poultry litter is the preferred short term processing option because it will produce the minimum volume of a product and because in terms of crop performance, it is likely to be similar to raw poultry manure
- Compost will have greater long term benefits that will more than compensate for any added cost and is likely to be the long term processing option
- The equipment and planning approvals necessary to establish a conditioning facility will be similar to those required for establishing a composting facility which will leave an investment in conditioning, relatively free to move into composting at some future date
- Composting will be the processing option for cage bird manure and other poultry manures that cannot be conditioned because they are not litter based
- When required, conditioning facilities can switch to composting without additional capital out lay.

8.3.3 Stable Fly Control on Cattle

Trial work has identified the effectiveness of Python® eartags which can provide up to 12 weeks relief from stable fly attack. This option provides some relief for cattle owners in the event of occasional future stable fly outbreaks

8.4 Best Practice Development

An essential step toward managing the stable fly problem is to have management practices that enable this problem to be prevented or at least adequately controlled. Best management practices adequately deal with Stable fly breeding associated with livestock including poultry industry practices as well as with crop waste situations in horticulture.

However it is clear that best management practices for using poultry manure in horticultural crop production cannot adequately deal with stable fly breeding which results in the need for poultry manure to be treated.

The importance and the need for best practices to be adopted is greatest for the horticultural industries. This is because their failure to apply best practice will directly affect the livestock industries, but not themselves. On the other hand, a failure to apply good management in the livestock industries will affectively create a stable fly problem for themselves.

The ‘Best Crop Production Practices for Managing Fly breeding and for Using Manure’ have been developed in conjunction with the Crop Industries Stable Fly Management Working Group which comprises representatives from the vegetable industry as well as the strawberry and turf industries. The endorsement of this best practice document by the various industry associations as well as relevant government agencies that have regulatory responsibility in this area will enable the adoption of these practices to be underpinned/enforced with legislation.

Outcomes:

- Best Crop Production Practices for Managing Fly breeding and for Using Manure are unable to adequately reduce stable fly breeding associated with the use of poultry manure in crop production
- Best Crop Production Practices for Managing Fly breeding and for Using Manure need to be finalised in conjunction with the various industry associations as well as the Health Department of Western Australia and the Department of Environmental Protection, when poultry manure treatment details are finalised and formally accepted
- The further development of ‘Livestock Industries Best Management Practices’ can be left to the respective industries

8.5 The Fly Problem in General

Although the emphasis and the direction behind this project was stable fly breeding and its control, it must be recognised that with the exception of pure decomposing organic matter, house fly breeding occurs in far greater numbers than stable flies (Table 2 and 3). The age of poultry litter needs to be considered (see Figure 5) when assessing data obtained on fly breeding associated with this material.

The following points are made with respect to these two major flies:

- In most situations and most of the time, house fly breeding exceeds considerably that of stable fly
- Management practices that prevent and or reduce stable fly breeding, are equally effective at controlling house fly
- Stable fly breeding is associated with poultry litter and decaying crop wastes, but not with cage bird manure (Table 3), presumably because cage bird manure does not contain organic matter such as sawdust, which makes up around 30% poultry litter
- Stable fly breeding may occur in horticulture when cage bird manure is applied in the presence of crop wastes
- In poultry litter, stable fly breeding increases as the manure ages, whereas house fly breeding is dominant when the poultry litter is fresh

- Decaying crop wastes breed stable flies almost exclusively and per metre of fly breeding resource, breed the largest numbers, however this source of stable fly breeding is much less common
- House flies represent a health risk to livestock and the community with their ability to transmit a range of diseases

8.6 Legislation

The critical aspects to managing the stable fly problem are:

- Facilitate the establishment of manure processing works at which conditioning and composting would be carried out by providing clear guidance for the establishment of these facilities
- Use the available legislation to minimise health and environmental impacts from the facility
- Underpin the adoption of best management practices with regards to managing stable fly breeding associated with crop waste management in horticulture and in livestock production
- Increase the penalties under the Fly Eradication regulations.

8.7 Biological Control

Within the term of the Stable fly Management Steering Group, options for investigating and developing biological control options for stable fly management have not been considered because:

- A number of stable fly biological agents are not present in Australia and their introduction is a long term project
- The stable fly problem in Western Australia is largely associated with horticultural industries and therefore the possibility for biological control is more difficult because of the amount and frequency of pesticides that are required

Outcome:

Biological control of stable fly in Western Australia is not an option that the Stable fly Management Project can address at this stage, and given the proposed options, may not need to be considered for some time to come.

8.8 Alternative Uses for Poultry Manure

In the Report on Options for the Disposal and Utilisation of Poultry Manure , the consultant team from Agriculture Western Australia included a brief resume of overseas options that included an estimate of return on capital using the POULTMAN model. They concluded that there is high risk for the poultry industry in directing its manure disposal efforts exclusively to one use, namely crop production and that it would be sensible to investigate a much wider range of poultry manure utilisation or disposal strategies, including:

- Methane gas production - The investment in digestion units and associated gas cleaning equipment attached to an existing co-generation power station could be a viable proposition with a possible return on capital of 13%.
- Manure for energy production - A purpose built power station fuelled by burning poultry manure supplied by sheds in the Perth region appears to be viable in providing power at current domestic charge rates and a residual ash fertiliser. The return on investment was estimated to be around 8%.
- Ethanol production - A limited analysis indicates that an integrated plant could generate a return on capital of 9% if manure is obtained free and there are no extra management costs associated with plant operation. Small scale plants that integrate the production of gas/electricity, ethanol and a soil conditioner exist in the United Stares.
- Landfill - Sites that would accept raw manure are limited, and landfill charges together with transport costs will be a direct impact on the poultry industry.

