Importation of Crocodile Meat from Zimbabwe into Australia

Draft Import Risk Analysis Paper

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Australian Quarantine and Inspection Service
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AUSTRALIA
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# Abbreviations and Definitions

## Abbreviations and Acronyms

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<th>Definition</th>
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<tbody>
<tr>
<td>AFFA</td>
<td>Agriculture Fisheries and Forestry - Australia, Department [formerly the Department of Primary Industries and Energy (DPIE)]</td>
</tr>
<tr>
<td>ALOP</td>
<td>Appropriate Level of Protection</td>
</tr>
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<td>AQIS</td>
<td>Australian Quarantine and Inspection Service</td>
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<tr>
<td>CFAZ</td>
<td>Crocodile Farmers Association of Zimbabwe</td>
</tr>
<tr>
<td>CITES</td>
<td>Convention on International Trade in Endangered Species of Wild Fauna and Flora</td>
</tr>
<tr>
<td>CVO</td>
<td>Chief Veterinary Officer</td>
</tr>
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<td>EA</td>
<td>Environment Australia</td>
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<tr>
<td>IRA</td>
<td>import risk analysis</td>
</tr>
<tr>
<td>kg</td>
<td>kilogram(s)</td>
</tr>
<tr>
<td>OIE</td>
<td>Office International des Epizooties (World Organisation for Animal Health) (refer IRA handbook for further information)</td>
</tr>
<tr>
<td>ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>spp.</td>
<td>species</td>
</tr>
<tr>
<td>SPS</td>
<td>sanitary or phytosanitary</td>
</tr>
<tr>
<td>SPS Agreement</td>
<td>WTO Agreement on the Application of Sanitary and Phytosanitary Measures</td>
</tr>
<tr>
<td>TVC</td>
<td>total viable count</td>
</tr>
<tr>
<td>WTO</td>
<td>World Trade Organization</td>
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DEFINITIONS

Code means the OIE International Animal Health Code

Hazard in the context of this draft risk analysis paper, means a biological agent which may have an adverse effect

Hazard identification is the process of identifying the biological agents which could potentially be introduced in the commodity considered for importation

Incubation period means the longest period which elapses between the introduction of the pathogen into the animal and the occurrence of the first clinical signs of disease

Manual means the OIE Manual of Standards for Diagnostic Tests and Vaccines

Risk the integration of the likelihood and the magnitude of the consequences of an adverse event to animal or human health in the importing country

Risk assessment the process of estimating the risk presented by a hazard, in quantitative or qualitative terms

Risk management the process of selecting and implementing measures that can be used to reduce the level of risk

Standard means the Australian Standard for the Hygienic Production of Crocodile Meat for Human Consumption
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This document is a draft report of an import risk analysis (IRA) on the importation of crocodile meat from Zimbabwe.

The policy for the importation of crocodile meat from Zimbabwe will be based on the final outcome of this risk analysis.

The IRA process followed by AQIS is in accordance with the OIE International Animal Health Code and includes the following steps:

- Hazard identification
- Risk assessment, comprising
  - Release assessment
  - Exposure assessment
  - Consequence assessment
  - Risk estimation
- Risk management

This risk analysis identifies which disease agents are potential hazards and assesses the risk of establishment of these hazards in reptiles and other animals in this country. The human food safety aspects of importation of crocodile meat are not considered here, except where they relate to the introduction of exotic pathogens.

Risk management options are considered for disease agents which pose a moderate to extreme risk of being introduced and becoming established. For each of these agents quarantine measures are recommended which are least trade restrictive and minimise the risk of establishment of unwanted organisms. Measures for each disease agent are consolidated into proposed quarantine conditions.

The following disease agents were identified as hazards requiring further consideration in the risk assessment:

- *Chlamydia* spp.
- *Mycoplasma crocodyli*
- *Salmonella* spp.
- Adenovirus-like agent
- *Dujardinascaris* spp.
- *Trichinella* spp.
- *Agema* spp.
- *Subtriquetra* spp.

As a result of risk assessment it was concluded that risk management measures were needed for exotic *Salmonella* spp. and *Trichinella* spp.

For these disease agents risk management options were identified and considered. The restricted risk was again compared with Australia’s ALOP. This led to the specification of acceptable risk management measures for each disease agent.
The following provides a summary of recommended risk management measures identified for diseases agents requiring risk management.

*Salmonella* spp.
- Hygienic procedures to minimise faecal contamination of meat according to the Australian Standard.
- Monitor crocodile meat for the presence of *Salmonella* spp.
- Apply an approved antimicrobial treatment to the meat prior to packaging

*Trichinella* spp.
- The establishments where crocodiles originate are free of trichinellosis.
- The abattoir monitors crocodile meat for the presence of *Trichinella* by an approved technique.
- No *Trichinella* spp. larvae have been detected in crocodile meat at the abattoir for at least twelve months.
- Crocodile meat is frozen at –15°C for at least 20 days prior to export.

These risk management measures are incorporated into the proposed quarantine requirements and are included in the report.

The proposed quarantine requirements ensure that the risk of introducing disease agents present in crocodilians in Zimbabwe through the importation of meat meets Australia’s appropriate level of protection (ALOP).
1. INTRODUCTION

1.1. Background and Reason for IRA

Animal Quarantine Policy Memorandum (AQPM) 1998/59 entitled "Import Risk Analysis: Crocodile meat from Zimbabwe - Notification of policy development” was issued on 10 July 1998. This document advised stakeholders that quarantine policy for the importation of crocodile meat from Zimbabwe was to be developed, and invited stakeholder comment. AQIS confirmed that a routine approach to the IRA would be adopted in AQPM 1998/92 entitled “Import Risk Analysis: Crocodile meat from Zimbabwe – Confirmation of approach” issued on 30 November 1998.

1.2. Scope of Risk Analysis

The risks attributed to all disease agents of quarantine concern that may be introduced into Australia through the importation of crocodile meat from Zimbabwe are analysed in this paper.

For the IRA report, the definition of ‘crocodile meat’ is limited to crocodilian muscle tissue, blood confined to muscle vasculature, bone and bone marrow, and any other tissues (for example, fat) that may be considered inseparable from muscle.

This approach means that the issues associated with the introduction of disease agents as a result of the importation of ‘crocodile meat products’ derived from offal, blood, bone or neurological tissue, will not be considered.

In order for imported meat to act as a vehicle for the transmission of a disease agent, that agent must:
- either be present in the product at the time of slaughter or contaminate the product within the abattoir,
- survive within the product during any subsequent processing and storage, and
- be capable of infecting susceptible animals when presented as infected animal feed.

In the early bacteraemic or viraemic phase of any infection, it is possible for a pathogen to infect or passively contaminate muscle tissue. Infection of muscle tissue may occur as a result of a break in the barrier offered by skin and subcutaneous tissue, by translocation of the organism through the bloodstream or as a result of the migration of an organism from another site in the animal’s body. Contamination of muscle tissue may occur as a result of a break in the animal’s skin, or through the presence of contaminated blood or lymph in muscle vasculature at the time of slaughter. Depending on characteristics of the disease agent and the stage of infection, organisms may be present in serum or extra-cellular fluid, or may invade the animal’s red or white blood cells.

In addition to contamination during the course of an animal’s infection with a disease agent, muscle tissue may be contaminated within the abattoir. The likelihood that a disease agent will contaminate muscle tissue at the time of slaughter, evisceration, deboning or during the division of the carcase, will depend on the physical
characteristics of the disease agent and on sanitary conditions and procedures upheld in abattoirs within Zimbabwe.

Finally, regardless of the means by which a disease agent has infected or contaminated muscle tissue, survival of the agent during storage of the meat will depend on its physical characteristics, the period of storage prior to exportation and the conditions of pH and temperature within the stored meat.

The disease risks associated with other products derived from crocodilians, such as skins, are not considered in this IRA.

For the purposes of this risk analysis, the distribution of disease caused by an agent is based on the OIE concept of regionalisation using data on outbreaks of disease. Zimbabwe is thus considered as part of the African region and any disease agent reported in crocodilians in Africa is assumed to be present in Zimbabwe, unless there is clear evidence to the contrary.

1.3. Current Quarantine Policy and Practice

AQIS’s objective is to adopt quarantine policies that are, wherever appropriate, based on international standards and which provide the health safeguards required by government policy in the least trade restrictive way. In developing quarantine policies, the disease risks associated with importations are analysed using a structured, transparent and science-based process known as import risk analysis.

The *Quarantine Act* 1908 and subordinate legislation, including Quarantine Proclamation 1998 is the legislative basis of human, animal and plant quarantine in Australia. The *Act* defines the scope of quarantine, in section 4, as follows:

> “In this Act, Quarantine has relation to measures for the inspection, exclusion, detention, observation, segregation, isolation, protection, treatment, sanitary regulation, and disinfection of vessels, installations, persons, goods, things, animals, or plants, and having as their object the prevention of the introduction, establishment or spread of diseases or pests affecting human beings, animals, or plants.”

Subsection 13(1) of the Act provides, among other things, that the Governor-General in Executive Council may, by proclamation, prohibit the importation into Australia of any articles likely to introduce any infectious or contagious disease, or disease or pest affecting persons, animals or plants. The Governor-General may apply this power of prohibition generally or subject to any specified conditions or restrictions.

The matters to be considered when deciding whether to issue a permit are set out in Section 70 of Quarantine Proclamation 1998 and include the quarantine risk, whether the imposition of conditions would be necessary to limit the quarantine risk to a level that would be acceptably low and anything else that is considered relevant. Quarantine risk means the likelihood of the importation leading to the introduction, establishment or spread of a disease or a pest in Australia, the likelihood that harm will result (to humans, animals, plants, the environment or economic activities) and the likely extent of any such harm.
For articles prohibited by Proclamation, the Director of Animal and Plant Quarantine may permit entry of products on an unrestricted basis or subject to compliance with conditions, which are normally specified on a permit. An IRA provides the scientific and technical basis for quarantine policies that determine whether an import may be permitted and, if so, the conditions to be applied.

This draft IRA report will provide the basis for future consideration of applications for import permits in relation to the importation of crocodile meat from Zimbabwe. In keeping with the scope of the Quarantine Act, only the factors relevant to the evaluation of quarantine risk will be considered in the IRA. Questions related to the potential economic consequences of importation (other than the economic impact of a disease) are not part of AQIS’s process of evaluation.

The actions of the Director of Animal and Plant Quarantine or his delegate in reaching a decision under the Quarantine Act must take into account relevant provisions of other Commonwealth legislation, including the Endangered Species Protection Act 1992 and the Environment Protection (Impact of Proposals) Act 1974.

The Environment Protection (Impact of Proposals) Act and the Administrative Procedures under that Act require consideration of whether Commonwealth action (such as the granting of an import permit) is an action which will, or is likely to, affect the environment to a significant extent, or which will have the effect of permitting or facilitating an action by another person which will or is likely to result in such an effect. Decisions made by AQIS to permit the entry of animal products, made under the Quarantine Act, and consistent with Australia’s conservative approach to risk, would generally be unlikely to constitute actions leading to significant adverse effects on the environment.

Trade in all live crocodilians and their products is controlled internationally by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Commonwealth legislation that regulates the international movement of endangered species under CITES is the Wildlife Protection (Regulation of Exports and Imports) Act 1982. This is administered by Environment Australia. AQIS informs Environment Australia of proposals to develop new quarantine policies, to provide an opportunity for comment.

Currently there are no conditions for the importation of crocodile meat from Zimbabwe into Australia. Policy relevant to this report is the IRA for the import of live crocodilians which was completed in January 2000. Information considered in this IRA is common to the live crocodilian IRA. In 1990 conditions for the importation of crocodile meat from Papua New Guinea (PNG) were released. These are based on Quarantine Proclamation 134A (superseded by Proclamation 1998) and were developed in the late 1980’s. They have not been reviewed since that time. These conditions largely focus on risks associated with livestock disease agents and human food safety concerns.

The conditions for the importation of crocodile meat from PNG are in Appendix 1.
2. DESCRIPTION OF INDUSTRY

2.1. Australia

Crocodile farms and ranches have been operating commercially in Australia since 1985 when the CITES listing for the saltwater crocodile, *Crocodylus porosus*, was transferred from Appendix I to Appendix II allowing ranching and trade. Ranching of crocodiles is dependent on the supply of eggs or hatchlings from the wild. This necessitates a healthy wild breeding population which conserves the species and habitat without depleting the overall wild population, as natural mortality is high. Farming relies totally on captive breeding, once the founder breeding stock had been obtained from the wild. This is the case in Queensland, but the Northern Territory and Western Australia operate on a combination of ranching and captive breeding.

The Australian freshwater crocodile, *Crocodylus johnstoni* was farmed significantly, but farm numbers have declined over the last ten years in favour of *C. porosus*. This is because of the premium quality of the *C. porosus* skins, with small belly scales and no osteoderms (bony plates under the skin), factors that are highly sought after by international markets. Commercial production is orientated around the international skin market, but there is an increasing demand for meat most of which is sold domestically.

Currently in Australia there are 20 crocodile farms / ranches, varying in size from a few animals to several thousand, stocking a total of about 60 000 saltwater crocodiles. About half are solely commercial farms, producing the majority of skins and meat. Others are also combined with tourism ventures. There are 10 abattoirs licensed for domestic and / or export crocodile meat production. The construction, equipment and procedures of all premises where crocodiles are slaughtered and processed for the production of crocodile meat for human consumption are required to comply with the Australian Standard for Hygienic Production of Crocodile Meat for Human Consumption (Anon, 1998a) (the Standard).

In 1998 / 99 the total crocodile meat production in Australia was about 98 tonnes, valued at $1.5M. The overall Australian crocodile farming industry (skin, meat and other by-products) is estimated to be valued in the vicinity of $4M annually (excluding tourism which may add a further $3M).

2.2. Zimbabwe

The crocodile farming industry in Zimbabwe utilises the Nile crocodile, *Crocodylus niloticus*. In 1983 *C. niloticus* was transferred from CITES Appendix I to II under conditions of ranching. There are currently about 50 farms / ranches of varying size stocking in excess of 150 000 crocodiles.

As with the Australian industry, the meat is a by-product of skin production. There are three abattoirs licensed by the Zimbabwe Department of Veterinary Services for the production of domestic and / or export crocodile meat.

