Australian Government
Department of Agriculture and Water Resources

AUSTRALIAN Pork

To investigate the practicalities and regulatory requirements of utilising food waste as a feed source for pigs

Final Report
APL Project 2016/2243

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GHD acknowledges and thanks stakeholders who were consulted during the project and who provided valuable insights into the utilisation of food waste and benefits as a pig feed. Without your inputs the task of analysing the various elements included in the feasibility study would not have been possible. Through your assistance, the project provides guidance to APL on how food waste streams can be exploited in the future, including the immediate need to develop proof of concepts of the commercial (supermarket) and household food waste streams.

Executive Summary

GHD was engaged by Australian Pork Limited (APL) to conduct a feasibility study into food waste recycling (both commercial and domestic waste) for use in Australia as pig feed, with a particular emphasis on procurement of sufficient volumes, effectiveness and costs of treatment, contaminant removal, distribution networks, regulatory approvals required, and cost compared to traditional sources.

The project was completed through a desktop review of literature, targeted consultation with industry participants with experience in using food waste as a source of pig feed, and economic analysis of potential food waste streams.

The study included an analysis of three different categories of food waste streams:

1. Manufacturing (food processing) waste – waste products from dedicated food processing plants
2. Commercial waste – waste from supermarkets, green grocers and food service outlets
3. Domestic (household) waste – generally the household component of the Municipal Solid Waste (MSW) stream.

The potential for using human food waste as a source for pig feed varies considerably depending on the source of the waste. A summary of the findings is included in Table 1.

***Main outcomes*:**

The manufacturing (food processing) stream: has a high economic return but with a limited number of food processing companies and pig producers participating, with participants highly protective of the relationship. However, there is likely to be potential to expand the current number of new entrants (food processors and pig producers) through an awareness campaign that highlights the avoided landfill costs to processors and economic benefits of a cheaper pig feed source for pig producers.

The commercial food waste stream (supermarkets etc.): shows a positive (although marginal) economic return from the treatment of food waste as a pig (or other livestock) feed, although the analysis is theoretical and is based on assumptions for treatment that are unproven. The advantage of this stream is the high volume of potentially suitable waste and the increasing desire by the supermarket sector to avoid disposal to landfill. An important risk is the presence of Restricted Animal Material (RAM) in food waste and the need to ensure treatment eliminates the disease risk such as foot and mouth disease (FMD).

The household waste stream: similar to the commercial waste stream, except that the risks of this source in terms of uncertain economic returns and disease risk are amplified. Despite this, the sheer volume of food waste means that the source is likely to be a potential contributor to pig (or other livestock) feed.

Recommendations: for APL to consider:

1. Raising awareness of the potential economic benefits of using manufacturing food waste to both food processors and pig producers with a view to expanding the number of participants who could take advantage of the opportunity while ensuring the commercial-in-confidence protection of existing participants.

2. In conjunction with the supermarket sector, consider investing in the construction of a pilot food waste treatment plant to take advantage of the desire to avoid consigning waste to landfill and at the same time demonstrating the technical and economic feasibility of this concept

Caveats

The analyses are presented on the basis of providing guidance on the merits of utilising different sources of food waste into pig rations. Due care is required when interpreting the outcomes, especially if individual businesses wish to incorporate food waste into their existing systems. In particular, the following need to be considered:

- Certain food wastes (e.g. good quality whey) are relatively easy to use. Others (e.g. packaged products, high mineral/salty products) require additional consideration and may incur additional costs and labour requirements. Note however that there are examples of these products being successfully used, including instances where producers may need to be paid to take these wastes.
- Depending on the relationship between the source of food waste products and the pig producer, some supply chains could include middlemen/brokers who may aggregate, blend and de-package wastes. Additional costs for these services would need to be considered.
- The cost of transporting low dry matter content products means that distance from sources needs to be considered in costing.
- Conversion of conventional feeding systems to liquid waste feeding systems is likely to be more difficult and costly compared to installation in new farms.
- The benefit:cost for individual producers would need to consider the above, however the breakeven economic analyses completed for this project indicate the potential benefits of using food waste in circumstances where costs are higher than those assumed for each of the base cases.