Outcome:

The poultry industry needs to undertake feasibility studies of various options available for poultry manure utilisation and or disposal

9.0 Recommendations

To achieve the Stable fly Management Projects objective of reducing stable fly breeding associated with horticulture and agricultural practices to levels that do not cause significant problems for livestock industries and the community, the Stable fly Management Steering Group recommends:

> ***Banning the application of raw poultry manure to land for either crop production or any other purpose after December 31, 1999, or earlier. After that date, only poultry manure that has been treated to prevent it breeding flies can be applied to land in Western Australia.***

> ***That in relation to horticultural and turf crop wastes, these industries will be required to formally adopt the practices as defined in the "Best Crop Production Practices for Managing Fly breeding and for Using Manure" by December 31, 1999 or earlier.***

<u>To facilitate this, the Stable fly Management Steering Group recommends that the Minister for Primary Industry and Fisheries approach the Ministers for Health, Environment, Planning and Local Government to</u>

Urgently facilitate development of guidelines for the licensing of manure processing works that will minimise costs on the facility and hence on the cost of treated manure by:

- ***establishing buffer distances and***
- ***providing adequate security within land use planning instruments to minimise future forced relocation of the manure processing works***

Support amendments to the Health Act that will:

- ***Raise penalties for fly breeding under the Fly Eradication Regulations of the Health Act (1911) to a maximum of $5,000 with a minimum fine $750 for first a offence;***
- ***Initiate a system of modified penalties that will allow infringement notices to be issued by Environmental Health Officers***

<u>The Stable Fly Management Steering Group also recommends that the Minister for Primary Industry and Fisheries:</u>

- ***Support finalising the 'Best Horticultural Crop Production Practices for Managing Fly breeding and for Using Manure' with the endorsement of the major horticultural industry associations as well as the Health Department of Western Australia, the Department of Environmental Protection and the Water and Rivers Commission, after details of poultry manure processing are finalised.***
- ***Support the use and if necessary the enforcement of best horticultural, livestock and poultry management practices to control stable fly breeding associated with the management of horticultural crop wastes (unharvested, unmarketable crop waste left in the paddock, buried or fed to livestock), livestock feed and manures.***
- ***Advise the Western Australia Chicken Meat Council, Inghams Enterprises and Steggles Ltd. of the urgent need to undertake a feasibility study into the range of options for utilisation or disposal of poultry manure, including its processing for use in crop production, as recommended in the recent consultant report from Agriculture Western Australia. The results and findings are to be referred back to the Stable fly Management Steering Group for its evaluation prior to being presented to the Ministers for Primary Industry, Health, Environment, Planning and Local Government.***
- ***Advise the Minister for Planning that the use of poultry manure in horticulture is the major cause of stable fly breeding and ask him to support the use of the Town Planning and Development Act to prevent its use in horticultural, including turf, development applications;***

- ***Seek an assurance from the Ministers for Planning and Local Government that no impediments be put in the way of Local Government taking the necessary measures, either through changes to their Town Planning Schemes or introduction of Local Laws, to assist in managing the stable fly problem at a local level.***
- ***Support Agriculture Western Australia undertaking the proposed 12 month study, providing full agency costs above the committed $25, 000 in 1998/99 are met from other sources. The study will determine conclusively if the conditioning process will prevent fly breeding, and will evaluate its performance compared to raw poultry litter in vegetable, turf and strawberry production.***

The Stable Fly Management Steering Group will regularly review progress and evaluate research undertaken by industry and make further recommendations as deemed necessary to the Minister.

10.0 List of Appendices

Appendix 1

STABLE FLY MANAGEMENT STEERING GROUP -

OBJECTIVE, TERMS OF REFERENCE, MEMBER RESPONSIBILITIES AND MEMBERSHIP

Steering group objective

Coordinate the development and promote the adoption of practices that reduce stable fly below levels that cause disruption to rural industries, and the community.

Terms of reference

The Steering Group will operate for no more than three years and will be chaired by Mr Colin Philpott. The Steering Group will:

- review progress and ensure that the necessary research and investigation projects are well coordinated, and that they address the issues and needs of all parties;
- identify responsibilities and seek commitment of resources from participating parties to achieve the control of stable fly;
- guide the development of solutions to the stable fly problem that centre on management practices in the first instance and if necessary, develop the framework for regulations;
- keep the Ministers for Primary Industry and Health and other relevant agencies fully informed; and
- keep stakeholders and the wider community informed.

Member responsibilities

Member of the steering group will:

- commit to finding solutions to the stable fly problem that recognise both the complexity of the issues and the needs of all parties involved; and
- represent their industry or organisations concerns, make resource commitments on their behalf and keep them informed of developments.