The sole abattoir currently exporting crocodile meat, produced 70 tonnes of meat in 1998.
2.3. Abattoir Procedures

The current operations and abattoir procedures in Zimbabwe are similar to those in Australia. A report by Purdie (1999) on a visit to an export approved abattoir in Zimbabwe provides background information on general procedures to assist in this IRA report. It was not intended as an evaluation of the abattoir. The abattoir was not observed operating and some maintenance was being carried out at the time of the visit. A comparison of known procedures at an export approved Zimbabwe crocodile abattoir (Purdie, 1999) and the minimum requirements according of the Standard is given below in Table 1.
### Table 1: Comparison of a Zimbabwe export crocodile meat abattoir and the Australian Standard

<table>
<thead>
<tr>
<th>ABATTOIR CONSTRUCTION:</th>
<th>Zimbabwe abattoir</th>
<th>Australian Standard summary</th>
<th>Compliance with the Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Site and Services</strong></td>
<td>Sited above high water line of Lake Kariba, 20 km from township. Lake water is rendered potable by in-line ozone treatment; energy supply is hydroelectricity; liquid waste is diverted to a septic tank and solids are burned; traffic ways are dirt.</td>
<td>Located on a site not subject to flooding, and free from environmental contamination. Premises shall be provided with potable water; a reliable energy supply; sufficient waste disposal; and traffic ways constructed so as not to create dust.</td>
<td>Complies except for traffic way. Plans to brick pave around abattoir.</td>
</tr>
<tr>
<td><strong>Animal Holding Facilities</strong></td>
<td>Not applicable – transported to abattoir alive.</td>
<td>Where facilities are provided, requires animal welfare is not jeopardised and facilities are not a source of contamination.</td>
<td>Not applicable.</td>
</tr>
<tr>
<td><strong>Premises Construction</strong></td>
<td>Some rust present on window frames; vermin and pests may be able to gain access; hatch between slaughter floor and the skinning room allows bodies to contact walls.</td>
<td>Exposed surfaces shall be corrosion resistant; designed to exclude entrance of any animals not intended for meat processing ie cats, birds, rodents, insects; door openings and passageways shall be of a size ensuring product does not come into contact with walls.</td>
<td>Examples listed do not comply. Rectifiable with minor maintenance. Other requirements (eg lighting intensity) not evaluated.</td>
</tr>
<tr>
<td><strong>Drainage and Effluent</strong></td>
<td>Floors drained to a central open drain without grating; liquid waste diverted to a septic tank; solid waste burned.</td>
<td>A minimum of 1 in 100 fall in processing areas shall be provided; septic systems shall drain separately from other drainage systems;</td>
<td>Complies, without specific evaluation.</td>
</tr>
<tr>
<td><strong>Hygiene and Sanitation Facilities</strong></td>
<td>Knee operated hand wash facilities; sterilisers provide water at 82°C or hotter.</td>
<td>Hand washing facilities provided with hot and cold water, effective sanitising agent, taps which are not operated by hand, sterilisers provided with potable water at not less than 82°C.</td>
<td>Complies where observed.</td>
</tr>
<tr>
<td><strong>Processing areas</strong></td>
<td>Designed to remove inedible material with skins passing through a hatch and offal via a chute. Hoses were provided at convenient locations. Rails are of sufficient height to prevent carcases contacting the floor.</td>
<td>Designed so that inedible material does not pass through edible material areas. Rails shall be of sufficient height to ensure that there is adequate carcase clearance over equipment and structures to prevent cross-contamination</td>
<td>Complies.</td>
</tr>
<tr>
<td><strong>Chillers and Freezers</strong></td>
<td>Vacuum packed meat is held in a chest freezer until there is sufficient quantity to fill a carton. There is no need for a chiller for the storage of undressed carcasses as all carcasses and skinned and processed immediately. The blast freezer operates at −18°C. Product is stored off the floor on plastic crates.</td>
<td>Capacity shall be adequate for maximum daily production and able to accommodate the total quantity of product likely to be held at one time. A chiller solely for the storage of undressed carcasses shall be provided. Freezers used to store crocodile meat shall be capable of maintaining temperatures of −15°C or colder when fully loaded. The cartons and the product therein are protected from contamination through floor contact.</td>
<td>Complies, although procedural differences.</td>
</tr>
<tr>
<td>Zimbabwe abattoir</td>
<td>Australian Standard summary</td>
<td>Compliance with the Standard</td>
<td></td>
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<td>-------------------</td>
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<tr>
<td><strong>Loading Areas</strong></td>
<td>Load-out area is via the packaging room.</td>
<td>Loading in or loading out shall be carried out in a manner that does not represent a source of contamination to meat.</td>
<td>Probably complies. Plans to construct a load-out area directly from the freezer.</td>
</tr>
<tr>
<td><strong>Amenities</strong></td>
<td>Separate amenities are provided for employees involved in slaughtering and processing. Laundered protective clothing is stored in lockers within the change rooms.</td>
<td>Amenities shall be located so as to not jeopardise the hygienic processing of animals. Access to amenities shall be achieved without employees from areas where edible product is handled passing through areas where inedible product is handled, or vice versa.</td>
<td>Complies.</td>
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**HYGIENIC PRODUCTION:**

<table>
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<tr>
<th><strong>Operational Hygiene Requirements</strong></th>
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<tbody>
<tr>
<td>• A cleaning program for the premises is in place.</td>
<td>• Each crocodile processing premises shall have a program of hygiene control approved by the controlling body.</td>
<td>Probably complies.</td>
</tr>
<tr>
<td>• Pest control program in place. Flytraps are used and there is regular spraying for cockroaches.</td>
<td>• There shall be an effective and continuous program for the control of insects, birds, rodents and other pests.</td>
<td>Probably complies.</td>
</tr>
<tr>
<td>• A training program exists for methods of hygienic handling of edible product and includes practical demonstrations with agar plates. All workers are tested for <em>Salmonella</em> and <em>E. coli</em> prior to commencement of slaughtering season. Any employees with positive results are treated and rechecked. Workers are provided with clean protective clothing, which is laundered daily in a laundry at the farm. Employees involved in the slaughtering process are not permitted into skinning, processing or packing areas.</td>
<td>• A program of continuing training in the hygienic handling of edible product shall be implemented in each processing premises. No employee while known to be suffering from, or to be a carrier of, a disease capable of being transmitted through meat, or while afflicted with infected wounds, sores or diarrhoea, is permitted to work in any capacity in which it is possible either directly or indirectly to contaminate product with pathogenic micro-organisms. Protective clothing shall be properly cleaned at the end of each day. Persons employed in areas for inedible products such as the growing pens shall not be permitted to engage in the dressing or handling of edible product until they have thoroughly washed and ensured their outer clothing, head covering and footwear is free from contamination originating in inedible areas.</td>
<td>Complies.</td>
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<thead>
<tr>
<th><strong>Ante-mortem Inspection</strong></th>
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<tbody>
<tr>
<td>Crocodiles are examined for skin quality and health prior to slaughter.</td>
<td>Animal health surveillance and disease detection systems should be in place on-farm to ensure that only healthy crocodiles are presented for slaughter.</td>
<td>Complies.</td>
</tr>
</tbody>
</table>
## Slaughter and Processing Procedures

<table>
<thead>
<tr>
<th>Zimbabwe abattoir</th>
<th>Australian Standard summary</th>
<th>Compliance with the Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Crocodiles are fasted for 2 days prior to slaughter.</td>
<td>• Feed shall be withheld from crocodiles for 2 – 3 days prior to slaughter.</td>
<td>Complies</td>
</tr>
<tr>
<td>• Crocodiles are captured and jaws fastened shut, individually bagged in clean,</td>
<td>• Killing shall be performed by a humane method. As soon as possible after killing, crocodiles will be washed and the bleeding site swabbed with an approved sterilising agent then bled in an approved manner. A maximum of 10 minutes should elapse between killing and bleeding.</td>
<td>Probably complies</td>
</tr>
<tr>
<td>washable synthetic bags and transported to the abattoir. Spinal cord is severed</td>
<td>• Carcasses shall be placed into an environment of 5°C or less within 1 hour after killing. Processing shall be completed within 24 hours of killing.</td>
<td>Probably complies – different procedure.</td>
</tr>
<tr>
<td>and immediately pithed. The carcase is hung on a frame and allowed to bleed out.</td>
<td>• The carcase shall be washed with an approved detergent or disinfectant prior to skinning. Where leakage of ingesta of faecal material is likely to occur, a method to prevent or control such leakage shall be used. Skinning shall be done on approved processing tables or while the carcase is suspended.</td>
<td>Partly complies (skin not disinfected prior to skinning).</td>
</tr>
<tr>
<td>Carcase is washed with water.</td>
<td>• Any meat that can be removed without evisceration taking place should be removed prior to opening the body cavity. Where carcase is eviscerated, this may be done on processing table, or by suspending the carcase vertically so that viscera falls directly into a container.</td>
<td>Does not comply (evisceration takes place prior to removal of meat)</td>
</tr>
<tr>
<td>• Carcase is passed by hand through hatch to processing room.</td>
<td>• Crocodile meat shall be subjected to antimicrobial treatment.</td>
<td>Probably complies – different procedures.</td>
</tr>
<tr>
<td>• The carcase had been washed with water. The cloaca and throat are plugged.</td>
<td>• Meat for human consumption shall be packed in clean, unused, impervious material, and then completely enclosed in a clean, unused approved container. Cartons shall display the information listed in the Standard and packaging comply with the Australian National Food Standards Code.</td>
<td>Probably complies</td>
</tr>
<tr>
<td>Carcase is hung on a rail and skinned.</td>
<td>• Not specified in Standard, but proposed quarantine requirements specify freezing at –15°C or less for at least 20 days.</td>
<td>Complies</td>
</tr>
<tr>
<td>• Carcase is carried to the evisceration room and placed on a frame with sterilised</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chains used to hold it open for evisceration. The carcase is then transported into</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the boning room and boned on tables and tail and legs removed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Meat is decontaminated by a quick dip in chlorine and then blanched at 82°C for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 seconds.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Meat is vacuum packed into 1 kg bags and placed in a chest freezer until sufficient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>number to fill a carton.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Cartons loaded to blast freezer at –18°C and held for a minimum of 3 weeks.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Feed shall be withheld from crocodiles for 2 – 3 days prior to slaughter.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## OTHER:

### Microbiological Testing

- Carried out by the government laboratory on a monthly basis.
- Total viable counts (TVCs) and E. coli are carried out on surfaces, equipment and hands. TVC, E. coli and Salmonella are performed on meat samples.
- Microbiological testing requirements are specified in Appendix A of the Standard.
- Probably complies.

### Auditing

- The Department of Veterinary Services inspect abattoir operations and audit records 3 times each year.
- Not within the scope of the Standard. Australian crocodile meat abattoirs are subject to State / Territory food hygiene regulations.
- Probably complies.
2.4. Conclusion

This section does not attempt to cover all aspects of the Standard as processing procedures were not observed. There are two main procedural differences between Australia and Zimbabwe crocodile slaughter and processing. Firstly, in Australia crocodiles are slaughtered the day prior to processing and stored in a chiller whereas in Zimbabwe crocodiles are processed immediately after slaughter. The Standard also requires that the crocodile skins are washed in a disinfectant prior to processing. The other main difference is the method of antimicrobial treatment of the meat. Australian crocodile abattoirs dip the meat in an antimicrobial solution whereas in Zimbabwe the meat is blanched. The Zimbabwe abattoir visited also plans to trial and, if successful, adopt ozone treatment to reduce microbial contaminants on the meat surface.
3. DESCRIPTION OF IRA METHOD

The OIE Code states that;

“... The principal aim of import risk analysis is to provide importing countries with an objective and defensible method of assessing the disease risks associated with the importation of animals, animal products, animal genetic material, feedstuffs, biological products and pathological material ....”

In order to achieve a consistently objective and defensible method, import risk analyses carried out by AQIS follow the principles laid out in the AQIS publication, *The AQIS Import Risk Analysis Process: A Handbook* (AQIS, 1998). This process is consistent with Australia’s obligations under the SPS Agreement, and relevant recommendations of the OIE. Copies of the Handbook may be obtained from AQIS, or viewed on the AQIS homepage\(^1\).

The IRA process provides the scientific underpinning of quarantine policy and practice. Quarantine Proclamation 1998 states that the Director of Quarantine, when making a decision on whether to permit an import access request, must consider the conditions that would be necessary to reduce quarantine risk to an acceptably low level. The IRA documents relevant information for the Director of Quarantine to consider when making a decision on an import access request.

In accordance with the OIE Code, the determination of the quarantine risk associated with a proposed importation should comprise three sequential steps:

1) **Hazard identification**: Identification of the disease agents relevant to the importation of the proposed commodity and considered to be of quarantine concern

2) **Risk assessment**, comprising
   a) **Likelihood evaluation**: Estimation of the unrestricted or unmitigated likelihood that each identified disease agent will enter Australia (release assessment) with the importation of the proposed commodity and become established in susceptible species (exposure assessment)
   b) **Consequence assessment**: Estimation of each agent’s impact on human health, animal health or production, wild or native fauna and the environment, domestic disease control costs and loss of or damage to domestic and international markets
   c) **Risk estimation**: Integration of the unrestricted likelihood of entry and exposure, and the magnitude of consequences, to yield an unrestricted risk estimate for each disease agent. The acceptability of each unrestricted risk is subsequently determined by comparing it with Australia's appropriate level of protection (see below). Where necessary, risk management is considered

3) **Risk management**: Investigation of the efficacy and practicability of the OIE’s recommended safeguards and, where insufficient, other available risk management strategies (testing, quarantine, processing, etc)

\(^1\) available at http://www.aqis.gov.au/
Describing and addressing these phases in a standardised manner improves the consistency of an IRA and, thus, its transparency. As stated in the OIE Code;

“… transparency is essential because data are often uncertain or incomplete and, without full documentation, the distinction between facts and the analyst’s value judgements may blur …”.

In addition to these steps risk communication is an essential element of import risk analyses. This is the process by which information and opinions regarding hazards and risks are gathered from potentially affected and interested parties during a risk analysis, and by which the results of the risk assessment and proposed risk management measures are communicated to the decision makers and interested parties.
4. HAZARD IDENTIFICATION

Hazard identification was carried out in two stages:

(1) Identification of a preliminary index of diseases relevant to the importation of crocodiles or crocodile derived products from Africa

(2) Refinement of the preliminary index in accordance with specified hazard identification criteria (*hazard refinement*)

4.1. Preliminary Index of Disease Agents

The *preliminary index* of disease agents listed below was derived by identifying disease agents of crocodilians considered to be of potential quarantine concern:

**Disease agents**

**Bacteria**
- *Acinetobacter* spp.
- *Aeromonas hydrophila*
- *Bacillus* spp.
- *Chlamydia* spp.
- *Citrobacter* spp.
- *Corynebacterium pyogenes*
- *Dermatophilus congoensis*
- *Escherichia coli*
- *Edwardsiella* spp.
- *Enterobacter* spp.
- *Erysipelothrix insidiosa*
- *Flavobacterium* spp.
- *Klebsiella* spp.
- *Micrococcus* spp.
- *Moraxella* spp.
- *Morganella* spp.
- *Mycobacterium* spp.
- *Mycoplasma crocodyli*
- *Pasteurella multocida*
- *Providencia* (formally *Proteus*) *rettgeri*
- *Pseudomonas* spp.
- *Salmonella* spp.
- *Serratia* spp.
- *Staphylococcus* spp.
- *Streptococcus* spp.

**Viruses**
- Adenovirus-like agent
- Poxvirus

**Fungi**
- *Mucor* spp.
- *Paecilomyces* spp.
Parasites

- Protozoa
  - *Eimeria* spp.
  - *Entamoeba* spp.
  - *Cryptosporidium* spp.
  - Haemogregarines

- Helminths
  - *Dujardiniascaris* spp.
  - *Micropleura vivipera*
  - *Oswaldofilaria* spp.
  - *Paratrichosoma* spp.
  - *Spirometra erinacei*
  - *Trichinella* spp.

- Trematodes
  - Kidney fluke (Exotidendriidae)

- Pentastomes
  - *Agema* spp.
  - *Alofia* spp.
  - *Leiperia* spp.
  - *Sebekia* spp.
  - *Subtriquetra* spp.

4.2. Hazard Refinement

Hazard refinement denotes the process whereby causative agents associated with each of the diseases in the preliminary index are categorised. This is determined according to the criteria set out below. Where definitive data relevant to categorisation are lacking, AQIS makes conservative judgements that draw on scientific knowledge and observations made in similar situations and any other appropriate information.

A. The disease agent must have been found in association with crocodilians in Africa, not just generally reported in reptiles.

B. The disease agent is infectious. Putative disease agent must cause or be causally associated with a recognised disease and the disease must have been shown to have an infectious aetiology. The disease agent must be transmissible to susceptible hosts and may have been isolated. Ideally Koch’s\(^1\) or Evans’ (Thrusfield, 1995) postulates have been satisfied. This excludes diseases caused by environmental (eg. toxicosis), genetic or nutritional factors.

C. The disease agent is exotic to Australia. The disease agent is considered to be exotic if there is no report of the disease or detection of the causal agent in animals in Australia. The level of confidence that can be attributed to such a

\(^1\) Koch’s postulates refer to the experimental evidence required to establish a relationship of causation between a microorganism and a disease. The conditions are: 1) the microorganism must be present in every case of the disease, 2) it must be isolated and cultivated in pure culture, 3) inoculation of such culture must produce the disease in susceptible animals, 4) it must be observed in, and recovered from, experimentally diseased animal.
determination depends on factors such as the virulence of the organism, severity of expression of clinical disease and nature of targeted surveillance applied to the disease/agent in question. Where a disease agent is present in Australia, but the strain(s) present in other countries is/are significantly more virulent, these strains will be considered to be exotic to Australia and to meet this criterion.

OR

The disease agent is present in Australia but subject to official control. If a disease agent or disease occurs in Australia, one or more State/Territory Government(s) must have enacted legislation and be taking action to control or eradicate the disease/agent. For the purpose of this process, mandatory control measures would be deemed to exist if such measures relate to products within the scope of this analysis.

D. The disease agent is listed by the OIE. The disease agent causes a notifiable or other significant disease as listed by the OIE. There is no OIE listing for reptile diseases.

OR

The disease agent would be expected to cause significant disease in Australia. The disease agent must satisfy one or more of the following criteria:

- it would be expected to cause significant disease;
- it would be expected to cause significant damage to the environment and/or native species; and/or
- it would be expected to cause significant economic harm, for example, increased mortality, reduced growth rates, decreased product quality, loss of market access, increased management costs.

In summary, a disease agent will be given detailed consideration in the IRA if it is:

- reported in association with crocodiles in Africa
  and
- infectious
  and
  - exotic to Australia, or
  - present in Australia but subject to official control
  and
  - would cause significant disease in Australia.