Table 1 Summary of the findings for each of the waste streams considered

Issue	**Manufacturing (food processing waste)**	**Commercial (supermarket waste)**	**Household (domestic waste)**
Source	Food waste/surplus from food processing factories, including out of specifications for the market. Wide range of products from dairy processing plants, milling industry (grains, malt), bakeries, fish processing, brewing and distilling and pet food wastes.	Food waste component from supermarkets, green grocers and food services (restaurants). Requires separation from non-food components and treatment to be suitable as a pig feed.	Food waste component of municipal solid waste (MSW) (or similar) requiring separation from non-food components and treatment to be suitable as a pig feed.
Supply chain, distribution	Food processing source → farm	Commercial source (e.g. supermarket) → treatment plant → feed pellet manufacturer(optional) → farm	Household waste (potentially including separation of food component) → municipal waste centre → treatment plant → feed pellet manufacturer(optional) → farm

Volume	High but unknown volumes, subject to commercial-in-confidence arrangements between processors and producers to protect ongoing supply.	High volume of raw material – approx. 350,000 tonnes per year in NSW alone (see Table 3).	High volume of raw material – approx. one million tonnes per year in NSW alone (see Table 3).
Treatment, incl. contaminant removal	Generally no treatment required. Some products require removal of packaging (wrapping and cans). Packaging materials can be recycled.	Separation of physical contaminants and non-food components followed by heat treatment. Non-food components can be composted, packaging recycled. Risk of contamination with RAM.	Separation of physical contaminants and non-food components followed by heat treatment. Non-food components can be composted, packaging recycled. Risk of contamination with RAM.
Regulatory approvals	None	EPA approval for use of industrial waste, approval that treatment meets Australian Standard for the Hygienic Rendering of Animal Products. Local Government development approval for treatment plant.	EPA approval for use of industrial waste, approval that treatment meets Australian Standard for the Hygienic Rendering of Animal Products. Local Government development approval for treatment plant.
Capital costs	On-farm liquid feeding system ~$200K per farm	Treatment plant $35-40M	Treatment plant $35-40M
Economic return	High: 22% IRR (high confidence due to the system being operational)	Marginal: 9% IRR (low confidence due to extrapolation from non-pig feed systems)	Not calculated
Overall risk (GHD assessment)	Low for existing producers Medium for new entrants (stranded asset if producers lose access to feed source)	High: disease risk, uncertainty of treatment costs, yield and nutritional quality of pig feed, uncertainty of price received for pig feed output	High: disease risk, uncertainty of treatment costs, yield and nutritional quality of pig feed, uncertainty of price received for pig feed output
Future Outlook	Likely potential for expansion to new users as the costs of landfill increase and benefits of food waste in a liquid feeding system are promoted. Existing users will endeavour to protect their current sources of supply.	Volume of food waste from supermarkets is likely to increase and there is potential to explore opportunities to value add waste to avoid landfill costs, with outputs including livestock feed as well as garden compost. The impetus for treatment of food waste will be driven more by corporate social responsibility issues rather than demand from the pig industry. A pilot treatment plant needs to be constructed to establish proof of concept.	Volume of food waste from supermarkets is likely to increase and there is potential to explore opportunities to value add waste to avoid landfill costs, with outputs including livestock feed as well as garden compost. The impetus for treatment of food waste will be driven more by corporate social responsibility issues rather than demand from the pig industry.

	A pilot treatment plant needs to be constructed to establish proof of concept.

Table of Contents

List of Tables

1. Background to Research

Historically, pigs were used by many households to convert food waste into a protein and fat source for human consumption. The risk of feeding pigs untreated food waste or food scraps that either contains or has come into contact with meat or meat products, poses a significant risk of exotic disease introduction to livestock industries. International outbreaks of diseases such as Foot and Mouth which devastate agricultural industries, have reinforced the risks of feeding animals untreated food waste.

Approximately one third of all food produced for human consumption is wasted globally, with Australians discarding 361 kg of edible food annually per person, costing more than AUS$8 billion per year (www.environment.gov.au/protection/national-waste-policy/food-waste). Whilst food waste may be viewed as significant source of energy and protein, a number of significant issues must be further addressed before any potential opportunities for the Australian pork industry can be realised. It is recognised that State, Territory and local governments are addressing food loss and waste through the public food waste education and awareness initiatives, organic waste diversion activities, and by investing in organic waste and recycling infrastructure.