Steering group membership

A single voting members will be appointed to the working party by the Minister for Primary Industry from:

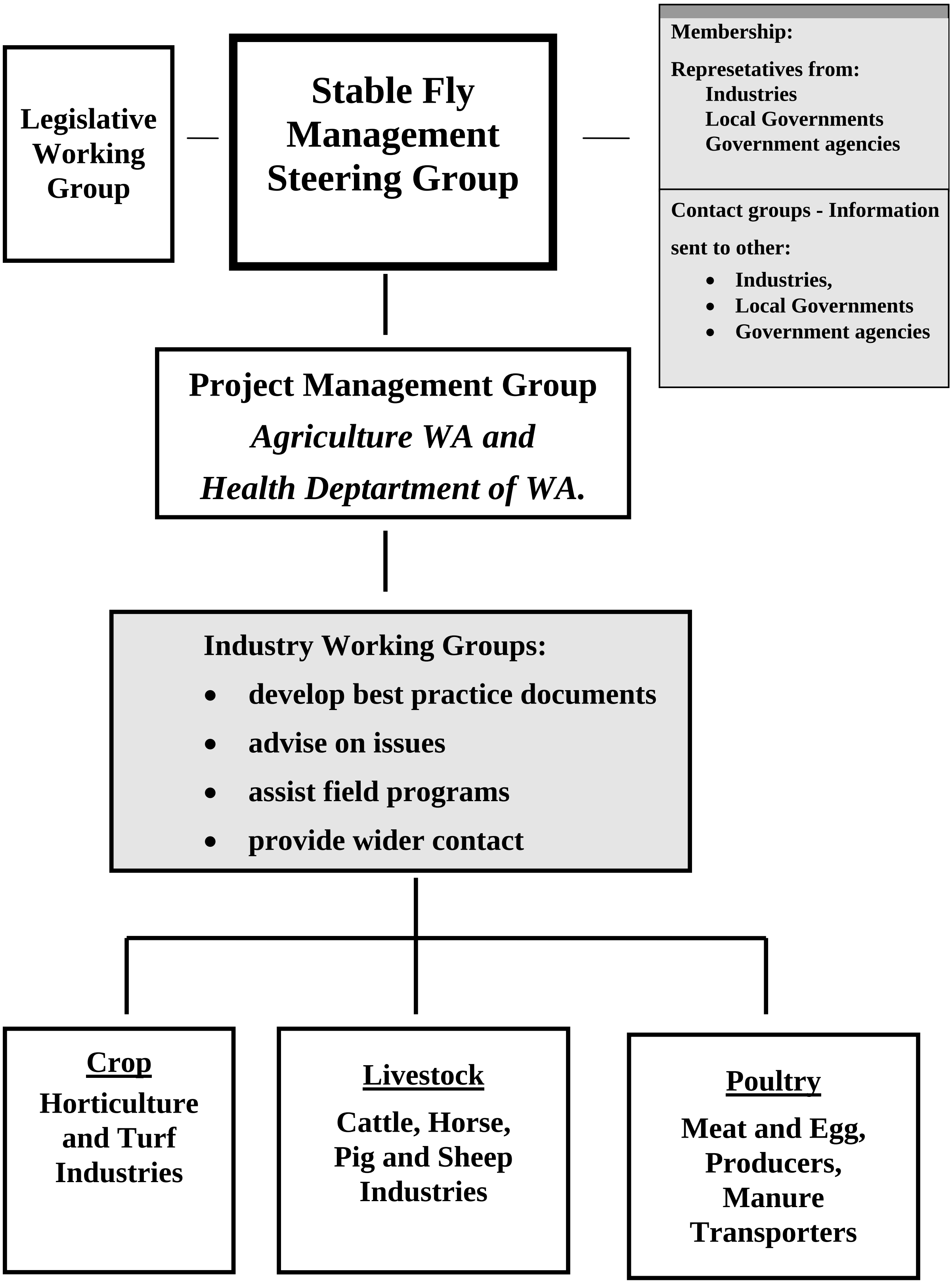
- Agricultural Industries: Horticultural, Poultry and Livestock industries
- Local Government: Shire of Gingin, City of Wanneroo and Town of Kwinana
- Government agencies: Agriculture Western Australia, Health Department of Western Australia and the Department of Environmental Protection.

The following agencies and organisations that are not directly represented on the steering group will be kept informed and may be involved on a need basis:

- Shires of Chittering, Swan, Serpentine Jarrahdale and City of Bunbury;
- Western Australian Municipal Association
- Water and Rivers Commission, the Ministry for Planning, and CSIRO
- Farmers Federation, and the Pastoralists and Graziers Association
- Other horticultural, livestock (cattle, horse pig)and poultry industries

Appendix 2

STABLE FLY MANAGEMENT PROJECT STRUCTURE



Appendix 3

LIST OF REPORTS AND PUBLICATIONS

1. Report on Gingin Stable fly Survey and Photographs - Report prepared by Health Department of Western Australia, February/March 1996

2. Report on Survey of Poultry Broiler Farms and Photographs - Report prepared by Health Department of Western Australia, November 1996

3. Report on Wanneroo Stable fly Survey and Photographs - Report prepared by Health Department of Western Australia, January/February 1997

4. Report on Survey of Manure Cartage Contractors and Photographs - Report prepared by Health Department of Western Australia, November 1996

5. Report on Vietnamese Education program for Vegetable Growers - Report prepared by Health Department of Western Australia, November 1997

6. Circular Issued to Local Government on 'Best Management Practices to Minimise Fly Breeding in Crop (Horticulture and Turf) Production' - jointly prepared by Health Department of Western Australia and Agriculture Western Australia, July 1997.