The results of this procedure are shown in Table 2. All diseases listed in the table satisfy the first two criteria of being associated with crocodiles in Africa and infectious.
<table>
<thead>
<tr>
<th>Disease agent</th>
<th>Occurrence in Australia</th>
<th>Control measures in Australia</th>
<th>Economic, ecological or pathological effect</th>
<th>Include as an identified hazard?</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chlamydia</em> spp.</td>
<td>Not present</td>
<td></td>
<td>significant</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Dermatophilus congolensis</em></td>
<td>Present</td>
<td>No control measures</td>
<td>significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Eschericia coli</em></td>
<td>Present</td>
<td>No control measures</td>
<td>not significanta</td>
<td>No</td>
</tr>
<tr>
<td><em>Mycobacterium</em> spp. (other than mammalian serotypes)</td>
<td>Present</td>
<td>No control measures</td>
<td>not significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Mycoplasma croculydi</em></td>
<td>Not present</td>
<td></td>
<td>significant</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Salmonella</em> spp.</td>
<td>Serovars not present</td>
<td></td>
<td>significant</td>
<td>Yes</td>
</tr>
<tr>
<td>All other bacteria listed in 4.1</td>
<td>Present or probably present</td>
<td>No control measures</td>
<td>not significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Adenovirus-like agent</em></td>
<td>Not present</td>
<td></td>
<td>significant</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Poxivirus</em></td>
<td>Present</td>
<td>No control measures</td>
<td>significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Fungi</em></td>
<td>Present</td>
<td>No control measures</td>
<td>not significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Eimeria</em> spp.</td>
<td>Present</td>
<td>No control measures</td>
<td>significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Entamoeba</em> spp.</td>
<td>Probably present</td>
<td></td>
<td>not significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Cryptosporidium</em> spp.</td>
<td>Probably present</td>
<td></td>
<td>not significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Haemogregarines</em></td>
<td>Probably present</td>
<td></td>
<td>not significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Dujardinascaris</em> spp.</td>
<td>Species not present</td>
<td></td>
<td>significant</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Micropleura vivipera</em></td>
<td>Possibly present</td>
<td></td>
<td>not significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Osvaldofilaria</em> spp.</td>
<td>Genera present</td>
<td></td>
<td>not significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Paratrichosoma</em> spp.</td>
<td>Present</td>
<td>No control measures</td>
<td>significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Spirometra erinacei</em></td>
<td>Present</td>
<td>No control measures</td>
<td>not significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Trichinella</em> spp.</td>
<td>Not present</td>
<td></td>
<td>significant</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Kidney flukes</em></td>
<td>Present</td>
<td>No control measures</td>
<td>not significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Agema</em> spp.</td>
<td>Not present</td>
<td></td>
<td>significant</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Alofa</em> spp.</td>
<td>Genera present</td>
<td>No control measures</td>
<td>significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Leipenita</em> spp.</td>
<td>Genera present</td>
<td>No control measures</td>
<td>significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Sebekia</em> spp.</td>
<td>Genera present</td>
<td>No control measures</td>
<td>significant</td>
<td>No</td>
</tr>
<tr>
<td><em>Subtriquetra</em> spp.</td>
<td>Not present</td>
<td></td>
<td>significant</td>
<td>Yes</td>
</tr>
</tbody>
</table>

a See discussion of hazard refinement criteria in section 4.2 above
b Include as an identified hazard:

Yes: This indicates that characteristics of the disease meet the necessary criteria and will be examined more closely in this IRA report

No: This indicates that at least one of the necessary criteria are void, and that there is no cause to further examine the disease

# *E. coli* has been isolated from crocodiles in Zimbabwe (Foggin, 1992a) but pathogenic strains were not identified
4.3. Conclusions: Hazard Identification

Based on the hazard identification process above the following disease agents will be included for further consideration in this IRA report:

- *Chlamydia* spp.
- *Mycoplasma crocodyli*
- *Salmonella* spp.
- Adenovirus-like agent
- *Dujardinascaris* spp.
- *Trichinella* spp.
- *Agema* spp.
- *Subtriquetra* spp.

Disease agents identified in Table 2 as not meeting the necessary criteria will not be considered further in this report.
5. RISK ASSESSMENT

5.1. Method for Risk Assessment

Risk assessment is defined in the OIE Code as

“...an evaluation of the likelihood and the biological and economic consequences of entry, establishment or spread of a pathogenic agent within the territory of an importing country.”

The likelihood that a pathogenic agent will enter Australia, and the likelihood that susceptible animals will be exposed, are determined by carrying out a release assessment and an exposure assessment, respectively. The likelihood of establishment and spread, and its biological and economic consequences, are determined by undertaking a consequence assessment. The risk assessment for each identified agent concludes with the combination of likelihood and consequence, to give an unrestricted risk estimate.

5.1.1. Likelihood evaluation

Release assessment

The ‘biological pathway’, or ordered sequence of steps undertaken in sourcing, processing and exporting a commodity, is termed its release scenario. According to the approach adopted by AQIS, the end-point of a release scenario is the arrival in Australia of infected or contaminated commodity. In this context, ‘the arrival in Australia’ is taken to imply the arrival of infected or contaminated commodity at the point of entry - whether this is an airport or a shipping port.

The release scenario for crocodile meat from Zimbabwe is described by the following discrete stages:

- animals are exposed to the disease agent AND,
- animals are infected at the time of slaughter AND,
- the predilection sites of the disease agent include tissues comprising meat OR the meat becomes contaminated during processing AND,
- the meat remains infected or contaminated on importation.

The stages are illustrated in the pathway diagram in Figure 1. The initial event is that farmed crocodiles are exposed to an infectious agent. In Zimbabwe many farms source water from rivers (Foggin, 1987) that are natural habitats for many animals (including reptiles, amphibians and wild crocodiles) that may carry agents infectious to farmed crocodiles. It is also common practice to feed meat from wild animals that have died naturally without ascertaining the cause of death (Foggin, 1992a). These carcases may contain agents capable of infecting the farmed crocodiles. There are also numerous agents that may be present in the farm environment. This may include agents transmitted by vectors or intermediate hosts, such as rodents that may enter open pens (Huchzermeyer, 1997). It is also common for crocodiles that die on the farm, and parts of the carcases not kept for meat for human consumption, to be fed back to the farm crocodiles (Obwolo and Zwart, 1992; Revol, 1995).
To proceed further, it is then necessary for the agent to be present in the crocodile at the time of slaughter. The agent may be present in the meat or contaminate the meat during processing. Contamination of the meat is likely because the skin is valuable and must be removed carefully. Because the skin does not ‘peel’ off easily, the crocodiles must be skinned on a flat surface, which provides greater opportunity for contamination of the meat. Contamination is more likely if the carcases are eviscerated during processing (Millan et al., 1997).

Due to the risk of contamination during skinning, it is common practice to apply an antimicrobial treatment, such as dipping, to the meat to destroy any surface contaminants. Recognised dip solutions used include acetic acid and chlorine (Rickard et al., 1995). It is most probable that dipping will be effective and the agent destroyed. However, it is possible that an infectious agent may remain viable on the meat after dipping. This may be because the dipping solution was incorrectly prepared or used (under strength, insufficient contact time); the meat became contaminated again after dipping due to poor hygiene (Madsen et al., 1992); or the agent was resistant to the dipping treatment. Other decontamination procedures such as gamma irradiation have been trialed and found effective on crocodilian meat (Thayer et al., 1997) but are not currently considered practical.

Assuming the agent is present in the crocodile meat after skinning, the agent will need to be resistant to pH 6 or lower in order to remain viable in the meat. The pH of muscle falls during the onset of rigor mortis, as a result of the accumulation of lactic acid.

After packaging, the meat will be stored by either refrigeration or freezing. The probability of an agent surviving depends on the nature of the agent and the temperature reached and the length of time the meat is maintained at that temperature. In order for an agent to be considered an import risk, it would need to remain viable in the meat at the time of export.

For the purpose of the release assessment it is the unrestricted risk (see section 3) of a disease agent being present in crocodile meat without intervention or control measures that is considered. For example, since the detection of Trichinella spp. larvae in crocodile meat in Zimbabwe (Foggin and Widdowson, 1996) several control measures have been implemented. These include monitoring meat for the presence of cysts; delisting abattoirs from exporting meat if cysts are detected; banning the feeding of crocodile or carnivore/omnivore meat to farmed crocodiles intended for meat production and freezing meat at –18°C for at least 7 days (Foggin, pers. comm.; Purdie, 1999). These and other measures are not considered in the release assessment of the disease agents as their inclusion would mean it was a managed or restricted risk being determined rather than the unrestricted risk.

The four stages of the release assessment pathway described above, and summarised in Figure 1, will be considered specifically for each agent identified as a hazard (see section 4.3).
FIGURE 1 – Scenario pathway diagram for the release assessment

1. Farmed crocodiles exposed to agent
   - Clinical disease detected
   - Animal treated / recovers
   - Infected crocodile slaughtered for meat for human consumption
     - Disease not detected
       - Meat contaminated
         - Agent survives in meat
         - Agent present in exported meat
     - Meat infected
       - Agent present in exported meat
   - No clinical disease observed
The likelihoods associated with the events at each stage in the release scenario, are described for each specific disease agent in the following section (see 5.2). These likelihoods represent the probability that infection will not be detected at a given stage, or that infectious agent will not be inactivated. Individual qualitative likelihoods for each stage were expressed using the nomenclature below:

- Extreme: The event would be virtually certain to occur
- High: The event would be likely to occur
- Moderate: The event would occur with an even probability
- Low: The event would be unlikely to occur
- Very low: The event would be very unlikely to occur
- Negligible: The event would almost certainly not occur

The likelihoods of each stage were subsequently combined by sequentially applying the probability derived from Table 3 (see example below). The result of the first two stages was combined with the probability of the next stage. This process was continued as many times as determined by the number of stages in the release assessment pathway. The result of this process was termed the probability of entry. For the purpose of this IRA, if the probability of stage 1 is \( P_1 \), stage 2 is \( P_2 \) and so on, this process may be represented by the following equation:

\[
(P_1 \times P_2 \times P_3 \times P_4) = \text{probability of entry}
\]

**Table 3: Derivation of probability of entry from likelihood evaluation**

<table>
<thead>
<tr>
<th>Probability (_1)</th>
<th>Negligible</th>
<th>Very low</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Very low</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Very low</td>
<td>Very low</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>Low</td>
<td>Negligible</td>
<td>Very low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Moderate</td>
<td>Negligible</td>
<td>Very low</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>High</td>
<td>Negligible</td>
<td>Very low</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Extreme</td>
<td>Negligible</td>
<td>Very low</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>Extreme</td>
</tr>
</tbody>
</table>

**Example:**
Assume the following probabilities were found for disease agent \( X \) at each stage of the release assessment: Stage 1: Extreme; Stage 2: Moderate; Stage 3: Low and Stage 4: High. From Table 3 the probabilities of the first two stages (Extreme and Moderate) give a combined probability of Moderate. This is then combined with Stage 3 (Low) to give a probability of Low, which is combined with the final Stage 4 (High). This results in the probability of entry for disease agent \( X \) of Low.
Exposure assessment

The exposure of susceptible animals in Australia may occur as a result of one or more discrete pathways, or exposure scenarios. Exposure scenarios comprise a series of stages that characterise the exposure of susceptible animals to biological agents imported with crocodile meat, and the subsequent establishment of disease in a population/sub-population. It is assumed for the purpose of developing exposure pathways that the meat entering Australia does carry an infectious disease agent.

The exposure scenario for crocodile meat imported into Australia is described by the following discrete stages:

- the pathogen is transmitted to another susceptible host (or vector) or survives exposure to environmental stressors, e.g., desiccation, ultraviolet light,
- one or more exposed hosts become infected as a result of exposure,
- the pathogen spreads from the index case(s) to a sufficient number of susceptible hosts to sustain infection in the population and become established.

The stages are illustrated in the pathway diagram in Figure 2. The most probable event is that the meat will be cooked and consumed. Thorough cooking is considered to be heating to at least 75°C. Crocodile meat that is prepared for human consumption requires virtually no further trimming. Waste consisting of uncooked meat is considered insignificant. If the agent survived in cooked meat, any waste would either be discarded in garbage and buried, or enter the sewerage and waste water treatment. This scenario is indicated by heavy lines and arrows in Figure 2.

Alternative, although considerably less probable, events that may occur are included in Figure 2. If the meat containing an agent arrived in Australia but was not prepared for human consumption susceptible hosts could potentially be exposed to the agent. For example, if the packaging was not intact on arrival, or the product had spoiled in transit the meat would be discarded as unfit for human consumption. It is most probable this uncooked meat would be disposed of as garbage and buried. The probability of the agent surviving would be dependent on its resistance to environmental stressors. It may then be possible that an animal (possibly scavenging) is exposed to the agent.

The meat may alternatively be recovered for use as animal feed and fed directly to susceptible hosts. This is a highly unlikely event, as the volume of crocodile meat to be imported will be relatively small and the amount discarded uncooked as damaged will be a fraction of that, and probably only on rare occasions. It is not common practice for crocodile meat to be fed to crocodiles in Australian farms.

Regardless of the means of entry, the agent may ultimately reach the first stage of the exposure scenario, and be transmitted (through inhalation, ingestion, via a vector or fomite or direct contact) to a susceptible host.

Once the agent has been transmitted to the host or vector, it is then dependent on a number of variables as to whether the host will become infected. Agent variables include the infectious dose, pathogenicity and the route of transmission.
The final stage requires that an infected host is in contact (direct or indirect) with other susceptible hosts and the agent spreads becomes established within a population.

The stages in the pathway will be discussed in detail relating to specific disease agents in the risk assessment.

The likelihoods associated with the events at each stage in the exposure scenario, are described for each specific disease agent in the following section. These likelihoods represent the probability that the agent will persist after each stage. For each disease agent the likelihoods for each stage were expressed using the nomenclature described above in the Release assessment section. The likelihoods of each stage were combined by the same procedure described above using Table 3. The result of this process was termed the probability of exposure.

Probability of entry and establishment

The results of the release and exposure assessments were combined to give an overall probability of entry and establishment. Release and exposure assessments were combined as illustrated in the table below.

Table 4: Derivation of the probability of entry and establishment

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<tr>
<th>Probability of entry</th>
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FIGURE 2 – Scenario pathway diagram for the exposure assessment

- Imported crocodile meat containing agent
- Uncooked meat discarded (Spoiled or damaged in transit)
- Meat cooked for human consumption in restaurant, home, or outdoors
- Consumed by susceptible host (Rodents, pets, reptiles)
- Spoiled or unused product discarded
- Waste products
- Agent transmitted to susceptible host (or vector)
- Landfill
- Waste water treatment
- Agent survives in environment
- Environmental contamination
- Agent spreads to other hosts
- Disease established in animal population in Australia
5.1.2. Consequence assessment

*Consequence assessment criteria*

Consequence assessments carried out for each identified hazard were based on the following *direct* and *indirect* consequences of disease establishment:

**Direct consequences**
- Animal infection, disease and production loss
- Public health consequences
- Adverse consequences to the environment

**Indirect consequences**
- Surveillance and control costs
- Compensation costs
- Potential trade losses
- Social consequences
- Adverse effects on other industries

*Estimation of consequences*

The classifications outlined below were used to estimate the extent of each direct and indirect consequence (see above). These classifications may be interpreted in dollar terms, in terms of particular societal values or social wellbeing, or as a combination of both.

**Extreme:** The impact on a given criterion is likely to be highly significant at the national level. This classification implies that national economic stability, societal values or social wellbeing would be seriously affected.

**High:** The impact on a given criterion is likely to be significant at a national level, and highly significant within affected zones. This classification implies that the impact would be of national concern. The serious effect on economic stability, societal values or social wellbeing would, however, be limited to a given zone.

**Moderate:** The impact on a given criterion is likely to be recognised at a national level, and significant within affected zones. The impact is likely to be highly significant to directly affected parties.

**Low:** The impact on a given criterion is likely to be recognised within affected zones, and significant to directly affected parties. It is not likely that the impact on the given criterion will be recognised at the national level.

**Negligible:** The impact on a given criterion is likely to be minor to directly affected parties. The impact is unlikely to be discernible at any other level.
Qualitative classifications assigned to each direct and indirect consequence were subsequently combined to derive a single overall assessment of consequence. This was achieved by adhering the conditions outlined below. These conditions are mutually exclusive, and were addressed in the order that they appear in the list below. For example, if the first set of conditions did not apply, the second set was considered. If the second set did not apply, the third set was considered, and so forth.