High quality ingredients are fed to pigs and equate to approximately 50-60% of the total cost of production. Food waste will have inconsistencies in the nutritional and dry matter content and the level of contamination will vary, thereby making the use of food waste challenging. Further, costs of obtaining food waste, treatment, and distribution need to be determined to quantify the cost-effectiveness of its use as a source of feed. Before the pork industry is in any position to utilise food waste as a source of feed, appropriate treatment processes will be required, and regulatory approvals obtained.

2. Objectives of the Research Project

GHD was engaged by Australian Pork Limited (APL) to conduct a feasibility study into food waste recycling (both commercial and domestic waste) for use in Australia as pig feed, with a particular emphasis on procurement of sufficient volumes, effectiveness and costs of treatment, contaminant removal, distribution networks, regulatory approvals required, and cost compared to traditional sources.

This feasibility study will:

1. Summarise and analyse targeted consultation of three pig producers and one nutritionist with experience of using recycled food waste as a pig feed source.
2. Provide an economic comparison and some analysis of the cost involved for pig growers of utilising different food waste sources (liquid and dry). The economic comparison is based on cost estimates provided by consultation which are assumed to be accurate.
3. Provide some context to food waste volumes and identifies potential sources or new opportunities.

3. Introductory Technical Information

3.1 Pig feed

Pig feeds are generally in the form of pelletised formulations derived from cereal grains, vegetable protein meals, and specialised vitamins and minerals. Feeds can also contain Restricted Animal Material – RAM (e.g. meat meal, blood and bone meal, fish meal, feather meal) that has been rendered and treated as per the Australian Standard for the Hygienic Rendering of Animal Products. "Waste" products that are not considered to be "swill" can also be fed to pigs; milk, eggs (excluding Queensland), dairy waste, vegetable waste and bread (excluding meat toppings).
It is illegal in Australia to feed swill to pigs. Swill includes any of the following:

- all meat, meat scraps, meat trimmings including chicken
- offal such as liver, kidney, tongue, intestines, etc.
- blood, bones, and mammalian and chicken carcasses
- any food cooked with, or that has been in contact with, meat, meat products or meat by-products
- food scraps from food processors, homes, any food outlet, and rubbish dumps
- vegetable oils used to cook meat
- food of unknown origin.

Swill can potentially contain viruses that have caused disease outbreaks overseas. If such viruses entered Australia's livestock industries, devastating results could follow. These viruses include foot and mouth disease, African swine fever, classical swine fever, swine vesicular disease and Aujeszky's disease. Many of these viruses are extremely resistant to treatments and survive boiling, freezing and curing processes, making thorough treatment of these products in the consideration of recycling for pig feed vitally important.

3.2 Waste potential

A 2011 report estimated that Australians generated 361 kilograms of food waste annually per person (equivalent to almost 9 million tonnes per year for a population of 24 million). For the purposes of this project, waste is categorised as:

1. Manufacturing waste – waste products from dedicated food processing plants
2. Commercial waste – from supermarkets, green grocers and food service outlets
3. Domestic (household) waste. It is estimated that NSW households dispose of more than 800,000 tonnes of edible food per year.

In NSW, commercial and manufacturing food waste sent to landfill in the Sydney metropolitan area was estimated to be 190,000 tonnes in 2014. Food waste makes up 9% of the total commercial and industrial waste stream.

3.3 Recovery of food waste

Recovery of food waste for use as a feed source for pigs is likely to be technically feasible, however a number of issues need to be considered, including nutritional value, contamination, and costs associated with collection, treatment, and distribution. In addition, regulatory oversight and quality assurance issues will need consideration.

The extent of the issues will vary between manufacturing, commercial and domestic waste sources and feasibility will be further influenced by economies of scale that can be achieved. Factors influencing economies of scale include an increase in awareness of food waste and its management. For example, local governments have identified the significant amount of food in their waste streams and are taking steps to reduce food waste through a range of programs, including pilot programmes for restaurants and cafes to assess their food waste practices and reduce the amount of food they send to landfill, and supporting local businesses to source food waste, in order to turn it into valuable products.