7. A Study of the Issues Surrounding the Disposal and Utilisation of Poultry Manure, the Benefits and Costs of Possible Treatment, and Recommendations for Industry Stakeholders in Combating the Stable fly Problem. Report prepared by the Economics Group, Agriculture Western Australia , May 1998

Appendix 4

REGIONAL TRAP MONITORING OF STABLE FLY POPULATIONS

During 1996-97, 35 cylinder traps were serviced weekly across the Shire of Gingin, 25 traps across the Town of Kwinana and 20 traps across the Shire of Wanneroo. Each trap was left in the field for 7 days after which all stable flies caught on the sticky surface were counted. The traps were located across a diverse range of environments, including horse properties, vegetable gardens and wetlands. The traps were serviced weekly (i.e., counted, cleaned and fresh Tac-gel applied) with the assistance of Local Government Environmental Health Officers.

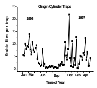


Figure 1. Mean numbers of stable fly per cylinder trap across the Shire of Gingin for 1996 and 1997.

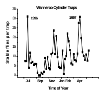


Figure 2. Mean numbers of stable fly per cylinder trap across the Shire of Wanneroo for 1996 and 1997.

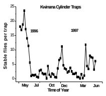


Figure 3. Mean numbers of stable fly per cylinder trap across the Town of Kwinana for 1996 and 1997.

Fly activity and rates of development (egg, larvae, pupae) are all temperature dependent, hence warmer temperatures increase fly activity, larval development and generation time. During winter, egg to adult development time can be as long as 3 months, whereas in the peak of summer development time can be as short as 15 days.

In Gingin, peak abundance of stable flies occurred during the summer and early autumn months, with considerable variation between weekly trapping events. From late January till mid April, an average of approximately 10 stable flies per trap was maintained. By mid winter, stable fly numbers had declined to less than 1 per trap (Figure 6).

Similarly in Wanneroo, numbers per trap were greatest throughout the summer and early-mid autumn months. A peak of >30 flies per trap was recorded in both July 1996 and April 1997. Stable flies only fell below 1 per trap in early spring (Figure 7). Although there was considerable variation between weekly trapping events, there was evidence of a series of peak abundance and then a general decline, possibly indicating periods of favourable conditions (ie., moisture and warm temperatures).

In Kwinana, numbers were greatest during late autumn 1996, with a dramatic decline to less than 2 flies per trap. Only two further peaks in stable fly abundance occurred thereafter in early summer and mid autumn (10/trap) (Figure 8).

The trapping results indicate that there are localised outbreaks of stable fly. These outbreaks are predominantly located near horse properties surrounded by market gardens and other livestock properties. The surrounding area enables access to a blood meal, larval breeding mediums and moisture. Associated with both these outbreaks has been an increase in complaints by members of the community.

Appendix 5

FLY BREEDING IN POULTRY MANURE HEAPS

Poultry litter is mixed in with jarrah sawdust or a similar organic bedding material, and therefore represents an ideal breeding medium for stable flies, when it becomes wet. Poultry industry practice is to removed manure from poultry shed and the property, as soon as the birds are removed. When ever possible it is delivered immediately to horticultural properties. There is potential for moist manure from poultry sheds to be struck by flies prior to being applied to crops/turf as either a preplant or sideband application. This can occur either (i) as soon as the poultry are removed from the sheds, (ii) in transit to horticultural properties, or (iii) whilst stored in a heap on a property (wet from either sprinkler drift or rain)

The tunnel houses were made of fine, white mesh erected over raw poultry manure heaps either a) immediately on delivery, or b) 7 days after delivery to a horticultural property. To determine the extent of fly breeding occurring both pre and post-delivery, all flies emerging from the manure were trapped out over several weeks using the white cylinder traps (see equipment development section).

Table 3. The numbers of stable flies and house flies emerging from poultry manure heaps ($10m^3$) either immediately on delivery, or 7 days after delivery to a property.

Time of Year	On Delivery		7 Day Post Delivery	
	Stable fly	*House Fly*	*Stable fly*	*House Fly*
Sept	0	133	64	3742
Oct	44	31	-	-
Nov	4	254	1	1172
Jan	74	354	0	1238
Feb	0	90	5	656
March	0	58	1	53
Average	**20**	**153**	**14**	**1372**

Appendix 6

EQUIPMENT AND TECHNIQUES FOR ASSESSING FLY BREEDING

Emergence Cages

Identification and quantification of the breeding sites for stable flies was made using standard emergence cages. A one square meter metal frame was pushed into the ground above which a flat pyramid of dark green shade cloth led into a circular port. A clear cylinder with a brass mesh cone pointing upwards was attached to this port. Being photopositive, the flies which emerged within the square meter area made their way towards the clear cylinder and entered the cylinder space through the brass mesh cone. One inside the cylinder, the flies are permanently trapped for later collection, identification to species level and counting.