- Where the impact on any direct or indirect criterion is *extreme*, the overall consequence is also considered *extreme*.
- Where the impact on more than one criterion is *high*, the overall consequence is considered *extreme*.
- Where the impact on a single criterion is *high* and the impact on each remaining criterion is *moderate*, the overall consequence is considered *extreme*.
- Where the impact on a single criterion is *high* and the impact on remaining criteria is not unanimously *high*, the overall consequence is considered *high*.
- Where the impact on all criteria is *moderate*, the overall consequence is considered *high*.
- Where the impact on one or more criteria is *moderate*, the overall consequence is considered *moderate*.
- Where the impact on all criteria is *low*, the overall impact is considered *moderate*.
- Where the impact on one or more criteria is considered *low*, the overall impact is considered *low*.
- Where the impact on all criteria is *negligible*, the overall consequence is considered *negligible*.

5.1.3. Risk estimation

Risk estimation infers the integration of likelihood evaluation and consequence assessment. The result of risk estimation is thus a unit representing the *expected loss* associated with each hazard.

Risk estimation is undertaken using the “risk estimation matrix” in Table 5. The cells in this table describe expected loss in the same terms as the criteria used in the original consequence assessment. For example, a designation of ‘low’ infers that when the likelihood of a disease incursion and its consequences are combined, the expected loss will be equivalent to the scale of monetary or social impact described as ‘low’ in the preceding section (see 5.1.2).

Interpretation of this risk estimation matrix in the light of Australia’s ALOP is discussed below in Risk Management (see 6.1).
Table 5: Risk estimation matrix

<table>
<thead>
<tr>
<th>Probability of entry and establishment</th>
<th>Consequence of entry and establishment</th>
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<tbody>
<tr>
<td></td>
<td>Negligible</td>
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<td>Extreme</td>
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5.2. Risk Assessment for the Identified Hazards

5.2.1. *Chlamydia* spp.

*The agent*

Chlamydiae are highly infectious obligate intracellular bacteria that invade host epithelial and mucosal cells. There are four recognised species of *Chlamydia*, with *C. psittaci* most commonly affecting animals (Carter *et al.*, 1995). Strains of *Chlamydia* spp. are considered host and disease specific.

There are only limited reports of chlamydiosis in poikilotherms (two in African frogs, one in puff adders and in an asymptomatic iguana and chameleon). Chlamydiosis (presumably due to *C. psittaci*) was isolated from farmed hatchling Nile crocodiles (Huchzermeyer *et al.*, 1994a). Recently Berger *et al.* (1999) reported the first case of chlamydiosis (*C. pneumoniae*) in poikilotherms in Australia. This limited to a single case in a free-ranging frog. *C. pneumoniae* commonly affects the respiratory tract in humans, and has also been previously reported in animals.

*C. psittaci* is a recognised disease in birds and zoonosis in humans, and is commonly carried in the spleen and kidney of clinically healthy birds. Large numbers of organisms may be shed in the faeces, which then dry, producing a dust that is infectious to susceptible hosts (Carter *et al.*, 1995). It is also possible that arthropod-borne infections occur. Other animals affected include sheep, cattle, buffalo, goats, pigs, horses, rabbits, mice, guinea pigs, cats, dogs and koalas.

Chlamydiosis in crocodilians appears to be confined to southern Africa and is considered a major disease problem on crocodile farms in Zimbabwe (Huchzermeyer *et al.*, 1994a). The disease has not been observed in east Africa (Cooper, 1999) nor Australia (Ladds, 1994). There have been no human cases of chlamydiosis associated with infected crocodiles to date.
Likelihood evaluation

Release assessment

Huchzermeyer et al (1994a) suggests the source of infection on crocodile farms may be from the use of river water contaminated by the African clawed frog and adult crocodiles may also act as a reservoir of infection for younger animals.

The likelihood of farmed crocodiles being exposed to chlamydiosis is uncertain as the source of infection remains unidentified, but due to the confirmation of disease and the common practice of farms using river water, is considered HIGH.

Chlamydiosis has been reported as a cause of frequent outbreaks of hepatitis and conjunctivitis in young farmed Nile crocodiles (Huchzermeyer, 1997). The disease is characterised by sudden death with post mortem findings usually consisting of enlarged livers and spleens (Huchzermeyer et al, 1994a). It is therefore most probable that infection in farmed crocodiles would be detected prior to slaughter and the carcase destroyed.

The clinical signs associated with chlamydiosis in farmed crocodiles are severe and therefore the likelihood of infected crocodiles being slaughtered for meat is considered LOW.

If an infected crocodile was not detected clinically prior to slaughter, pathology may be detected at processing, although this is less likely if the carcase is not eviscerated as the affected organs may not be observed. Chlamydial organisms are recognised as spreading via the blood, resulting in systemic disease. It is therefore feasible that the infectious agent may be present in meat. Faecal contamination of meat from asymptomatic carrier animals may occur during processing.

The likelihood of gross pathology not being detected or meat becoming contaminated, based on current methods in Zimbabwe abattoirs, and therefore the organism present in the meat is considered HIGH.

There is no evidence to demonstrate the persistence of *C. psittaci* in the meat of eviscerated carcasses of other animals, such as small ruminants (Pepin et al, 1997). Chlamydiae can survive in the pH range 7 – 8 (Eugster, 1980), which is outside the normal pH range of chicken meat (6.2 – 6.4) (Jay, 1996).

Due to the unlikely survival and transmission of chlamydial organisms in meat, the likelihood of the agent being present in crocodile meat from Zimbabwe is NEGLIGIBLE.

In summary, according to the procedure described in 5.1.1, the probability of entry of chlamydiosis in crocodile meat from Zimbabwe is NEGLIGIBLE.
Exposure assessment

If *Chlamydia* spp. were present in imported crocodile meat from Zimbabwe the most probable pathway depicted in Figure 2, that the meat will be cooked for human consumption, would be sufficient to destroy the organism. *C. psittaci* is inactivated after 5 minutes at 56°C (Anderson et al, 1997). In the unlikely event that uncooked meat was discarded, the survival of infectious chlamydial organisms is unlikely. The organisms are intracellular parasites and therefore unlikely to multiply on the meat surface, and unlikely to survive at the pH of meat. Reports have implicated mechanical transmission of avian chlamydiosis by arthropods, but their role remains uncertain (Anderson et al, 1997) and is not considered further.

The likelihood of transmission to a susceptible host or vector from discarded crocodile meat is considered NEGLIGIBLE.

If chlamydiosis was transmitted to a susceptible host, the organisms could readily multiply, as demonstrated in birds and other animals.

The likelihood of that host becoming infected is HIGH.

*Chlamydia psittaci* has been shown to be transmitted by infectious organisms being shed in the faeces, drying and producing a dust that is infectious to susceptible hosts by inhalation or ingestion (Carter et al, 1995). *C. psittaci* survives for a few days in naturally infected bird faeces (Mitscherlich and Martin, 1984). The organism therefore has the potential to survive in the environment when passed from a live animal.

The likelihood of chlamydiosis spreading to other hosts and becoming established in a population is HIGH.

The probability of exposure of chlamydiosis in Australia if it entered in crocodile meat imported from Zimbabwe is calculated as NEGLIGIBLE.

Probability of entry and establishment

The results of the release and exposure assessments were combined, according to Table 4, to give an overall probability of entry and establishment of chlamydiosis from the importation of crocodile meat from Zimbabwe of NEGLIGIBLE.

Consequence assessment

The presence of *Chlamydia* spp. in humans, production animals and wildlife (including poikilotherms) in Australia is well documented.

The consequence assessment of disease establishment for chlamydiosis was based on the direct and indirect criteria listed in section 5.1.2. The direct consequence of chlamydiosis and loss of production in farmed crocodiles on the Australian crocodile industry is considered MODERATE. All other criteria were estimated as having a NEGLIGIBLE consequence of establishment. From this, according to the conditions described in 5.1.2, the overall assessment of consequence for chlamydiosis is MODERATE.
**Risk estimation**

Based on the risk estimation matrix (see Table 5) for evaluating the risk associated with *Chlamydia* spp., integration of the probability of entry and establishment (NEGligible) and the consequence assessment (Moderate) results in a risk estimation of NEGLIGIBLE. The risk does not exceed the ALOP and risk management is not required.

5.2.2. *Mycoplasma crocodyli*

**The agent**

Mycoplasmas are the smallest and simplest prokaryotic cells capable of replication. There are over 60 *Mycoplasma* species associated with animals. Infections are most frequently acquired by inhalation. Many of the mycoplasmas are commensals in the upper digestive, respiratory and genital tracts. Some have a predilection for infecting serous cavities and joints. Species show considerable host specificity. The mechanism by which mycoplasmas cause disease are poorly understood. Infections are frequently chronic and low grade. *Mycoplasma* are more fragile than bacteria and are readily killed by drying, sunlight and chemical disinfection. (Carter et al, 1995).

*Mycoplasma* spp infect animals and humans worldwide. Mycoplasmas were recovered from farmed Nile crocodiles in the early 1990’s without apparent disease (Huchzermeyer et al, 1994b). Subsequently, outbreaks of polyarthritis on several Zimbabwe crocodile farms were found to be due to mycoplasmosis. The isolates were recovered from joints and lungs of affected crocodiles and the infection was experimentally reproduced in crocodile yearlings (Mohan et al, 1995). An outbreak due to *Mycoplasma* sp. was also reported in captive alligators in Florida (Brown et al, 1996). The Nile crocodile organism was later classified and given a new species description of *Mycoplasma crocodyli* (Kirchhoff et al, 1997) and was distinct from the species (provisionally named *Mycoplasma lacertae*) isolated from alligators. There have been no other reports of mycoplasmosis in crocodilians.

**Likelihood evaluation**

**Release assessment**

The source of infection in the Zimbabwean outbreak is unknown although the farmers suspected poultry carcasses fed to the crocodiles (Mohan et al, 1995). The crocodile *Mycoplasma* did not share biochemical characteristics typical of pathogenic avian isolates (Mohan et al, 1995). Due to the recognised host specificity in other mycoplasmas it is unlikely transmission from chickens to crocodiles would occur.

Mycoplasmas in poultry affect the respiratory system and one species, *M. synoviae*, affects the joints. The disease is transmitted by direct contact, through aerosols and vertically in eggs (Kleven, 1997). The mode of transmission of *M. crocodyli* may be similar, but no lateral transmission occurred between experimentally infected crocodiles and in contact animals (Mohan et al, 1995). Eggs collected from the wild may be a potential source of introducing the disease into crocodile farms.
Based on the limited current knowledge of mycoplasmosis in crocodiles, the likelihood that farmed crocodiles are exposed to the organism is considered MODERATE.

Sick animals consistently displayed swollen joints, as well as progressive lameness and paresis (Mohan et al., 1995). It is unlikely that clinically affected crocodiles would be processed for meat. Crocodiles experimentally infected with *M. crocodyli* all recovered clinically within 6-8 weeks from the date symptoms were first seen (Mohan et al., 1995). The organism has also been reported in asymptomatic Nile crocodiles (Huchzermeyer et al., 1994b).

The likelihood that infected crocodiles, not showing acute clinical signs, may be slaughtered for meat production is considered MODERATE.

Mycoplasmas present in the intestines may potentially contaminate the meat during processing. Organisms may also be present in the muscle of infected crocodiles from endogenous spread.

The likelihood of mycoplasmas present in the meat is HIGH.

*Mycoplasma* spp. have been shown to survive for a few hours to a few days in chicken muscle held at 20-37°C (Mitscherlich and Marth, 1984). Avian *Mycoplasma* spp. are unstable below pH 6.8 (Kleven, 1997) and would be unlikely to survive at the pH of meat.

The likelihood of *M. crocodyli* surviving in crocodile meat from Zimbabwe is VERY LOW.

In summary, according to the procedure described in 5.1.1, the probability of entry of *Mycoplasma crocodyli* in crocodile meat from Zimbabwe is VERY LOW.

Exposure assessment

If *Mycoplasma crocodyli* was present in imported crocodile meat from Zimbabwe the most probable pathway depicted in Figure 2, that the meat will be cooked for human consumption, would be sufficient to destroy the organism. Avian mycoplasmas are sensitive to temperature greater than 39°C (Kleven, 1997). If uncooked meat was discarded, the organisms are fragile and unlikely to survive in the environment. If it is assumed that like other mycoplasmas, *M. crocodyli*, is host specific for Nile crocodiles there are no susceptible hosts in Australia. It would be reasonable to assume that Australian crocodiles may be susceptible hosts, but not other Australian animals or birds. Wild crocodiles would not have access to discarded garbage containing infected imported crocodile meat. The only possibility of a susceptible host in Australia being exposed to the agent would be if farmed crocodiles were directly fed the discarded uncooked meat. Crocodile meat is not normally fed to farmed animals in Australia.

The likelihood of transmission to a susceptible host from discarded crocodile meat is considered NEGLIGIBLE.
If mycoplasmas were transmitted to a susceptible host, the organisms could multiply. The likelihood of that host becoming infected is MODERATE.

Avian mycoplasmas may survive in faeces for up to 3 days at 20°C and for up to 1 day at 37°C (Mitscherlich and Marth, 1984). Experimentally, lateral transmission of *M. crocodyli* has been shown not to occur in crocodiles (Mohan *et al*, 1995).

The likelihood of mycoplasmosis spreading to other hosts and becoming established in a farm population is VERY LOW.

The probability of exposure of *M. crocodyli* in Australia if it entered in crocodile meat imported from Zimbabwe is calculated as NEGLIGIBLE.

**Probability of entry and establishment**

The results of the release and exposure assessments were combined, according to Table 4, to give an overall probability of entry and establishment of *M. crocodyli* from the importation of crocodile meat from Zimbabwe of NEGLIGIBLE.

**Consequence assessment**

The consequence assessment of disease establishment for *M. crocodyli* was based on the direct and indirect criteria listed in section 5.1.2. The direct consequence of *M. crocodyli* on animal infection, disease and loss of production in farmed crocodiles is considered MODERATE. All other criteria were estimated as having a NEGLIGIBLE consequence of establishment.

From this, according to the conditions described in 5.1.2, the overall assessment of consequence for chlamydiosis is MODERATE.

**Risk estimation**

Based on the risk estimation matrix (see Table 5) for evaluating the risk associated with *M. crocodyli*, integration of the probability of entry and establishment (NEGLIGIBLE) and the consequence assessment (MODERATE) results in a risk estimation of NEGLIGIBLE. The risk does not exceed the ALOP and risk management is not required.

5.2.3. *Salmonella* spp.

**The agent**

Members of the genus *Salmonella* are a morphologically and biochemically homogenous group of gram-negative, motile, facultatively anaerobic bacilli. Salmonellae are considered to be hardy and ubiquitous pathogens. They survive freezing and dessication well and persist for years in suitable organic substrates. Salmonellae are rapidly inactivated by heat and sunlight, do not sporulate and are destroyed by common phenolic, chlorine and iodine based disinfectants (Carter *et al*, 1995).

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Salmonellae have been isolated from Nile crocodiles and the meat in Zimbabwe (Greenburg and Sechter, 1992; Obwolo and Zwart, 1993; Madsen, 1996; Huchzermeyer, 1997; Madsen et al, 1998); from Nile crocodiles in South Africa (van der Walt et al, 1997); from alligators in America (Scott and Foster, 1997) and from Australian crocodiles (Manolis et al, 1991; Millan et al, 1997).

Many of the serovars or species reported from Nile crocodiles and meat have not been identified in any animal (or humans) in Australia (Murray, 1994; Anon, 1998b; Davos, pers. comm.). Although they may be environmental contaminants and the pathogenicity is unknown, they are considered exotic to Australia (see Appendix 2).

It is only *Salmonella* spp. or serovars that are exotic to Australia that are considered in the risk assessment.

The serovars in subspecies I most commonly cause disease in humans. Several isolates from crocodile meat in Zimbabwe have been associated with human disease (Madsen, 1996). Of the 24 subspecies I salmonellae listed in Appendix 2, 17 have been isolated from humans in the USA since 1987 (PHLIS, 1999).

**Likelihood evaluation**

**Release assessment**

*Salmonella* spp. are normally carried in the intestinal tracts of reptiles and shed intermittently when animals are stressed (Austin and Wilkins, 1998). A report from Zimbabwe isolated *Salmonella* spp. from intestinal swabs of healthy crocodiles and this supports findings in other reptiles that they are part of the normal gut flora (Obwolo and Zwart, 1993). Farmed crocodiles may also become infected with other species of *Salmonella* that are present in contaminated feed from local meat sources (Huchzermeyer, 1991; Greenberg, 1992; Van der Walt et al, 1997).