The food processing industry's peak body, the Australian Food and Grocery Council, has a target to reduce waste to landfill by 40 per cent by 2020. The council recognises there are strong incentives for food processors and retailers to reduce their food waste. These include increased efficiency and profitability and opportunities for businesses to stand out from their competitors in a highly competitive industry. Major grocery retailers also include food waste reduction goals in their business objectives.

4. Research Methodology

For this feasibility study, GHD completed the following range of activities.

4.1 Inception meeting

An inception meeting was held between APL and GHD in Canberra on 24 May 2017. This meeting included confirmation of the scope of works and outputs of the feasibility study, and also discussion on the extent and process of consultation with pig producers and pig nutritionists. Regular phone and email correspondence between APL and GHD occurred throughout the project.

4.2 Desktop review

GHD completed a literature review of domestic and international waste sources with a view to understanding the types and volumes of food waste and the extent of recycling as a source of pig feed, or examples of research or pilot programs for demonstrating potential use.

4.3 Targeted consultation

APL selected three pig producers and one nutritionist with experience in utilising food waste as pig feed sources for targeted consultation. Consultation was initially performed via a questionnaire that was emailed to participants, with the contents of the questionnaire agreed in advance with APL. Respondents emailed completed questionnaires to GHD via APL, after which GHD phoned the respondents to explore responses in more depth. A summary of the phone conversations was emailed to participants who then returned edits and additional information for each of the summaries. The consultation phase provided valuable insights into experiences and potential future directions for the feeding of food wastes. Summaries from the questionnaires and phone discussions are provided in Appendix A and Appendix B.

4.4 Economic analysis

Using information obtained from the consultation phase and desktop review, GHD completed a high level economic analyses of the costs and benefits for the development of two distinct food waste feeding systems: (i) Industrial – use of food processing waste as described earlier in existing piggery liquid feeding systems; and (ii) Commercial – theoretical treatment and feeding of food waste from supermarkets. This included the adoption of a number of assumptions on key parameters for which there is (mostly) a paucity of information.

4.5 Draft and final report

GHD's draft feasibility study report was supplied to APL for review. GHD considered APL's comments on the draft prior to finalising this report.

5. Results

5.1 Desktop review

This section provides the background to the food waste context, with a discussion around recycling food waste as pig feed in various countries and the potential presented in Australia.

5.1.1 Wasted potential

Human food waste has recently come into the limelight in Australia, particularly among the rise of programs and public advocacy such as the ABC's "War on Waste" campaign in 2017. It is estimated that Australian households wasted $10 billion of food in 2016 (Rabobank, 2016) in addition to waste from commercial outlets and industrial processes. While some pig producers have recognised the potential of reusing human food waste as pig feed, adoption of recycled food waste to feed pigs has not been widespread in Australia. It is illegal to feed pigs any food which contains meat products or that may have been in contact with meat unless treated appropriately, due to the risk of certain diseases. Despite the risks of contaminants, several countries have taken advantage of the sheer volume of food waste available to decrease the production and environmental costs of feeding pigs. For example, 42.5% of food waste is recycled as animal feed in South Korea (Salemdeeb et al., 2016), demonstrating the significant potential where collection and processing facilities are in place.

In Australia, the main use of food waste as pig feed is delivered in liquid feed form. The consultation undertaken as part of this feasibility study concerns liquid feed systems. However other countries, particularly in Asia, have demonstrated a preference for dry feeding systems which are successfully being used.

5.1.2 Early adoption in Japan

The Japanese government initiated the Food Recycling Law in 2001 which provided impetus to the reuse of food waste in Japan. Kawashima (2002) details the early adoption of food waste recycling for animal feed in Japan. Despite initial bans on food waste containing mammalian meat following reports of Bovine Spongiform Encephalopathy (BSE) in 2001, use of processed food waste was shortly reinstated for use with swine.

The three main methods of processing human food waste for pig feed are dehydration, production of silage and liquid feeding. Dehydration includes methods such as heating, fermentation and fry cooking. The products require certification, including of nutritive quality, by the Ministry of Agriculture, Forestry and Fisheries. Despite fluctuations in the nutritional content of individual food waste products, collection and combination from a variety of waste sources results in dehydrated feed products with relatively consistent chemical composition. Dehydration temperatures range from 70 to 230 °C, with higher temperatures conferring greater security of sterilisation but also greater risk of denaturing proteins which reduces nutritive value. Alternative processing pathways of silage and liquid feeding have not been popular in Japan due to higher logistical and investment costs, and the difficulty of incorporating through standard feeding systems (Kawashima, 2002).