Emergence Tubs

Large grab samples of fly breeding material (approximately one square meter) were reared in large black, plastic tubs in an enclosed house facility. An overhead reticulation system kept the samples moist (twice daily watering for 5 minutes) to prevent larval desiccation. After a 5 day watering regime, no more water was added to allow the larvae to pupate in dry sand. the adult flies were trapped in clear cylinders above the tubs as per the emergence cages.

Grab Sample Evaluation

When visiting either horticultural or livestock properties, samples of material containing fly larvae were collected from numerous different sources throughout the course of the project. These larvae were reared through to adult flies under optimal laboratory conditions to verify fly species and numbers. This information was used to further qualify and quantify stable fly breeding sites.

Exposed Dung Pad Trial System

Fresh manure and/or livestock dung was collected and thoroughly homogenised. Each manure type was then exposed in the field as uniform 1 L pads. All exposed manures (except cattle dung, which has >80% moisture content) had water added to make the dung up to 70% moisture content, which is optimal for fly breeding. Ten replicate dung pads of each treatment (dung type) were set out in a Latin-square design, 1.2m apart with each pad randomly designated a plot number.

The pads were left exposed to flies in the field on a range of livestock properties where stable flies were prevalent, for 2 days. The pads were left exposed for additional days if within the first 48h of exposure the weather was not conducive to fly activity (ie., rain, high winds, cool temps (<20°C). After exposure to flies, each dung pads was placed individually onto a 3 cm layer of sand within a plastic box (25cm square by 12cm deep) covered with a fine mesh lid. The pads were returned to the laboratory and any fly larvae allowed to develop into adult flies. The pads were sprayed with water daily for the first 3 days after collection to keep the dung moist and optimal for fly development. After 5 days, no more moisture was added to allow for pupation and adult emergence. Representative samples of the manure from each treatment were kept frozen at -20°C prior to analysis for moisture content, pH, % nitrogen and % phosphorus. Whenever dung pads were exposed in the field, a set of 6 white cylinder traps were set around the trial site to monitor the stable fly population.

Cylinder Traps

White cylindrical traps were used to monitor stable fly populations across the worst-affected shires (Gingin, Wanneroo and Kwinana) in 1995/96 and 96/97. Prior to cylinder traps being located in these shires, Williams traps were set up in Gingin (for a description see Williams, DF (1973) *Journal of Economic Entomology*, **66:** 1279-1280), and a series of trials were conducted to compare the Williams traps to the cylinder traps. Williams traps consist of two white panels interlocked at right angles to each other, to create 4 wings (22.5 cm by 35 cm) placed vertically in slots cut into wooden stakes 1m above the ground and painted with a sticky adhesive (Tac-gel). The cylinder traps consist of a 3 litre, opaque cylindrical jar, covered with white contact (Nylex©) 15cm wide and 36cm long, which was also painted with Tac-gel. The cylinder traps caught as many flies per surface area as the Williams traps. A similar study conducted by Broce, AB (1988) *Journal of Medical Entomology*, **25:** 406-409, demonstrated that the trapping efficiency of the cylinder traps was greater than the Williams traps (ie., greater numbers of stable flies per surface area). In addition, the Williams traps proved cumbersome under field conditions and it was decided to use cylinder traps instead.

Large white cylinders were placed upside down onto star pickets and secured to a metal lid attached 25cm from the top of the star picket. Each cylinder trap had a 20cm band of tac-gel (non-drying glue) around the circumference of the cylinder. This caught any flies that landed on the surface. The white surface is highly attractive to stable flies, particularly post-feeding, when they look for a cool, vertical perch to rest and ingest their bloodmeal.

During 1996, 35 cylinder traps were serviced weekly across the Shire of Gingin, 25 traps across the Town of Kwinana and 20 traps across the Shire of Wanneroo. Each trap was left in the field for 7 days after which all stable flies caught on the sticky surface were counted. Directional information was also gathered, by dividing the cylinder into 8 sections, with each section representing 45 degrees of the compass. The site location for each cylinder trap was established across a diverse range of environments, including horse properties, market gardens and wetlands. The cylinder traps were serviced weekly (ie., counted, cleaned and fresh Tac-gel applied) with the assistance of each shire's Environmental Health Officer

Stable Fly Laboratory Cultures

Considerable but unsuccessful effort was made to rear stable flies in the laboratory.

Appendix 7

PROPOSED GUIDELINES FOR CONDITIONING POULTRY LITTER

Site requirements

Site for processing poultry manure, must have Local Government approval to operate as a manure works and must comply with all statutory requirements. These premises are also prescribed under the Environmental Protection Act and are subject to formal assessment, works approval and an operating licence.

To get these approvals, they will need to comply with the Guidelines for sighting and constructing manure works that are currently being finalised by the Department of Environmental Protection.

Site Facilities and Equipment

Windrow turning equipment is needed together with water tankers and or equipment that is capable of wetting dry manure as quickly as is possible.

Dry poultry litter is hard to wet and the use of a suitable wetting agent will help to reduce the time needed to get the poultry litter to around 50% moisture which is when composting/conditioning will commence.