The likelihood of farmed crocodiles in Zimbabwe being exposed to salmonellae not present in Australia is considered EXTREME.

Asymptomatic carriers of salmonellae are recognised in animals including reptiles and crocodiles (Huchzermeyer, 1997; Madsen et al, 1998). Predisposing stressful conditions including overcrowding in farms may result in salmonellosis causing severe pathology and acute mortalities, or a protracted course of disease (Huchzermeyer, 1991). Groves and Harrington, 1998, consider that reptiles are particularly likely to be asymptomatic carriers, and that faecal carriage rates of *Salmonella* spp. may exceed 90%.

The ubiquitous presence of salmonellae in the environment and common occurrence of asymptomatic carriers, suggests the likelihood that infected crocodiles are slaughtered for meat production is EXTREME.

Salmonellae may invade the meat of crocodiles during the stress of handling just prior to slaughter (Huchzermeyer, 1997). The skinning of crocodile carcases provides opportunity for the meat to come into contact with the skin surface that may be
contaminated from pond water (Madsen, 1996) as well as the possibility of faecal contamination during processing (Huchzermeyer, 1997).

The likelihood of salmonellae being present in the meat is HIGH.

Salmonellae can survive at pH values between 4.0 and 9.5 (Anon, 1999). Salmonellae have been isolated from crocodile meat from Zimbabwe abattoirs after chilling at 4°C, freezing at –20°C (Madsen, 1996) and after dipping in chlorine (Foggin, 1992). It is assumed for the purpose of considering the unrestricted risk (see section 3) that effective antimicrobial treatment to reduce surface contamination is not applied to the crocodile meat.

If salmonellae are present in crocodile meat or as a surface contaminant the likelihood that they will survive in meat is EXTREME.

In summary, according to the procedure described in 5.1.1, the probability of entry of exotic Salmonella spp. in crocodile meat from Zimbabwe is HIGH.

Exposure assessment

Salmonellae present in meat may survive cooking although reports demonstrate variation between strains and the method of cooking (eg microwave vs convection). It is recommended that heating to 75°C is sufficient to destroy salmonellae (Anon, 1999). It is most probable that imported crocodile meat would be cooked sufficiently to destroy any salmonellae present.

Salmonellae present in uncooked discarded crocodile meat, however, may survive in the environment. Salmonella spp. have contaminated poultry yards for over 6 months (Mitscherlich and Marth, 1984). They will survive in water and in temperature ranging from 7 to 47°C (Anon, 1999).

The likelihood of a susceptible host ingesting infectious salmonellae is MODERATE.

The infective dose varies depending on the host and the food material. About $10^5$ Salmonella per gram is sufficient to cause disease, although outbreaks have occurred in humans where only 1 to 10 Salmonella per gram of food were detected (Anon, 1999). The pathogenicity of many salmonellae isolated from crocodiles and crocodile meat is uncertain.

The likelihood of an animal that ingested salmonellae from imported crocodile meat becoming infected is HIGH.

Salmonella spp. have survived for over 2 months in reptile faeces kept at room temperature (Mitscherlich and Marth, 1984). An infected host may contaminate the environment and water sources. Other animal species drinking from the source may ingest an infectious dose of salmonellae sufficient to become infected.

The likelihood of an exotic strain of Salmonella spreading to other hosts and therefore establishing in Australia is considered HIGH.
The probability of exposure, calculated from the above likelihoods, is MODERATE.

Probability of entry and establishment

The results of the release and exposure assessments were combined, according to Table 4, to give an overall probability of entry and establishment of *Salmonella* spp. from the importation of crocodile meat from Zimbabwe of MODERATE.

Consequence assessment

The pathogenicity of exotic strains of *Salmonella* are uncertain, but may cause disease in Australian crocodiles, be of public health concern and contaminate the environment. Reptiles are recognised as an important reservoir of *Salmonella* but are considered as only potential sources of human disease because of inadequate study (Minette, 1983). The consequence assessment of an exotic strain of salmonellosis establishing in Australia was considered HIGH for public health consequences and MODERATE for the remaining two direct consequences. It was considered that there may be a MODERATE impact on surveillance and control costs, and the remaining indirect consequences were considered to be LOW or NEGLIGIBLE.

From this, according to the conditions described in 5.1.2, the overall assessment of consequence for *Salmonella* spp. is HIGH.

Risk estimation

Based on the risk estimation matrix (see Table 5) for evaluating the risk associated with *Salmonella* spp., integration of the probability of entry and establishment (MODERATE) and the consequence assessment (HIGH) results in a risk estimation of HIGH. The risk exceeds the ALOP and risk management is required.

5.2.4. Adenovirus-like agent

The agent

Adenoviruses are highly species-specific and infections tend to be persistent and subclinical. Infections are associated with long periods of latency and virus can often be recovered from the lymphoid organs of apparently healthy animals (Fenner *et al*., 1993). Adenovirus has been associated with inclusion body hepatitis in chickens. This condition is difficult to reproduce experimentally and is thought to be caused by concurrent infection with other infectious agents (Fenner *et al*., 1993).

Viral particles, consistent with adenovirus, were first identified in farmed Nile crocodiles in Zimbabwe (Jacobson *et al*., 1984). The infection is associated with hepatitis or enteritis and is considered common in Zimbabwe, having been recorded on 57% of crocodile farms (Foggin, 1992b). The disease is considered rare in South Africa, probably due to lack of contact with wild virus carriers (Huchzermeyer *et al*., 1994b). Vertical transmission is suspected (Foggin, 1992b) and the disease is thought to have been introduced into farms through collection of wild eggs. Experimental infection indicates an incubation period of 2 – 18 weeks (Foggin *et al*., 1988).
The disease has not been reported in other crocodilians and has not been recorded or suspected in Australia.

Likelihood evaluation

Release assessment

Once adenovirus has been introduced into a farm from hatchlings it is likely to persist and be transmitted between crocodiles horizontally. It is possible that faecal contamination of the river water by wild crocodiles may also be a source of infection for farmed crocodiles.

This disease is common in Zimbabwe farms and therefore the likelihood that farmed crocodiles are exposed to adenovirus is considered MODERATE.

Clinical signs are non-specific, but crocodiles showing lethargy and anorexia are unlikely to be slaughtered for meat production. Furthermore, acute disease causing runting and mortality affects young hatchlings and is considered rare in animals over 5 months of age (Foggin, 1992b). Farmed Nile crocodiles are slaughtered at 3 – 4 years of age (Madsen, 1996). It is possible that adenovirus persists in the organs and tissues of older asymptomatic crocodiles, as happens in other species, but this has not been demonstrated.

The likelihood that infected crocodiles are slaughtered for meat production is considered LOW.

Although adenoviruses are present in viscera, there are no reports of its isolation from muscle in other species. Crocodiles subclinically infected with enteric adenovirus may contaminate the meat during processing.

The likelihood that adenovirus is present in crocodile meat is VERY LOW.

Avian adenoviruses are reported to be resistant to extremes of pH ranges, between 3 – 9 (McFerran, 1997) and unlikely to be inactivated in meat.

If adenovirus was present in crocodile meat, the likelihood that it would remain viable is HIGH.

In summary, according to the procedure described in 5.1.1, the probability of entry of adenovirus in crocodile meat from Zimbabwe is VERY LOW.

Exposure assessment

Adenovirus present in imported crocodile meat is unlikely to remain viable after cooking, although heat resistant strains of avian adenovirus have been shown to survive at 70°C for 30 minutes (McFerran, 1997). Adenoviruses may survive in discarded uncooked meat as they are considered fairly resistant to temperature extremes including freezing. Adenovirus remained infectious in turkey carcases (prevented from drying) for several weeks. Persistence in the environment has been shown to be a contributing factor to the spread of adenovirus infections through
poultry flocks (Pierson and Domermuth, 1997) and crocodile farms (Foggin, 1992a). Adenovirus has apparently been reported in other reptiles (Jacobson et al, 1984) but the transmission of the strain infecting Nile crocodiles to other reptiles or crocodilians is unknown. It is highly unlikely that Australian crocodiles (wild or farmed) would be exposed to discarded uncooked imported crocodile meat. If the Zimbabwe virus is as host specific as other adenoviruses, it is very unlikely that scavenging birds would be susceptible.

Therefore, the likelihood of the Zimbabwe strain of adenovirus being transmitted via crocodile meat to a susceptible host in Australia is VERY LOW.

If a reptilian, or other susceptible host, was exposed to adenovirus it is feasible that it will become infected, although it may be subclinical.

In the absence of reported evidence in crocodiles or reptiles, the likelihood that a host exposed to adenovirus would become infected is considered MODERATE.

Horizontal transmission of adenovirus is recognised in Zimbabwe crocodile farms. Also considering the probable persistence of infection in the host and survival in the environment, it is feasible that adenovirus could establish in a population.

The likelihood of this disease establishment is considered HIGH.

The overall probability of exposure, based on the likelihoods determined above is calculated as VERY LOW.

Probability of entry and establishment

The results of the release and exposure assessments were combined, according to Table 4, to give an overall probability of entry and establishment of adenovirus from the importation of crocodile meat from Zimbabwe of NEGLIGIBLE.

Consequence assessment

The consequences of adenovirus entry and establishment is difficult to predict. Infections are most likely to occur in a wild population but may remain subclinical, or outbreaks of mortality may occur.

Runting is already commonly recognised as a constraint to production in Australian crocodile farms (Ladds, 1994) although no specific aetiology has been identified. The impact of adenovirus on the crocodile farming industry due to production loss is estimated to be MODERATE. There are no known public health risks associated with adenovirus in other species, and therefore the consequence is NEGLIGIBLE. Adenovirus may have a HIGH adverse impact on the environment. All the indirect consequences of the introduction of adenovirus are considered NEGLIGIBLE.

According to the conditions described in 5.1.2, the overall assessment of consequence for adenovirus is considered HIGH.
**Risk estimation**

Based on the risk estimation matrix (see Table 5) for evaluating the risk associated with adenovirus, integration of the probability of entry and establishment (NEGLIGIBLE) and the consequence assessment (HIGH) results in a risk estimation of NEGLIGIBLE. The risk does not exceed the ALOP and risk management is not required.

5.2.5. *Dujardinascaris* spp.

**The agent**

The nematode ascarid genus, *Dujardinascaris* (*formally Gedoelstascaris*) contains eleven species, all of which parasitise crocodilians (Sprent, 1977). Eggs containing infectious larva are passed in the faeces of the crocodile. The life cycle is uncertain (Sprent, 1984) but an intermediate host, the lake sardine, has been implicated in Zimbabwe (Foggin, 1987).

Large burdens may occur but are often not associated with loss of body condition of the host. Gastric ulceration may occur (Ladds and Donovan, 1989). Both mature and immature parasites have been found in crocodiles (Ladds and Sims, 1990; Foggin, 1992a) which may represent auto-infection. *Dujardinascaris* infestation is recognised as a significant parasitism of economic importance in Zimbabwe crocodile farms (Foggin, 1987).

The host specificity for the adult worms is considered low, and it is likely that speciation has occurred due to geographical isolation of the hosts (Sprent, 1977). Two species reported in Australian crocodiles are *D. mawsonae* and *D. taylorae*. Four species reported in Nile crocodiles are *D. dujardini, D. madagascariensis, D. gedoelsti* and *D. puylaerti*. These species are exotic to Australia and are those referred to further in this report as *Dujardinascaris* spp.

**Likelihood evaluation**

**Release assessment**

There appears to be a clear association between the presence of *Dujardinascaris* in crocodile farms and the feeding of fresh kapenta (sardines) (Foggin, 1992a). Frozen (and then thawed) fish fed to farmed crocodiles does not appear to lead to infestation. Over 25% of crocodiles farms in Zimbabwe with more than 1 000 animals use kapenta as the primary food source (Luxmoore, 1992).

The likelihood that farmed crocodiles are exposed to the parasite is considered MODERATE.

Clinical disease may be inapparent in the majority of cases. Clinically affected crocodiles that reach slaughter size are likely to be emaciated and not considered for meat production. Diagnosis can be made by detecting characteristic ascarid eggs in the faeces.
The likelihood that infected crocodiles are slaughtered for meat is MODERATE.

The larval migration within the crocodile host is uncertain but may occur and is reported in ascariid infections in other reptiles (Sprent, 1984). Immature larvae may migrate into tissues adjacent to the gastrointestinal tract, lungs, heart and blood vessels. It is possible that larvae may be present in meat. Faecal contamination during processing may result in eggs on the meat surface.

The likelihood of crocodile meat containing larval *Dujardiniascaris* spp. or being contaminated with eggs is LOW.

No information is available on the survival of ascarid larvae or eggs in meat.

The likelihood that the larvae or eggs of *Dujardiniascaris* spp. will survive in crocodile meat is considered VERY LOW.

The probability of entry of *Dujardiniascaris* spp. in crocodile meat from Zimbabwe is calculated as VERY LOW.

Exposure assessment

Immature stages of *Dujardiniascaris* spp. present in imported crocodile meat, would be readily destroyed during cooking. The survival of the parasite in discarded uncooked meat is considered unlikely. Unlike typical ascarid eggs, *Dujardiniascaris* spp. eggs are thin shelled (Frank, 1981) and therefore less resistant to environmental factors. The only possible exposure pathway that may result in the agent being transmitted is the direct consumption by a susceptible host. For *Dujardiniascaris* spp. this would have to be crocodiles or fish. As described in section 5.1.1 Exposure assessment, the meat is unlikely to be fed to farmed crocodiles in Australia. The chance of uncooked crocodile meat being used as a feed in aquaculture or as bait is remote, because of the insignificant volume of meat not likely be sold for human consumption.

The likelihood of *Dujardiniascaris* spp. being transmitted to a suitable host in Australia is considered NEGLIGIBLE.

If uncooked contaminated meat was fed directly to farmed crocodiles, the animal may become infected if the larvae were ingested. Although, auto-infection has been suggested, this is not consistent with other ascarids and transmission of infection by a crocodile ingesting eggs is unlikely to occur. Rainbow fish have been found infested with pentastomes (Buenviaje *et al*., 1994). The uncertainty of other suitable fish species that may be intermediate hosts for this parasite in Australia, and the remote possibility of exposure do not warrant considering this pathway further.

The likelihood that a farmed crocodile ingesting uncooked meat containing larval *Dujardiniascaris* spp. will become infected, and adult parasites develop, is NEGLIGIBLE.
The absence of a suitable intermediate fish host in crocodile farms would ensure the likelihood that the parasite spreads to other hosts and establishes in a population is NEGLIGIBLE.

The probability of exposure, from the above exposure assessment for *Dujardinascaris* spp. in imported crocodile meat, is calculated as NEGLIGIBLE.

**Probability of entry and establishment**

The results of the release and exposure assessments were combined, according to Table 4, to give an overall probability of entry and establishment of *Dujardinascaris* spp. from the importation of crocodile meat from Zimbabwe of NEGLIGIBLE.

**Consequence assessment**

Due to the lack of knowledge about the life cycle, and possible susceptible intermediate and definitive hosts, of *Dujardinascaris* spp. it is difficult to estimate the consequences of the parasite establishing in Australia. Considering the criteria listed in section 5.1.2, the only one that may be adversely affected by the establishment of *Dujardinascaris* spp. is the impact on the environment. The presence of endemic *Dujardinascaris* spp. in Australian crocodiles (the intermediate hosts have not been identified) suggests the impact to be at most MODERATE. All other criteria are considered to have a NEGLIGIBLE consequence.

According to the conditions described in 5.1.2, the overall assessment of consequence for adenovirus is considered MODERATE.

**Risk estimation**

Based on the risk estimation matrix (see Table 5) for evaluating the risk associated with *Dujardinascaris* spp., integration of the probability of entry and establishment (NEGLIGIBLE) and the consequence assessment (MODERATE) results in a risk estimation of NEGLIGIBLE. The risk does not exceed the ALOP and risk management is not required.

**5.2.6. Trichinella spp.**

**The agent**

Trichinellosis is a helminth disease of mammals. Its principal importance is as a zoonosis, associated with the eating of raw or improperly cooked infested meat. Pork is considered the most significant and likely source of human infection. Trichinellosis is caused by the nematode parasite *Trichinella spiralis*. Adult worms are found in the small intestine of their host. The larvae encyst in muscle, and therefore the meat must be ingested for the life cycle to be completed.