5.1.3 Food waste recycling in the US

Recycling waste as a food source for pigs is regulated at both the federal and state level in the United States (Leib et al., 2016). The Federal Swine Health Protection Act sets a baseline for heat treatment required by a licensed person to be performed for any food scraps potentially containing meat or

animal by-products. Items that are exempted from this treatment include bakery items, eggs, candy and dairy products. The level of control exerted by the states varies widely, with 15 states prohibiting feeding food scraps to swine containing any animal material, and nine of those states further banning vegetable waste being fed to swine (Leib et al., 2016). Variation state by state exists in prohibition of particular waste sources, heat treatments required and licensing requirements. For example, in Arizona garbage is defined as "waste consisting in whole or in part of animal waste resulting from handling, preparing, cooking and consuming of foods, including the offal from animal or poultry carcasses or parts thereof." While the feeding of untreated garbage to pigs is prohibited, treated product can be fed under licence (an annual permit). Treatment requires that all garbage must be heated to at least 100°C or boiling point for at least 30 minutes or else treated in some other manner approved by the state.

Rutgers University case study

Rutgers University demonstrates an arrangement between a large institution and a farmer for the benefit of both parties. This university contains the third largest student dining operation in the United States with catering for over 3.3 million meals and more than 5,000 events each year. Food waste and used napkins are separated into a trough by staff then moved to a pulper which pulverises the food scraps and removes excess water, reducing the volume by up to 80 per cent. The reduced quantities of waste are stored in a refrigerator to be collected by the farmer for transportation to the farm which is less than 25 km away. The farmer feeds just over one tonne of pulverised food scraps per day to his pigs and cattle. The farmer charges roughly $30 USD per tonne, as opposed to roughly $60 USD that Rutgers would pay for a tonne of waste to be landfilled.

5.1.4 Food waste in Australia

In Australia, vast amounts of food waste are landfilled each year from commercial, industrial and domestic sources. Published information in Australia generally combines volumes for commercial and industrial waste streams making these sources difficult to differentiate in terms of their quantity and composition. It is estimated that food material comprises approximately 14% of commercial and industrial landfilled waste (Table 2 below).

Table 2 Typical Commercial & Industrial Landfilled Waste Composition (DECCW, 2009)

Material	Average Composition
Food	13.6%
Plastic	13.2%
Wood	13.0%
Paper	8.0%
C&D	7.7%
Cardboard	5.75
Vegetation	3.4%
Glass	1.8%
Metal	1.5%
E-waste	0.6%
Total Recoverable	68.5%
Residual	31.5%
Total	100%

A GHD study for the NSW Office of Environment and Heritage (GHD, 2011) described the total quantities of household (municipal) waste for each region in NSW, categorised as recovered (recycles)

and residual (disposed to landfill). The prediction was that by 2036 there would be approximately 2 million tonnes of recoverable waste in NSW (see Table 3).

The limitations on the proportion of recoverable waste include:

- Responsibility for waste management often falling to local governments, many of which do not have sufficient resources or technological expertise to invest in establishing and operating alternative waste technology facilities.
- Food source components of domestic waste being generally quite contaminated and limiting re-use apart from composting.

Compostable organics comprise more than 50% of domestic waste, however recovery of the waste food component is limited as councils do not typically have facilities to separate food waste from other organic wastes, although household separation of food waste is promoted by some councils. Where systems are in place to allow early separation of food waste on a large scale, the potential for recycling is more evident. In China and South Korea domestic food waste is collected separately, allowing easier separation from other waste contaminants and subsequent conversion into animal feeds (Salemdeeb et al., 2016).

Rather than separating food waste at the collection stage, there is also the potential to separate it later at a waste transfer station or recycling facility. Where areas are experiencing a population boom (such as South Western Sydney), this requires rapid infrastructure development which can be an impetus to create facilities using more recent waste technologies that have an improved ability to recover food waste.