Apart from specified storage and manure conditioning areas, the site will need a small office to double as a laboratory which:

Equipment:

To determine moisture content including scales accurate to 1 gram and a drying or microwave oven

Test kit for ammonium nitrogen measurement

Refrigerator/freezer for storing samples prior to sending for laboratory nitrogen tests at an acceptable laboratory, such as the Western Australia Chemistry Centre

Sampling equipment, plastic sample bags, and records that provide the following minimum information for each batch of conditioned manure

Conditioning process

Poultry litter is layed out in a windrow with dimensions determined by the machinery to be used for turning the manure - for a tractor drawn turner, the windrow will be around 3 metre wide and 1.5 to 2.0 metre high.

- Apply water to bring manure to between 50 and 60% moisture content. The use of a wetting agent will increase the ease of wetting.
- As moisture content approaches 45 to 50 %. microbial action (composting) will accelerate and heat will be generated. The windrow needs to be turned at least daily and preferably, twice a day during the first three weeks. Note: the composting process requires oxygen at all times and turning provides aeration throughout the windrow. A temperature probe and a carbon dioxide meter will enable turning to be used strategically and should be used to manage temperatures (ideally between 50 to 60 degrees Celsius for maximum microbial activity) and to keep oxygen levels below 16%.

Note: anaerobic microbial activity will result in offensive odours and longer processing times.

- Through out the process, apply water to maintain windrow moisture levels between 45 to 55%.

Process completion

The conditioning process is completed when two consecutive samples, taken at least 5 days apart, return ammonium nitrogen levels of 0.1% or less, on a dry weight basis

Records

Records need to show details of each batch/windrow of manure processed.

A batch is one delivery of manure at one time. If one manure delivery fills more than one windrow, then each windrow is to be treated as a single batch. Record details should include:

- Date of receival;
- Source of manure and detail of transporter;
- Analysis of manure on arrival including moisture content and total nitrogen - total phosphorus and potassium optional;
- Calculation of water required to bring manure to between 50 to 60% moisture content,
- Records of conditioning process, including:
    - date that windrow turning commenced;
    - frequency of turning/date of each turning;
    - how turned;
    - dates samples collected for Ammonium nitrogen analysis;
    - details of how samples analysed and date/time of analysis;
    - analysis results for Ammonium nitrogen as well as at least one final analysis that provide Ammonium nitrogen plus Nitrate, Nitrate Organic and Total Nitrogen.
    - total potassium, phosphorus advisable as customer service but not essential

Sampling Procedure

Consistent sample collection techniques are essential for consistent meaningful results, - each sample for analysis is to be collected by the following standard procedure:

- Take a minimum 20 sub-samples consisting of 10 per side for each batch or windrow sampled;
- take each of the 20 sub-samples from between half way to 2/3rds the way up the side of the windrow and place into a clean bag or container;
- take each sub-sample at a depth of 100 to 250 mm;
- Immediately place each sample on a clean piece of sheeting and mix thoroughly. Place minimum 2 kg sample into a heavy duty plastic bag labelled with details that include date, batch and any other detail needed for future record keeping.

Sample Delivery for Analysis

For accurate nitrogen analysis, it is essential that the samples are either kept cool or ideally frozen as follows:

- For delivery to laboratory within 4 to 5 hours, store sample(s) in a refrigerator and deliver in an esky with ice bricks;
- For storage and later delivery to a laboratory, immediately place the sample(s) in a freezer until delivery, again in an esky.

Pre-dispatch Requirements

Before delivery, the following records and analysis results must be available for each batch of conditioned manure:

- Delivery details including to whom and by whom, the amount and the date delivered.
- ***Two Ammonium nitrogen analysis results, at least five days apart of less than or equal 0.1% dry weight; from a recognised laboratory.***
- Coinciding with one of the above or at a later date, an expanded analysis which includes at least
    - Full nitrogen analysis, including total, organic, Ammonium, nitrate and nitrite nitrogen.
    - Total phosphorus, potassium and other nutrients - optional.

Moisture content - optional.

Appendix 8

INSECTICIDE EVALUATION

Assessment of Common Horticultural Insecticides

Three trials were conducted to assess the effectiveness of several of the most widely used insecticides in vegetable production. These insecticides were applied with a hand held spray boom at label recommended rates to replicated (15m x 1.5m) plots within commercial brassica crops to which sideband application of poultry litter had been made. The insecticides were applied once the poultry litter had become struck with fly larvae. The following six 6 chemicals were used in each trial: methamidophos (Nitofol®); chlorpyrifos (Lorsban®); fluvalinate (Mavrik®); alpha-cypermethrin (Dominex®); mevinphos (Phosdrin®); carbaryl (Bugmaster®).

Table 1. The efficacy† of a range of horticultural insecticides against fly larvae in sideband applications of poultry litter. Values are the mean of assessments at days 3 and 6 post-spraying.