Numerous subtypes of *T. spiralis* have been identified. *T. nelsoni* (*T. spiralis* var. *nelsoni*) circulates among wild carnivores and pigs in eastern and southern Africa, southern USSR, Bulgaria and Switzerland (Acha and Szfres, 1987). Some authors recognise *T. nelsoni* as a species others regard *T. nelsoni* as a strain of *T. spiralis*. 

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There has never been any evidence of indigenous trichinellosis in humans or animals in Australia.

*Trichinella spiralis* and *T. nelsoni* have been identified in wild animals in Africa including South Africa (Young and Whyte, 1975), Tanzania (Pozio *et al.*, 1997), Kenya (Nelson and Dunsmore, 1983) and Zimbabwe (Foggin and Widdowson, 1996).

Until recently, there were no reports of *Trichinella* species infecting reptiles. Foggin and Widdowson (1996) reported *Trichinella*-like parasites (tentatively *T. spiralis nelsoni*) in crocodile meat from several farms in Zimbabwe. The identification of this parasite was questioned (Kapel *et al.*, 1998) but experimental transmission to baboons from infected crocodile meat suggests a zoonosis (Foggin, *pers. comm.*). There is continuing detection of the parasite in slaughtered crocodiles on some farms in Zimbabwe (Foggin, *pers. comm.*).

**Likelihood evaluation**

**Release assessment**

The source of *Trichinella* spp. in crocodiles is unknown. It has been suggested that infected rodents may enter open crocodile pens to eat meat scraps (Huchzermeyer, 1997) and are eaten by the crocodiles. *T. spiralis* has been often demonstrated in the muscle of wild African carnivores but numerous samples have failed to demonstrate the parasite in herbivorous species (Bengis and Veary, 1997). The larvae may remain alive for as long as 11 years in muscle cysts. Meat from wildlife (primarily elephants) is commonly fed to farmed crocodiles but meat from carnivores may be a potential source.

The likelihood of farmed crocodiles being exposed to trichinellosis is uncertain as the source of infection remains unidentified, but due to confirmed detection of the parasite, is considered HIGH.

There are no apparent clinical signs associated with trichinellosis and no diagnostic tests available in live crocodiles, and therefore the likelihood of infected crocodiles being slaughtered for meat is EXTREME.

Once a crocodile is infected, the encysted larvae would be present in the meat at slaughter. Cysts cannot be detected by visual examination and abattoir testing methods are used in the pig industry. In Zimbabwe, cysts were not detected in crocodile meat in the abattoir, but only after a survey examined tail muscle histologically (Foggin and Widdowson, 1996).

The likelihood of cysts not being detected and therefore present in the meat is HIGH.

*Trichinella* cysts have remained viable in meat after 4 months of decomposition. The encysted larvae are resistant to environmental temperatures, dessication, salting and smoking. Storage of pork by freezing at −15°C for 20 days is lethal to encysted *T. spiralis* larvae (Worley *et al.*, 1986; Acha and Szfres, 1987). In Zimbabwe, crocodile meat for export is usually stored for several months, due to the sporadic market (Madsen, 1993) but there are no reports of minimum storage times.
The likelihood of viable *Trichinella* cysts surviving in crocodile meat exported from Zimbabwe is HIGH.

In summary, according to the procedure described in 5.1.1, the probability of entry of trichinellosis in crocodile meat from Zimbabwe is HIGH.

Exposure assessment

If larvae remained viable in meat imported into Australia and entry followed the most probable pathway indicated in Figure 2, cooking is considered to be a reliable method of inactivating cysts in meat products. Pork heated to 60°C rendered *T. spiralis* larvae noninfective after 2 minutes (Kotula *et al.*, 1983).

There are two possible pathways for discarded uncooked meat that was damaged or spoiled in transit. The practice of feeding crocodile carcases back to farmed crocodiles in Australia is not likely. The premises into which the imported meat would arrive would be most probably not be in close proximity to crocodile farms. Therefore, the likelihood of infected imported crocodile meat being fed to Australian farmed crocodiles or other animals is negligible.

The alternate most probable pathway is that uncooked meat is disposed of as garbage. The larvae are reported in a wide range of host species including mammals, reptiles and birds. Meat is considered dangerous and capable of infection when harbouring at least one larva per gram, (Dupouy-Camet, 1998). Frequently used detection tests used in pig abattoirs examine one gram of meat, and are unlikely to detect infections of less than 5 cysts per gram (Gamble, 1997). The density of cysts found in crocodile meat was not reported, but experimental rats developed cysts after being fed infected muscle (Foggin and Widdowson, 1996). The cysts may remain viable for considerable time in the environment and potentially infect scavenging carnivores, wild pigs, rodents and birds.

The likelihood of trichinellosis being transmitted to animals from discarded uncooked meat is MODERATE.

Once a susceptible host has consumed infective cysts, the likelihood of that host becoming infected is considered HIGH.

All mammals are susceptible to trichinellosis, although infestation is most common in omnivores and carnivores. In wild animal species, infestations of wild pigs and rats and mice would have the greatest epidemiological significance. Once in the wild population trichinellosis would be highly likely to establish in a sylvatic cycle.

The likelihood of trichinellosis then spreading to other hosts and becoming established in a wild carnivore (or omnivore) population is HIGH.

The overall probability of exposure of trichinellosis in Australia if it entered in crocodile meat imported from Zimbabwe is calculated as MODERATE.
Probability of entry and establishment

The results of the release and exposure assessments were combined, according to Table 4, to give an overall probability of entry and establishment of MODERATE.

Consequence assessment

The consequence assessment of disease establishment for trichinellosis was based on the direct and indirect criteria listed in section 5.1.2. No consequences were estimated as having an extreme impact. The adverse consequences on the environment was estimated as having a HIGH consequence of establishment. The following criteria were estimated as having a MODERATE consequence of establishment: public health consequences, surveillance and control costs, potential trade losses, and adverse effects on other industries (such as the wild pig harvest). The remaining criteria were considered to have a LOW or NEGLIGIBLE consequence. From this, according to the conditions described in 5.1.2, the overall assessment of consequence for trichinellosis is HIGH.

Risk estimation

Based on the risk estimation matrix (see Table 5) for evaluating the risk associated with trichinellosis, integration of the probability of entry and establishment (MODERATE) and the consequence assessment (HIGH) results in a risk estimation of HIGH. The risk exceeds the ALOP and therefore risk management measures need to identified.

5.2.7. *Agema* spp. and *Subtriquetra* spp.

The genera *Agema* and *Subtriquetra* are similar pentastome parasites affecting crocodiles and will be considered together.

The agent

Pentastomids are primitive arthropods that live exclusively as internal parasites. The majority (more than 90%) of species infect reptiles, but carnivores and birds are also infected. The adults infest the lungs, and have the ability to bore through tissue. Infections may be asymptomatic, or there may be significant damage to the hosts tissues. Eggs produced are coughed up and swallowed, and then passed in the faeces. The eggs develop to an infective stage and are swallowed by an intermediate host, where larvae develop into an infective nymph. The life cycle is completed in the definitive reptile host, after ingestion of the intermediate host containing infective nymphs. The infective nymphs migrate from the intestinal tract and attach to the lungs.

Despite the migratory stage, the majority of wild reptiles are asymptomatic. Young hatchling crocodilians in captivity are considered highly susceptible, and severe tissue and pulmonary damage may result (Lane and Mader, 1996).

Two families of crocodile pentastomes are known. Sebekidae contains the genera *Sebekia, Leiperia, Alofia, Selfia* and *Agema*, and the family Subtriquetridae contains the single genus *Subtriquetra*. Host specificity is fairly high for pentastomids
(Telford, 1971) and is unlikely that these genera infect other reptiles. Pentastome species, however, have been recovered from different species of crocodilians sharing the same geographical range (Riley and Huchzermeyer, 1996; Riley et al, 1997). The only pentastome genera not reported in Australian crocodiles are Agema and Subtriquetra. Agema has been reported in African crocodilians (Riley et al, 1997) and their range overlaps that of the Nile crocodile. Junker et al (1998) identified infective larvae of Subtriquetra in two cichlid species in South Africa. The Nile crocodile is known to prey on these fish and probably serves as the definitive host.

Reported pentastomiasis in captive Nile crocodiles is limited to a single case in Botswana (Riley and Huchzermeyer, 1995). Pentastomes have caused serious disease in Australian crocodile farms (Buenviaje et al, 1994).

Humans have become infected with pentastomes after consuming raw or undercooked snake meat contaminated with eggs (Johnson-Delaney, 1996).

**Likelihood evaluation**

**Release assessment**

The life cycle for pentastomes in crocodiles is largely unknown. It is assumed that to become infected, crocodiles would have to ingest the fish intermediate host. If wild crocodiles introduced to farms were infected with pentastomes the infection would be self-limiting without the presence of an intermediate host. There are no reports of pentastomes in Zimbabwe but they are probably present in the wild. Adult (and larval) pentatstomes can be seen with the naked eye, so it is unlikely that infection remains undiagnosed in Zimbabwe crocodile farms. The disease could be introduced through the feeding of infected fresh fish. This occurred in Australia when farmed crocodiles were fed fish or prawns containing infective larvae (Buenviaje et al, 1994).

The likelihood that farmed crocodiles are exposed to the infective stage of Agema spp. or Subtriquetra spp. is considered LOW.

Clinical pentastomiasis in farmed crocodilians most commonly affects young hatchlings (Boyce et al, 1984; Ladds and Sims, 1990; Buenviaje et al, 1994). Most infections, especially in wild crocodiles, are asymptomatic (Lane and Mader, 1996). The disease can be diagnosed by detecting characteristic eggs in the faeces.

At slaughter age (2 - 3 years), the likelihood that asymptomatic infected animals would be slaughtered for meat is HIGH.

The larval pentastomes migrate through tissues from the intestine to the lungs, and may feasibly be present in muscles, although this has not been reported. Pentastomes have been found in the aorta and pulmonary artery (Junker et al, 1999) but their physical size would preclude being located within blood vessels in the muscles. When the host dies (or is slaughtered) the adult pentastomes leave the anoxic lungs and migrate into surrounding tissue (Overstreet et al, 1985). Examination of the lungs would be likely to reveal lesions and adult pentastomes in an infected crocodile. Carcasses are not always eviscerated in Zimbabwean crocodile abattoirs (Purdie, pers. comm.), so it is unlikely that the organs would routinely be examined during
processing. Faecal contamination during processing may result in eggs on the meat surface.

The likelihood that pentastomes are present in the meat of crocodiles is considered VERY LOW.

There are no reports of the survivability of crocodilian pentastomes in tissues or the environmental resistance of the eggs. The parasites were certainly dead, and beginning to breakdown after remaining in a carcase for several hours (Riley and Huchzermeyer, 1995).

The likelihood of pentastomes remaining viable in crocodile meat is considered VERY LOW.

The probability of entry of *Agema* spp. or *Subtriquetra* spp. in crocodile meat from Zimbabwe is calculated as NEGLIGIBLE.

Exposure assessment

Pentastomids present in imported crocodile meat, would be readily destroyed during cooking. The survival of the parasite or eggs in discarded uncooked meat is considered unlikely. The only possible exposure pathway that may result in the agent being transmitted is the direct consumption by a susceptible host. For *Agema* spp. and *Subtriquetra* spp. this would have to be crocodiles or fish. As described in section 5.1.1 Exposure assessment, the meat is unlikely to be fed to farmed crocodiles in Australia. The chance of uncooked crocodile meat being used as a feed in aquaculture or as bait is remote, because of the insignificant volume of meat not likely be sold for human consumption.

The likelihood of *Agema* spp. or *Subtriquetra* spp. being transmitted to a suitable host in Australia is considered NEGLIGIBLE.

If uncooked contaminated meat was fed directly to farmed crocodiles, the animal may become infected if the larvae were ingested. Infection may also occur in the definitive host (crocodiles) if eggs are ingested and hatch within the intestine (Cosgrove *et al*, 1984).

The likelihood that, in the unlikely event a farmed crocodile ingested uncooked meat containing larval *Agema* spp. or *Subtriquetra* spp. or the eggs, will become infected, and adult parasites develop is VERY LOW.

The absence of a suitable intermediate fish host in crocodile farms would ensure the likelihood that the parasite spreads to other hosts and establishes in a population is NEGLIGIBLE.

The probability of exposure, from the above exposure assessment for *Agema* spp. or *Subtriquetra* spp. in imported crocodile meat, is calculated as NEGLIGIBLE.
Probability of entry and establishment

The results of the release and exposure assessments were combined, according to Table 4, to give an overall probability of entry and establishment of *Agema* spp. and *Subtriquetra* spp. from the importation of crocodile meat from Zimbabwe of NEGLIGIBLE.

Consequence assessment

Due to the lack of knowledge about the life cycle, and possible susceptible intermediate and definitive hosts, of *Agema* spp. and *Subtriquetra* spp. it is difficult to estimate the consequences of the parasite establishing in Australia. Considering the criteria listed in section 5.1.2, the only one that may be adversely affected by the establishment of *Agema* spp. or *Subtriquetra* spp. is the impact on the environment. The presence of endemic pentastomes in Australian crocodiles suggests the impact to be at most MODERATE. The public health consequences are considered LOW. The consequences for all other criteria are considered NEGLIGIBLE.

According to the conditions described in 5.1.2, the overall assessment of consequence for adenovirus is considered MODERATE.

Risk estimation

Based on the risk estimation matrix (see Table 5) for evaluating the risk associated with *Agema* spp. and *Subtriquetra* spp., integration of the probability of entry and establishment (NEGLIGIBLE) and the consequence assessment (MODERATE) results in a risk estimation of NEGLIGIBLE. The risk does not exceed the ALOP and further risk management is not required.

5.3. Conclusions: Risk Assessment

Based on the risk assessment process above the following disease agents will require risk management consideration.

*Salmonella* spp.
*Trichinella* spp.
6. RISK MANAGEMENT

6.1. Method for Risk Management

The analysis presents a range of possible risk management options, the nature of which depend on the estimated risk associated with the agent and the characteristics of the disease. The most frequent source of recommended measures for the more commonly farmed species is the OIE Animal Health Code. Where recommended measures do not meet Australia’s appropriate level of protection, alternatives are considered.

The appropriate level of protection (ALOP), as defined in the SPS agreement, is the level of protection deemed appropriate (as a sovereign right) by the member country establishing or reviewing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory. Risk management measures, which are judged to be the minimum required to meet Australia’s ALOP, are proposed.

In the context of this IRA, Australia’s ALOP is considered to be that of a ‘low’ expected loss. This is portrayed in the risk estimation matrix (Table 5) as the diagonal band of light grey “Low” cells. In accordance with the requirements of the WTO, ALOP was utilised in the decision to implement risk management by adhering to the rationale outlined below.

- For each potential hazard, the level of risk, or expected loss, associated with the unrestricted or unmitigated importation of crocodile meat from Zimbabwe was estimated.
- The unrestricted risk was then evaluated using the risk estimation matrix (Table 5), so as to determine where it fell in relation to Australia’s ALOP.
- If the unrestricted risk was negligible or low, then it was considered to be acceptable and further risk management was not required.
- If the unrestricted risk was moderate, high or extreme, then alternative risk management strategies were identified and, for each, the risk was recalculated.
- Where the subsequently ‘restricted risk’ derived using a particular risk management strategy was low, that strategy was considered to be acceptable.
- Where the restricted risk derived using a particular risk management strategy was negligible, the strategy was considered unnecessarily restrictive. Overly restrictive risk management strategies were either rejected, or were manipulated so as to be less restrictive.

This procedure led to the specification of a set of acceptable risk management measures for each disease agent for which the unrestricted risk was considered higher than Australia’s ALOP. The relative practicality of risk management measures were subsequently investigated. This process was described as option evaluation. Option evaluation enabled measures considered equivalent to be identified, and subsequently incorporated in the quarantine recommendations (see section 7).
6.2. Available Quarantine Measures

Quarantine measures aim to reduce the likelihood that the importation of crocodile meat from Zimbabwe would lead to the introduction and establishment of exotic disease agents in Australia. There are two principal methods of achieving this outcome:

1. Reducing the likelihood of disease agents entering Australia in imported crocodile meat, by imposing conditions on the populations from which crocodiles are sourced or on other steps in the release scenario.
2. Reducing the likelihood that susceptible host species in Australia would be exposed to imported crocodile meat, or to other products or waste derived from crocodile meat, by imposing conditions on steps in the exposure scenario.

6.2.1. Pre-export measures

Stages in the release scenario that may affect the probability of entry were outlined in Section 5.1.1 Release assessment. These stages are reiterated in Table 6 below. For each stage possible risk management options have been identified as measures of reducing the risk associated with the importation of crocodile meat.