New waste technologies are becoming increasingly available. For example, EarthPower in Western Sydney utilises waste from Coles, Woolworths and Sydney Markets (GHD, 2009) however the end-product is compost. This plant only accepts contamination-free feedstock from commercial sources, which may reduce the risk of contamination as a potential pig feed source. In general, it is the high cost or lack of associated collection and separation systems which reduces uptake of these waste technologies for food and organic waste recycling (GHD, 2009).

Table 3 Municipal Waste Projections 2010 to 2036 by State Plan Region (GHD, 2009)

Region	Material	2010 Actual (t)	2036 Predicted (t)	Percent Change
Central Coast	Residual	86,609	119,570	38.1%
	Recovered	99,888	135,068	35.2%
Far West	Residual	17,390	12,088	-30.5%
	Recoverable	3,936	2,684	-31.8%
Hunter	Residual	229,581	314,911	37.2%
	Recoverable	108,237	146,573	35.4%
Illawarra	Residual	113,226	139,170	22.9%
	Recoverable	116,108	139,972	20.6%
Mid-North Coast	Residual	56,205	76,528	36.2%
	Recoverable	79,521	109,920	38.2%
New England-North West	Residual	65,660	59,349	-9.6%
	Recoverable	40,786	37,577	-7.9%
Northern Rivers	Residual	97,215	122,605	26.1%
	Recoverable	86,241	91,307	5.9%

Orana	Residual	40,055	36,520	-8.8%
	Recoverable	11,541	10,173	-11.9%
Riverina Murray	Residual	89,199	88,302	-1.0%
	Recoverable	44,396	47,044	6.0%
South East	Residual	70,624	93,081	31.8%
	Recoverable	50,306	66,778	32.7%
South Western Sydney	Residual	143,938	263,883	83.3%
	Recoverable	192,380	285,509	48.4%
Sydney	Residual	515,782	593,076	15.0%
	Recoverable	434,990	522,402	20.1%
Western Sydney	Residual	241,772	376,422	55.7%
	Recoverable	209,665	268,785	28.2%
Central West	Residual	75,660	69,368	-8.3%
	Recoverable	23,665	31,184	31.8%
Total	Residual	1,842,915	2,364,874	28.3%
	Recoverable	1,501,659	1,894,975	26.2%
	Total	3,344,574	4,259,849	27.4%

A summary of the three sources of food waste (manufacturing, commercial and domestic) in Australia, with their current advantages and disadvantages, and future potential for recycling as a pig feed is provided in Table 4 below.

Table 4 Summary of food waste sources in Australia

	Manufacturing (food processing waste)	**Commercial (supermarkets, green grocers, food service waste)**	**Domestic (household waste)**
Description	• Products from dedicated food processing plants deemed to be unsuitable for use in its intended supply chain or a by-product of the processing system. • Typically when recycled as a pig feed this source is delivered directly to pig producers for use. See Appendix A for further description.	• Waste products from supermarkets, green grocers and food service outlets (restaurants), including out of date and otherwise unsuitable produce (e.g. fruit with skin blemishes). • Typically this source may be individually packaged for human consumption or consist of large quantities of food prone to spoiling.	• Waste produced by households. This is collected by local councils and transported to a waste transfer station, before disposal as landfill or recycled to produce compost. The extent of sorting depends on local infrastructure and the number of specialised bins provided by councils to each household. • While this resource is currently not used in Australia as pig feed, other countries which use domestic waste have separate food waste collection and processing facilities.
Advantages as a potential pig feed source	• This waste is likely to be relatively homogeneous (i.e. single source origin) making it easier to predict its nutritional value, freedom from RAM and incorporation	• Although likely to be mixed waste there is some potential for segregation into components. • Likely to be available in large and fairly predictable quantities.	• This waste source is present in high quantities. • The populace is increasingly aware of food waste and the need to reduce or recycle waste.