Insecticide	Trial 1	Trial 2	Trial 3	Mean
Methamidophos	80	12	23	39
α-cypermethrin	2	35	41	26
Fluvalinate	38	4	0	14
Mevinphos	35	2	23	20
Chlorpyrifos	29	22	41	36
Carbaryl	44	24	64	44

† *according to the Henderson-Tilton formula*

Assessment of Insecticides Registered for Fly Control

Three Exposed Dung Pad Trials were carried out in Wanneroo (2) and Gingin (1). Five insecticides registered for use against fly larvae in manure and waste products were assessed in each trial. The insecticides tested, their active ingredient and rates of application were: Neocid 200P (diazinon) (25mL/L); Lepidex 500® (trichlorfon) (24mL/L), Vapona®/Doom 500EC (dichlorvos) (6mL/10L); Baycidal 250® (triflumuron) (2g/L), and Regent® (fipronil) (20mL/L). Pads were either treated with the respective insecticides immediately prior to exposure to flies in the field for 72h, or 72h after exposure to flies (when maggots were present in the poultry litter). All pads were returned to the laboratory to allow for fly development and emergence. All dung pads were watered for the first 3 days post-collection, after which no further water was added.

Table 2. Efficacy of insecticides registered for use against fly larvae in manure and waste products assessed via exposed dung pad trials using poultry litter.

Insecticide	% reduction in fly breeding		
	Trial 1^{PRE}	Trial 2^{POST}	Trial3^{POST}
Triflumuron	99	-	99
Diazinon	84	0	70
Trichlorfon	0	0	9
Fipronil	0	0	-
Dichlorvos	0	0	60

PRE =Poultry litter treated immediately prior to exposure to flies in the field for 72h

POST=Poultry litter treated after 72h exposure to flies in the field (ie. fly larvae already in the poultry litter)

Assessment of Grower-Applied Insecticides

Grower applications of insecticide were assessed against fly larvae infesting sideband applications of poultry litter. These trials have involved applications of Dominex®, Bulldock® and Neocid®. Counts of fly larvae were made immediately prior to spraying and at least one date post-application. A minimum of 10 randomly selected unit areas (either 30cm strips or one 24cm^2 box of poultry litter) were used to count live fly larvae.

Table 3. Mean numbers of fly larvae in sideband applications of poultry litter at various dates pre and post spraying by growers using either alpha-cypermethrin^{AC} , diazinon^{D} , or cyfluthrin^{CY} at 800-1000L/ha.

Date	Site								
	1^{AC}	2^{AC}	3^{AC}	4^{AC}	5^{D}	6^{D}	7^{D}	8^{AC}	9^{CY}
Pre-spray	9.6	38.8	13.3	1.8	5.3	63.1	321	4.8	37.1
1 dps									
3 dps	33.5	15.0	10.9	0.3	3.3	68.4	183	4.0	77.3
#Samples	n=11	n=10	n=15	n=10	n=10	n=10	n=10	n=10	N=30
Larval Mortality	0%	61%	0%	83%	38%	0%	43%	20%	0%

dps = days post spraying

Appendix 9

INSECTICIDE PRODUCTS REGISTERED FOR USE AGAINST FLIES IN WESTERN AUSTRALIA

Products registered for use against adult flies and fly larvae in Western Australia (current till May 1998) are as follows.

Residual & Knockdown (Adult Flies)	
Responsar Solfac 50 EW Outlast ME Reslin Alfacron 10 Plus Dy-Fly Plus (dry bait)	Ficam W (dry bait) Coopex Residual Demon Cislin 10 Crackdown Tugon Plus Fly Bait
Humans/Animals	
Perigen 500 Pestgard Residual	Multishield Repellant Imperator Residual
Fly Larvae	
Neocid 200 P Lepidex 500 David Grays DDVP 500	Dipterex 500 SL Vapona 500 Divap 500 EC
Cattle	
Coopers Arrest Python (ear tags)	Optimizer (ear tags)
Horses	
Nucidol Joseph Lyddy N-Dem	Switch Pharma-Chemical

Appendix 10

SUMMARY OF CURRENT BEST CROP PRODUCTION PRACTICES

The current version of 'Best Crop Production Practices for Managing Fly breeding and for Using Manure' were released in March 1997 and besides vegetable and strawberry production, deal with fruit and turf production. These provide advise on:

- Storage of manure
- Use of manure;
- Managing crop wastes in the paddock;
- Disposal of harvested crop waste;
- Chemical control of fly breeding;
- Monitoring fly breeding;

Briefly, the information provided can be summarised as follows:

Storage of manure Growers are advised to minimise storage time by ordering only what is required for immediate and to refuse deliveries of wet manure. Best practices include keeping manure heaps dry at all times, as well as out of sprinkler range and not in hollows or depressions.

Poultry manure utilisation Best practices deal with manure applications before and after crop establishment. Growers are advised to use manure that is free of clumps and to immediately incorporate pre-plant applications, noting that the more complete the burial of manure, the better fly control will be.

Side dressings or banded applications after crop establishment that cannot cannot be adequately incorporated should be avoided between October and May when fly breeding is greatest. . Advise is also provided on replacing side banding with fertilisers mainly containing nitrogen and potassium

Upper limits to manure application is provided and for vegetable crops are 50 cubic metres per hectare per crop to a maximum of 120 cubic metres per hectare per year on new land and for established land, 30 cubic metres per hectare per crop up to a maximum of 75 cubic metres per hectare per year. Rates and advise is also given for strawberries, turf and fruit crops. Details of poultry manures nutrient content which should be accounted for in the overall fertiliser program are also provides.