<table>
<thead>
<tr>
<th>Stage in the release scenario</th>
<th>Risk management option</th>
</tr>
</thead>
</table>
| Farmed crocodiles exposed to agent | • Source crocodiles from region free of disease agent  
• Treat river water used on farm  
• Destroy agents in feed source  
• Prevent feeding carcases to farm crocodiles  
• Prevent exposure to vectors or intermediate hosts  
• Vaccinate against disease agent |
| Infected crocodiles slaughtered for meat | • Ensure ante-mortem inspection of crocodiles to identify and reject diseased animals  
• Apply diagnostic tests to live crocodiles |
| Agent present in meat | • Ensure hygienic procedures to prevent contamination during processing of meat  
• Ensure post-mortem inspection of carcases to identify and reject diseased meat  
• Monitor for presence of disease agent in or on meat |
| Agent survives in meat | • Apply process to destroy agent |
Reliable, commercial vaccines are not produced for crocodilian diseases and this measure is therefore not available.

6.2.2. Post-arrival measures in Australia

Stages in the exposure scenarios that may affect the probability of establishment were identified in section 5.1.1 Exposure assessment. These steps are reiterated in Table 7 below. For each stage, possible risk management options have been identified.

Table 7: Risk management for the exposure assessment

<table>
<thead>
<tr>
<th>Stage in the exposure scenario</th>
<th>Risk management option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent transmitted to susceptible host or vector</td>
<td>• Monitor for presence of agent in imported meat</td>
</tr>
<tr>
<td></td>
<td>• Prevent feeding of uncooked meat to animals</td>
</tr>
<tr>
<td></td>
<td>• Apply process to destroy agent in uncooked meat</td>
</tr>
<tr>
<td>Host becomes infected</td>
<td>• Quarantine premises containing infected animal/s</td>
</tr>
<tr>
<td></td>
<td>• Control spread of agent to other hosts or vectors</td>
</tr>
<tr>
<td>Agent establishes in population</td>
<td>• Apply methods for disease agent eradication</td>
</tr>
<tr>
<td></td>
<td>• Implement surveillance and monitoring for agent</td>
</tr>
</tbody>
</table>

6.3. Risk Management for Identified Diseases

6.3.1. Salmonella spp.

The risk management options for the release scenario listed in Table 6 for reducing the likelihood of exposure of farmed crocodiles to Salmonella spp. are: to treat river water; destroy agent in the feed source; and prevent feeding carcases back to farm crocodiles. The other options are not applicable to this agent – salmonellae are ubiquitous and therefore it would be impossible to determine a free region, do not require intermediate hosts and there is no vaccine.

Zimbabwe crocodile farms recognise the potential disease risk from directly using water from rivers and lakes. Some farms chlorinate the water before it is introduced to the crocodile pens (Purdie, pers. comm.). The antimicrobial treatment of water used in crocodile pens is important for the overall health and welfare of farmed crocodiles, but would have little effect on the likelihood of the animals being exposed to Salmonella spp. Therefore this is not considered necessary as a management measure. Poultry and other animal carcases are recognised as a potential source of Salmonella spp. when fed to farmed crocodiles. The Zimbabwe Code of Practice for Crocodile Skinning and Butchering (CFAZ, 1998) mentions heat treatment of offal as a method
to reduce the introduction of pathogens through feeding animal carcases. Currently in Zimbabwe, carcases from the abattoir are not fed to meat production animals (Purdie, 1999).

The second stage of the release scenario, that infected crocodiles are slaughtered for meat production, does not have any risk management options that may be applied to *Salmonella* spp. There may be no apparent clinical signs in infected crocodiles, and infection would therefore remain undetected at ante-mortem inspection. Clinically unhealthy crocodiles, regardless of the agent, would not be processed for meat. Bacteriology would detect septicaemia due to salmonellosis, but those animals are likely to be clinically affected. Cloacal swabs are likely to detect salmonellae, but is meaningless as a risk management measure as the majority of cases may be commensal organisms.

Salmonellae are presumed to be present in the intestinal tracts and on the skin of healthy crocodiles. Surface contamination of the meat during processing is the most likely means of the agent being present on the meat. Hygienic procedures according to the Australian Standard for Hygienic Production of Crocodile Meat for Human Consumption (Anon, 1998a) will minimise the likelihood of contamination. Many of these procedures are already in place in Zimbabwean crocodile abattoirs (Purdie, 1999). Post-mortem inspection would not detect *Salmonella* spp. contamination of meat, but gross pathological changes may be evident due to septicaemia and the carcase condemned. Monitoring for the presence of salmonellae (and subsequent typing) from meat would minimise the risk that potentially pathogenic strains of *Salmonella* are not introduced into Australia.

After the meat is removed, *Salmonella* spp. that may be present on the meat can be destroyed by subjecting the meat to an effective antimicrobial treatment.

Based on this information the following pre-export risk management measures for *Salmonella* spp. are recommended to minimise the risk of entry in crocodile meat:
1. Hygienic procedures to minimise faecal contamination of meat according to the Australian Standard.
2. Monitor crocodile meat for the presence of *Salmonella*.
3. Apply an approved antimicrobial treatment to the meat prior to packaging.

The effect the recommended risk management measures have on the release assessment is summarised in Table 8 below. The release assessment considering unrestricted risk, prior to application of the measures, is taken directly from the risk assessment in section 5.2.3.
Table 8: Summary of effect of risk management measures on the release assessment for *Salmonella* spp.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Likelihood of release scenario stages</th>
<th>Probability of entry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exposed to agent</td>
<td>Slaughtered for meat</td>
</tr>
<tr>
<td>Unrestricted risk</td>
<td>EXTREME</td>
<td>EXTREME</td>
</tr>
<tr>
<td>After risk management</td>
<td>EXTREME</td>
<td>EXTREME</td>
</tr>
</tbody>
</table>

The application of the pre-export risk management strategies significantly reduced the probability of entry of exotic *Salmonella* spp. in crocodile meat. Consideration of risk management measures post-arrival are less critical to the overall risk estimation and are not considered necessary.

The application of risk management measures on the release assessment reduced the probability of entry to VERY LOW and from Table 4 the overall probability of entry and establishment for *Salmonella* spp. from the importation of crocodile meat from Zimbabwe is VERY LOW.

The consequence assessment for exotic *Salmonella* spp. remains HIGH. The final (restricted) risk estimate can now be calculated based on the identified risk management measures. From the risk estimation matrix (see Table 5) the risk estimation is LOW, which is accepted as Australia’s ALOP.

This procedure has identified acceptable risk management measures for exotic *Salmonella* spp. that will be incorporated in the quarantine recommendations in Section 7.2.

### 6.3.2. *Trichinella* spp.

The risk management options for the release scenario listed in Table 6 for reducing the likelihood of exposure of farmed crocodiles to *Trichinella* are: to source the animals from a free area; destroy agent in the feed source; prevent access to intermediate hosts and prevent feeding carcases back to farm crocodiles. The other options are not applicable to this agent – trichinellosis cannot be transmitted by contaminated water and there is no vaccine.

The risk associated with the importation of crocodile meat from Zimbabwe where *Trichinella* spp. are present in other animals can be reduced by sourcing animals from government approved establishments. Monitoring for the presence of *Trichinella* would be by examination of meat for cysts, and establishments would be considered free after negative results for at least 12 months. As the source of *Trichinella* spp. in
Crocodile meat has yet to be determined. Zimbabwean crocodile farms that produce meat do not feed meat sourced from wild carnivorous (or omnivorous) animals (Foggin, pers. comm.). Risk management measures on the feed source are therefore not considered necessary. Currently in Zimbabwe, carcases from the abattoir are not fed to meat production animals (Purdie, 1999). This does not pose a risk for the maintenance of trichinellosis on a crocodile farm, and is not necessary to be considered further as a risk management measure. Exposure of farmed crocodiles to intermediate hosts, such as rodents, was not perceived to occur on a large crocodile farm in Zimbabwe even though the pens were open (Purdie, pers. comm.).

The second stage of the release scenario, that infected crocodiles are slaughtered for meat production, does not have any risk management options that may be applied to *Trichinella*. There are no apparent clinical signs in infected crocodiles, and would therefore remain undetected at ante-mortem inspection, and no diagnostic tests are available for use in live crocodiles.

The infectious *Trichinella* cysts are within the muscle and therefore contamination of meat during processing is not applicable. The cysts cannot be detected grossly, but muscle samples examined microscopically will find cysts, although this varies with the technique used and the density of infection. Routine monitoring in this manner would ensure the slaughter crocodiles were free of the disease. Methods for the detection of *Trichinella* infection is described in the OIE Manual of Standards for Diagnostic Tests and Vaccines.

Encysted larvae readily survive many environmental stressors, but research on *T. spiralis* in pork has established that adequate freezing regimes will destroy the cysts.

Based on this information the following pre-export risk management measures for *Trichinella* spp. are recommended to minimise the risk of entry in crocodile meat:
1. The establishments where crocodiles originate are free from *Trichinella* spp.
2. The abattoir monitors crocodile meat for the presence of *Trichinella* spp. larvae by an approved technique.
3. No *Trichinella* spp. larvae have been detected in crocodile meat at the abattoir for at least twelve months.
4. Crocodile meat is frozen at −15°C for at least 20 days prior to export.

Although there are no OIE conditions for crocodile meat these measures are consistent with Chapter 3.5.3 of the Code (see Appendix 3) that provides recommended conditions for importation of fresh meat from pigs and horses which aim to ensure security with respect to trichinellosis.

The effect these risk management measures have on the release assessment is summarised in Table 9 below. The release assessment considering unrestricted risk, prior to application of the recommended measures, is taken directly from the risk assessment in section 5.2.6. The probability of entry of *Trichinella* spp. in crocodile meat is effectively reduced by applying these measures.
Table 9: Summary of effect of risk management measures on the release assessment for *Trichinella* spp.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Likelihood of release scenario stages</th>
<th>Probability of entry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exposed to agent</td>
<td>Slaughtered for meat</td>
</tr>
<tr>
<td>Unrestricted risk</td>
<td>HIGH</td>
<td>EXTREME</td>
</tr>
<tr>
<td>After risk management</td>
<td>VERY LOW</td>
<td>EXTREME</td>
</tr>
</tbody>
</table>

The risk management options for the exposure scenario listed in Table 7 are all applicable for reducing the likelihood of *Trichinella* spp. being transmitted to a susceptible host in Australia. Post-arrival measures, however, are not considered necessary. The risk management measures on the release assessment have reduced the probability of entry of *Trichinella* spp. in crocodile meat to NEGLIGIBLE. The absence of risk management measures on the exposure assessment will not affect the overall probability of entry and establishment, which is NEGLIGIBLE, as shown in Table 4.

The consequence assessment for trichinellosis remains HIGH. The final (restricted) risk estimate can now be calculated based on the identified risk management measures. From the risk estimation matrix (see Table 5) the risk estimation is NEGLIGIBLE.

The reduction of the risk estimation to NEGLIGIBLE is largely due to the risk management measure for reducing the likelihood of *Trichinella* spp. surviving in meat by ensuring adequate freezing to destroy infective cysts. No alternative risk management options were identified for that stage. Furthermore, the freezing of crocodile meat is common practice in Zimbabwe. Therefore, the risk management measures are not considered restrictive in this instance and the risk estimation is acceptable as Australia’s ALOP.

This procedure has identified acceptable risk management measures for *Trichinella* spp. that will be incorporated in the proposed quarantine requirements in section 7.2.
7. QUARANTINE CONDITIONS FOR CROCODILE MEAT FROM ZIMBABWE

7.1. Introduction

With effect from the publishing of AQIS’s findings, these conditions apply to Zimbabwe for the export of crocodile meat to Australia. The necessary arrangements are being set in place for formal recognition of:

- The competent authorities of Zimbabwe in relation to the health of farmed crocodiles.
- The system for monitoring and surveillance of health of populations from which crocodiles for meat production are sourced.

7.1.1. Recognition of the competent authority

The veterinary administration of Zimbabwe is responsible for supervising crocodile abattoir premises, ensuring compliance with standards, and certification and endorsements. It is proposed that importation of crocodile meat be permitted only from premises approved by AQIS. The process of evaluation of veterinary administrations is based on guidelines as specified in section 1.4.3 of the OIE International Health Code for the assessment of a country for approval to export to Australia. Assessment of veterinary services has recently been the subject of review and guidelines for such procedures specifically applicable to Australia developed. Although some countries may be able to provide quantitative data, in most cases AQIS’s assessment will be based on qualitative information. Where import requirements include pre-export processing as part of the risk management measures, AQIS may restrict the issue of permits to product prepared in plants that have been formally approved by the exporting country authority and/or AQIS. Zimbabwe would be expected to follow a standard that would provide an equivalent outcome to that provided by the Australian Standard for Hygienic Production of Crocodile Meat for Human Consumption (Anon, 1998a).

7.1.2. Systems for monitoring and surveillance of crocodiles

In Zimbabwe export approved abattoirs, microbiological testing is carried out by a government laboratory on a monthly basis. Total viable counts (TVC) and *E. coli* testing are done on work surfaces, equipment and workers hands. Meat samples are tested for TVC, *E. coli* and *Salmonella* spp. (Purdie, 1999).

In addition, as a requirement of the Zimbabwe food industry, all workers are tested for *Salmonella* and *E. coli* prior to commencement of the crocodile abattoir slaughtering season (May to October). Any workers with positive results are treated and rechecked (Purdie, 1999).

The crocodile meat is also tested regularly for *Trichinella* spp. cysts. Any farm found positive for trichinellosis is delisted for export. Samples from wild crocodiles are examined histologically on an *ad hoc* basis (Purdie, 1999).
7.2. Proposed Quarantine Requirements for the Importation of Crocodile Meat from Zimbabwe

QUARANTINE REQUIREMENTS FOR THE IMPORTATION OF CROCODILE MEAT FROM ZIMBABWE

1 GENERAL

1.1 Definitions

In Section 39 of Quarantine Proclamation 1998:

- meat means a part of an animal (other than a fish, a crustacean, a mollusc, a cnidarian, an echinoderm or a tunicate) that is intended or able to be used as food by a human being or an animal (whether or not cooked, dried or otherwise processed), and includes:
  (a) blood; and
  (b) bone meal, meat meal, tallow and fat.

1.2 Products to which these requirements apply

These conditions apply to the importation of crocodile meat that is neither heat processed nor canned that is intended to be used as food for human consumption. Crocodile meat is limited to crocodilian muscle tissue, blood confined to muscle vasculature, bone and bone marrow, and any other tissues (for example, fat) that may be considered inseparable from muscle.

These conditions do not apply to bone meal; meat meal; bone and fat not attached to the tissue from which it was derived; skin, feet, heads, viscera or any other products derived from crocodiles.

1.3 The crocodile meat must be derived from crocodiles slaughtered at establishments approved by AQIS and must be processed, prepared and stored in establishments approved by AQIS.

1.4 A Permit to Import crocodile meat into Australia from Zimbabwe, including Approval Advice for the source establishment, must be obtained in writing from the Director of Quarantine (Australia) (herein called the Director) prior to export of the first consignment from the approved source establishment.

1.5 Each application to the Director for permission to import must include the following details:

- the name and address of the importer and exporter and the name and veterinary control number of the approved abattoir and approved storage establishment in Zimbabwe;
- the cut or cuts (trade description) of the meat to be imported;
- the anticipated port or ports of entry of the crocodile meat.

1.6 Each consignment must be accompanied by a completed Sanitary Certificate and will require on arrival, a Quarantine Entry issued by AQIS at the port of entry.
1.7 The Sanitary Certificate must:
• be in accordance with the Office International des Epizooties (OIE) International Animal Health Code (herein called the Code) Model Certificate No. 4 and modified for crocodiles (see Attachment);
• include the Certifications listed under Section 2 of this document;
• be signed by an Official Veterinarian, (a veterinarian authorised by the Department of Veterinary Services in Zimbabwe to perform animal health and/or public health inspections of farmed crocodiles and crocodile meat and, when appropriate, perform certification in conformity with the provisions of Chapter 1.3.2. of the OIE Code);
• be stamped on each page with an Official Stamp.

1.8 Written permission from Environment Australia (EA) is required and a copy of the documentation must be provided to the Director when the application to import is made.

1.9 Each application will be assessed on the above criteria as well as any other criterion which is considered relevant by the Director. This may include a country's health status with regard to diseases not listed in these guidelines and standards of meat inspection services and export establishments.