Managing crop wastes in the paddock Growers are warned that stable fly breeding is prevalent during the natural breakdown process of crop wastes following the harvest of leafy crops such as celery, brassicas and lettuce.

Best practice is to use high speed rotary cultivation to break up and thoroughly incorporate crop wastes, 3 to 4 days after completing harvest. When large amounts of residue are present, this needs to be repeated within 7 to 8 days of harvest.

Disposal of harvested crop waste If other wastes from packing sheds and market preparations are not returned to the paddock and rotary cultivation back into the soil, they can be buried in pits, provided they are covered daily with at least 50 mm of soil. Alternatively they can be fed to livestock, providing it is spread out to avoid it being trampled into the ground where it will decay and breed stable fly.

Chemical control of fly breeding Advise is provided on getting the best control of fly larvae by strategically using insecticides registered for other common insect pests. Growers are also warned that insecticides are not as effective as widely believed and that reliance on them will lead to further development of pesticide resistance

Monitoring fly breeding Growers are advised to assess fly breeding and to take appropriate action to deal with it when larvae numbers exceed levels established in conjunction with Local Government Environmental Health Officers.

Appendix 11

POULTMAN - a POULTry MANure industry model

POULTMAN - a poultry industry model prepared in Excel spreadsheets was developed by the Economics Management Unit of Agriculture Western Australia. It was prepared in conjunction with a consultancy that reported on 'Options for poultry manure utilisation and or disposal' in May 1998 and has been developed to track both the physical and financial factors involved in some of the treatment and disposal options for poultry manure. The model comprises a number of spreadsheets titled:

Industry - Where the base description of the manure industry is made. Below it is the 'results' section to which the other individual worksheets are linked and where price testing can be done to achieve a predetermined IRR

Raw - Assumptions and outputs for calculating contractor costs in cleaning out sheds and transporting raw manure.

Delumping - Assumptions and outputs for calculating costs in milling facilities to remove lumps in raw manure.

Conditioned - Assumptions and outputs for calculating costs in conditioning raw manure.

Composted - Assumptions and outputs for calculating costs in composting raw manure.

Electricity and Gas - A very brief calculation of costs in operating a power station fuelled by burning of poultry manure.

Fuel - A very brief spreadsheet containing assumptions and outputs for calculating costs in setting up and operating an ethanol production facility.

Cattle feed - Assumptions and outputs for calculating equivalent energy requirements for cattle feeding. Links with the Industry sheet to calculate feed prices.

Market Garden - Assumptions and outputs for calculating equivalent costs of various classes of poultry manure compared to artificial fertiliser for nutrient value. Links back to the Industry sheet to determine cost savings.

Calculations are based on 15 year discounted cash flow analyses for each treatment option and determine Net Present Values and Internal Rates of Return. It can be used to find the change-over price for treated manure products which are equivalent to their fertiliser value, calculated in terms of the cheapest alternative fertiliser product.

The model calculates costs of manure treatment options that are based on assumptions that can be varied according to the information currently available and/or are possibilities depending on different perspective's to be applied. The assumptions used to provide the treated poultry manure prices quoted in this report are:

Assumptions in POULTMAN

The model presents as many of the individual assumptions as possible under each of the following treatment option sections and in the Appendices. They will be the source of some argument/discussion by interested parties - and the basic principles used in POULTMAN are as follows:

People involved in the industries were consulted to obtain estimates as close as possible to reality of the capital, operating, and overhead costs applicable in each case. However, some of the treatment options were only in experimental stages so some approximations have been made for a number of costs. As a principle, we have generally used costs at the higher end of the scale so that results will give 'worst case scenarios'. It is appreciated that a commercial operation will be able to trim costs and run a leaner business than the numbers indicate. Sensitivity tables included, attempt to cater for those types of adjustments.

In all cases, it is assumed that raw poultry manure is obtained by contractors from sheds for no charge. It is acknowledged that some sheds are attracting some small payment - and that the broiler growers wish to preserve this arrangement.

An Internal Rate of Return (IRR) of 12% has been used as a standard 'profit' outcome. That is, product sale prices are calculated on a delivered - on farm basis, where the contractor or processor will achieve a 12% IRR. This is after allowing a 7% interest charge on capital . Some would argue that in these circumstances, a 12% IRR is too high but it is defended on the basis that a healthy margin is needed by potential investors in this new and uncertain industry.

Sensitivity testing for scale of treatment operations has been done on 1 site handling the whole of the poultry industry manure production versus 3 sites each handling one-third of the manure. The broiler industry is particularly concerned about disease transfer and believes there will probably need to be around 6 individual sites - in which case there will be small increases in cost due to lower scale operations.

A standard $5/tonne freight rate has been applied to transfer treated products from the processing works to a market garden.

While total poultry manure production is estimated to be around 150,000 m^3 (refer Section 2.2 of the report), it was assumed that around 10,000 m^3 of that total would be diverted to other uses eg. backyard gardeners. Hence calculations have been based around a 140,000 total.

The advantage of the POULTMAN model format is that interested people can interrogate it by using their own cost estimates and/or new information to determine the impact on results.