1.10 Conditions of importation may be varied or reviewed at any time at the discretion of AQIS.

2 CERTIFICATION REQUIREMENTS

2.1 Each consignment of crocodile meat must be accompanied by a Sanitary Certificate which conforms with the template at Attachment, signed by an Official Veterinarian and which attests under IV. Attestation of Wholesomeness d) that:

a) the meat was derived from Nile crocodiles (Crocodylus niloticus) originating in and slaughtered in Zimbabwe on ……………… (dates);

b) each establishment, at which the crocodiles (from which the meat was derived) were slaughtered, has a current approval from AQIS for slaughter of crocodiles for meat to export to Australia;

c) each establishment where meat was prepared or stored, has a current approval from AQIS for export to Australia and a standard of construction of the establishment and meets the standard of inspection, slaughter and product handling equivalent to that in the Australian Standard for Hygienic Production of Crocodile Meat for Human Consumption;

d) the animals from which the meat was derived were subjected to ante-mortem and post-mortem veterinary inspection by officers employed by (or certified by) the Zimbabwe Department of Veterinary Services and found to be free from infectious and/or contagious diseases which could be transmitted in meat, or which could affect the quality of the meat;

e) the establishment of origin of the crocodiles from which the meat is derived is free from trichinellosis, and Trichinella cysts have not been detected for at least 12 months at the abattoir in crocodile meat;
f) an approved antimicrobial treatment was applied to the meat prior to packaging;
g) the meat was packed in a manner approved by AQIS:
   • each carton or similar packing container must contain only crocodile meat,
   • the meat has been prepared for export and packed on ……………. (dates), and only clean, new bags, wrappers or packaging containers were used,
   • the identification / veterinary control number of the establishment where the meat was packed is readily visible on the outer wrapping or package containing the meat and has been applied in such a way that the numbers cannot be readily removed without damaging the wrapping or package;
h) the meat is wholesome and fit for human consumption and subjected to regular microbiological testing and found to be free *Salmonella* spp. and *Trichinella* spp. by regular monitoring by an approved method;
i) the meat has been frozen and stored in an AQIS approved meat freezer at a temperature of –15 degrees C or colder for 20 days before being loaded into pre-cooled containers for shipment;
j) the meat was not exposed to contamination prior to export;
k) the meat must be transported from Zimbabwe directly to Australia in clean, sealed containers.

3 IMPORTER’S / AGENT’S RESPONSIBILITIES

3.1 It is the responsibility of the importer or importer’s agent to arrange for the provision of any documentation additional to that required by AQIS for the importation of crocodile product.

3.2 The importer or agent must nominate a person who can be contacted by AQIS officers and who will be responsible for ensuring that all import requirements are met.

4 POST-ARRIVAL CONTROLS

4.1 Each consignment must be accompanied by required official certification and will require, on arrival, a “Quarantine Entry” issued by AQIS.

4.2 Quarantine entry barrier clearance of each consignment will remain subject to examination of accompanying certification and sighting by a Quarantine Officer of a valid original Permit to Import.

4.3 The product and consignment details must correspond exactly with the certification and the Permit to Import.

4.4 The Quarantine Officer at the first port of entry shall note the following on the original Permit and print and sign his/her name against the notation and stamp the documentation:
   • the number of containers which have been offloaded at the first port of call and their identifying marks and seal numbers.
INTERNATIONAL SANITARY CERTIFICATE
FOR CROCODILE MEAT

Exporting country: .................................................................
Ministry of: .................................................................
Department: .................................................................
Province or District, etc: .................................................................

I. Identification of the meat

Type of portions of meat: .................................................................
Type of package: .................................................................
Number of objects or packages: .................................................................
Net weight: .................................................................

II. Origin of the meat

*Address/es and number/s of veterinary approval of the abattoir/s: .................................................................
*Address/es and number/s of veterinary approval of the cutting-up establishment/s: .................................................................

III. Destination of the meat

The meat is being sent from .................................................................
(place of dispatch)
to .................................................................
(country and place of destination)
Nature and identification of means of transport: .................................................................
Name and address of exporter: .................................................................
Name and address of consignee: .................................................................
IV. Attestation of wholesomeness

The undersigned Official Veterinarian certifies that:

a) the meat*, packages of meat* referred to above is/are stamped, thereby attesting that all the meat comes from crocodiles slaughtered in abattoirs;

b) the meat is considered to be fit for human consumption;

c) the meat was cut up in a cutting-up establishment;

d) the meat satisfies the following requirements:**

Official stamp:

Issued at ………………….. on …………………..
Name and address of Veterinarian …………………………………………………
………………………………………………
………………………………………………

Signature: …………………………………………………

* Delete where not applicable.

** These conditions are agreed between the Veterinary Services of the importing countries in accordance with the options provided in the Code.
8. REFERENCES


Anon, (1999), The Australian Food Safety Campaign Group’s Food Safety Tips. (http://www.safefood.net.au/)

ANZFA, (1999), Food Standards Code, Australian New Zealand Food Authority.


Davos D, *pers. comm.*, Australian Salmonella Reference Centre, Institute of Medical and Veterinary Science, Adelaide, Australia.


Foggin CM, *pers. comm.*, Veterinary Research Laboratory, Harare, Zimbabwe.


Madsen M, (1993), Microbial flora of frozen tail meat from captive Nile crocodiles (Crocodylus niloticus), International Journal of Food Microbiology, 18:71-76.


Nelson GS and Dunsmore JD, (1983), Wild animals as reservoir hosts of parasitic diseases of man in Kenya, In: Tropical parasitoses and parasitic zoonoses, 10th Meeting of the WAAVP, August 1983, Perth, Western Australia, World Association for the Advancement of Veterinary Parasitology, pp 59-72.


Purdie JL, *pers comm.*, Principal Inspector (Meat), Northern Territory Department of Primary Industry and Fisheries, Darwin, Australia.


9. APPENDICES

APPENDIX 1 Conditions for the Importation of Crocodile Meat from Papua New Guinea

CONDITIONS FOR THE IMPORTATION OF CROCODILE MEAT

These conditions apply to the importation of uncanned crocodile meat (ie meat not contained in a hermetically sealed container).

1. DOCUMENTATION

a) Permission to import the product into Australia must be obtained in writing from the Director of Animal and Plant Quarantine (Australia) [Herein called the Director], prior to the product first being exported.

b) Each consignment must be accompanied by a Permit issued in Canberra and the prescribed certification in Section 3; and will require on arrival, a Quarantine Entry issued by AQIS at the port of entry.

c) Each application to the Director for permission to import must include the following details:
   i) name and identification/veterinary control number of producing establishment,
   ii) product type
   iii) full details of any process of manufacture the meat has been subjected to.

Product type exported must correspond exactly to approved product.

d) Written permission from the Australian National Parks and Wildlife Service (ANPWS) is also necessary and a copy of the ANPWS documentation must be provided to the Director when the application to import is made.

e) Each application will be assessed on the above criteria as well as any other criterion which is considered relevant by the Director. This may include a country's health status with regard to diseases not listed in these guidelines and standards of meat inspection services and export establishments.

2. REQUIREMENTS

a) The meat must be derived from crocodiles originating in and slaughtered in Papua New Guinea.

b) The animals from which the meat is derived must have been subjected to regular veterinary inspection by officers of the Papua New Guinea Department of Agriculture and Livestock and must have been found to be free from any infectious or contagious disease.

c) Each establishment where the animals from which the meat was derived were slaughtered; and each establishment where the meat was prepared and/or stored, must have current approval from the Director. A standard of construction of the establishment and a standard of inspection, slaughter and product handling equivalent to that in the Uniform Code of Construction and Practice for Facilities for the Processing of Crocodile Flesh for Human Consumption are required.
d) Papua New Guinea must have been free from foot and mouth disease and rinderpest for the period of six months prior to the slaughter of the animals from which the meat was derived.

e) The meat must be packed in a manner approved by the Director:
   i) Each carton or similar packing container must contain only crocodile meat.
   ii) Only clean, new bags, wrappers or packing containers may be used.
   iii) The identification/veterinary control number of the establishment where the meat was packed (or the animals slaughtered if in carcase form) must be readily visible on the outer wrapping or package and on the meat. Numbers must not be able to be removed with damage.

f) The meat must be transported from Papua New Guinea directly to Australia in clean, sealed containers.

g) The meat must be stored for no less than thirty days after the slaughter of the animals from which it was derived before release from quarantine in Australia.

3. CERTIFICATION

A certificate, issued by a full time national Government veterinarian of Papua New Guinea, must accompany each consignment of meat.

The certificate must include the following information:

(i) That the meat was derived from crocodiles originating in and slaughtered in Papua New Guinea.

(ii) Date(s) on which the animals from which the meat was derived were slaughtered.

(iii) Date(s) on which the meat was prepared.

(iv) Identification/veterinary control number(s) of the establishment(s) where the animals from which the meat was derived were slaughtered and where the meat was prepared and/or stored; that these establishments have current approval.

(v) That the animals from which the meat was derived were subjected to regular veterinary inspection and were found to be free from contagious or infectious disease.

(vi) That the meat is wholesome and fit for human consumption.

(vii) That Papua New Guinea has been free from foot and mouth disease and rinderpest for the period of six months prior to the slaughter of the animals from which the meats was derived.

(viii) That the meat has been packed in a manner approved by the Director and has not been exposed to contamination before export.

(ix) That the meat is being shipped to Australia in a clean container the seal of which was intact at the time of export.

REVIEW

Conditions for importation may be reviewed if there are any changes in the import policy or the animal disease status of Papua New Guinea or at any time at the discretion of the Director.
APPENDIX 2 Reported salmonellae isolated from Nile crocodiles, *Crocodylus niloticus*, and never recorded from any source in Australia.

**Salmonella subspecies I**

<table>
<thead>
<tr>
<th>S. Aarhus&lt;sup&gt;a&lt;/sup&gt;</th>
<th>S. Agoueve&lt;sup&gt;a&lt;/sup&gt;</th>
<th>S. Antarctica&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Bangui&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. Brancaster&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. California&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>S. Cullingworth&lt;sup&gt;b&lt;/sup&gt;</td>
<td>S. Dabou&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. Diguel&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>S. Duval&lt;sup&gt;c&lt;/sup&gt;</td>
<td>S. Good&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. Millesi&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>S. Mutade&lt;sup&gt;c&lt;/sup&gt; (Matadi)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>S. Othmarschen&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. Phaliron&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>S. Schwerin&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. Simi&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. Solt&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>S. Somone&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. Tallahassee&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. Tanger&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>S. Tinda&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. Tsevie&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. Yaba&lt;sup&gt;a&lt;/sup&gt;</td>
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</table>

**Salmonella subspecies II**

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<th>S. II 1,9,12::1,7&lt;sup&gt;e&lt;/sup&gt;</th>
<th>S. II 4,12:e,n,x:1,2,7&lt;sup&gt;d&lt;/sup&gt;</th>
<th>S. II 4,12:f,g,t:–&lt;sup&gt;e&lt;/sup&gt;</th>
</tr>
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<tbody>
<tr>
<td>S. II 6,8:eh:enz&lt;sub&gt;15&lt;/sub&gt;&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. II 9,12:gz&lt;sub&gt;62&lt;/sub&gt;:–&lt;sup&gt;c&lt;/sup&gt;</td>
<td>S. II 9,12:m,t:–&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>S. II 16:gt:z&lt;sub&gt;42&lt;/sub&gt;&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. II 16:z:en&lt;sub&gt;x&lt;/sub&gt;&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. II 16:z&lt;sub&gt;4,24&lt;/sub&gt;:–&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>S. II 18:z&lt;sub&gt;4&lt;/sub&gt;,z&lt;sub&gt;23&lt;/sub&gt;:–&lt;sup&gt;c&lt;/sup&gt;</td>
<td>S. II 39:mt:en&lt;sub&gt;x&lt;/sub&gt;&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S. II 48:k:en&lt;sub&gt;xz&lt;/sub&gt;&lt;sub&gt;15&lt;/sub&gt;&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>S. II 55:–:–&lt;sup&gt;a&lt;/sup&gt;</td>
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</table>

**Salmonella subspecies III<sup>f</sup> and S. subsp. IV**

<table>
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<tr>
<th>S. III 50:–:–&lt;sup&gt;a&lt;/sup&gt;</th>
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<th>S. IIIb 28:–:–&lt;sup&gt;a&lt;/sup&gt;</th>
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<td>S. IIIb 48:r:en&lt;sub&gt;xz&lt;/sub&gt;&lt;sub&gt;15&lt;/sub&gt;&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>S. IV 50:z&lt;sub&gt;42&lt;/sub&gt;:z&lt;sub&gt;23&lt;/sub&gt;&lt;sup&gt;a&lt;/sup&gt;</td>
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<sup>a</sup> Van der Walt <em>et al</em>, (1997). Samples were from farmed Nile crocodiles in South Africa. Mostly from diseased crocodiles at post mortem examination, but also from healthy slaughtered crocodiles.

<sup>b</sup> Greenburg and Sechter, (1992). Serovar isolated and previously not recorded in Israel in Nile crocodiles imported from Zimbabwe.

<sup>c</sup> Madsen, (1996). Samples from fresh and frozen crocodile meat at a Zimbabwe abattoir.

<sup>d</sup> Davos, (<em>pers comm</em>). Presumed serovar as reported serovar was not recognised.

<sup>e</sup> Davos, (<em>pers comm</em>). Some of the subspecies reported are only partial serotypes.
APPENDIX 3  OIE Recommendations for the Importation of Fresh Pork and Horse Meat to Ensure Security with Respect to Trichinellosis.

CHAPTER 3.5.3.

TRICHLINELLOSIS
(Trichinella spiralis)

Preamble: Standards for diagnostic tests are described in the Manual.

Article 3.5.3.1.

Veterinary Administrations of importing countries should require:

for fresh meat of swine (domestic and wild)

the presentation of an international sanitary certificate attesting that the entire consignment of meat:

1) comes from domestic swine which have been slaughtered and have been inspected in an approved abattoir or wild swine which have been inspected;

AND

2) showed a negative response to a testing procedure for trichinellosis; or

3) comes from domestic swine which were born and bred in a country or zone free from trichinellosis in domestic swine; or

4) has been processed to ensure the destruction of all the larvae of the parasite.

Article 3.5.3.2.

A country or zone may be considered free from trichinellosis in domestic swine when:

1) trichinellosis is notifiable in the country;

2) there is in force an effective disease reporting system shown to be capable of capturing the occurrence of cases;

AND EITHER:

3) it has been ascertained that Trichinella infection does not exist in the domestic swine population of the country or zone under consideration; this is established by the regular surveillance of the swine population using an approved testing procedure, which provided negative results when:

   a) within a 5-year period, a serological survey was conducted on a statistically based sample size from within the slaughter sow population sufficient to provide at least 95% confidence of detecting trichinellosis if it was present at a prevalence exceeding 0.02%, and

   during this 5-year period, continuous testing was conducted on a statistically based sample size from within the annual slaughter swine population sufficient to provide at least 95% confidence of detecting trichinellosis if it is present at a prevalence exceeding 0.01%, following which:
b) a serological survey is carried out every third year on the slaughter sow population sufficient to provide at least 95% confidence of detecting trichinellosis if it is present at a prevalence exceeding 0.2%; during this time the number of samples in the slaughter swine population could be reduced to detect at the 0.5% level on an annual basis.

OR

4) in the country or zone under consideration, the following conditions are met:
   a) trichinellosis has not been reported in the domestic swine population for at least 5 years;
   b) wild susceptible species are subjected to a regular surveillance programme, and no clinical, serological or epidemiological evidence of trichinellosis has been found;

5) the regular surveillance described in paragraph 3) above is carried out and should be concentrated where infestation was last identified, and/or where the feeding of swill to swine occurs;

6) any suspicion of disease is followed at the field level by traceback, quarantine and laboratory testing;

7) if trichinellosis is confirmed, the infected premises remains under official veterinary control and is subjected to disease control measures using a stamping-out policy and rodent control;

8) all feeding of swill is officially regulated;

9) any human outbreaks of trichinellosis are investigated to determine the animal source.

Article 3.5.3.3.

Free herd (under study).

Article 3.5.3.4.

Veterinary Administrations of importing countries may require:
for fresh meat of equines (domestic and wild)

the presentation of an international sanitary certificate attesting that the entire consignment of meat:

1) comes from equines slaughtered and/or inspected in an approved abattoir;

AND

2) showed a negative response to a testing procedure for trichinellosis; or

3) has been processed to ensure the destruction of all the larvae of the parasite.