	into diets without temperature treatment. • Transport coordination is easier from large scale factories and organisations. • No specific regulations.		
Disadvantages as a potential pig feed source	• Often includes packaging that requires separation on farm. • Requires specialist handling equipment and storage facilities on farm, generally integrated into a liquid pig feeding system. • Generally high in moisture content resulting in high transport costs.	• Mixed sources results in variable nutritional content. High vegetable/fruit content reduces suitability for pig diets. • Not possible to guarantee freedom from RAM, thus requiring high temperature treatment and costs of regulatory compliance. • May have significant packaging to deal with.	• Not possible to guarantee freedom from RAM, thus requiring high temperature treatment and costs of regulatory compliance. • More likely to contain non-organic contaminants requiring separation. • Delay in collection results in higher risk of spoilage and putrefaction and therefore rejection for use regardless of treatment. • High vegetable/fruit content reduces suitability for pig diets.
Approximate total volume landfilled per year (NSW)	2.5 million tonnes total (as at 2009)(GHD 2011)		1.8 million tonnes total (as at 2010)(GHD 2009)
Food component of landfilled waste source (NSW) (annual)	13.6% of 2.5 million tonnes = 350,000 tonnes per year (as at 2009)(GHD 2011)		Compostable organics, including food: 51.3% of 1.8 MT = 945,415 tonnes (as at 2010) (GHD 2009)
Future potential in Australia	• Almost 70% of this commercial and industrial landfilled quantity could be recycled as compost with use of currently available waste technologies (GHD 2009). • The amount suitable for pig feed is yet to be determined.		• Population increases in areas such as Western Sydney could drive the implementation of new waste technologies for separation of food waste (GHD 2009). • Adoption of more specialised bins by councils in the future could aid the separation process (GHD 2009). • Increased public awareness of food waste presents potential for increased public responsibility to sort and advocate recycling of food waste. • Potential for small scale agreements between organisations and producers such as at Rutgers University, USA.

5.2 Consultation findings – manufacturing

GHD consulted with three pig producers and one pig nutritionist experienced in using industrial food waste as pig feed in Australia. Their detailed responses are provided in Appendix A and Appendix B, respectively. Waste products consist of a range of products including: pet food (e.g. dog biscuits), fish fillet/fish finer waste (fish, breadcrumbs, oil), dairy products (e.g. liquid whey, cheese, ice-cream), lollies, spreads, hazelnut husk, liquid sugar, molasses, chocolate/chocolate sauce, canned fruit, biscuits and bread. Because of commercial-in-confidence considerations, respondents provided relatively high-level comments on the financial aspects of utilising food waste in their enterprises. GHD has interpreted this information to make assumptions on a range of variables for inclusion in an economic analysis in section 5.3.1 "Manufacturing: on-farm liquid feeding system". Note that limited consultation was completed with stakeholders representing the other food waste sectors (commercial and domestic), however, apart from acknowledging the potential for the use of food waste as pig (or other livestock) feed, little specific information was obtained. As a result, GHD relied mainly on literature review findings to complete an economic analysis of this source of food waste (Section 5.3.2, "Commercial: collection and treatment of supermarket food waste"). Several key themes that arose from the consultation with respect to manufacturing food waste are summarised below.

5.2.1 The process

Reduced feed costs was the key reason for producers to source waste food supplies, despite the higher capital cost requirement for handling, storage and liquid feeding infrastructure. Producers have variable arrangements with suppliers for the purchase and transport of products. In many cases, product is supplied free of charge by suppliers because they avoid the alternative higher cost of disposing of the product to landfill. The suppliers may also pay the cost of the transport of the waste from the factory to the farm, although this is negotiable on an individual basis. The infrastructure required includes a liquid feeding system for the piggery, associated tanks and pits for the food waste materials, silos of "balancer" ingredients with the final diet formulated by a computerised system based on a least cost ration based on the nutritional quality of the full range of ingredients. The diet is generally based on advice of a pig nutrition consultant with knowledge of the nutritional content of each feed component. Food waste may comprise up to 65% dry matter of the total diet with the balance supplied by various grains and meals. Materials like milk, whey, yoghurt, ice cream, fruit juice etc. can be received into tanks and dispensed directly into the feed. Material like jam, custard, peanut butter, packaged milk etc. may need crushing and separation from the packaging using water and made up into solutions of known solids content, again for direct injection into liquid feed mixes. Some essentially dry (dog food) or semi moist materials (mustard meal, fish wastes) can be placed in a pit and homogenised into a slurry by adding water or one of the other liquid components (whey, milk, diluted jam) and then incorporated in the liquid feed.

Apart from infrastructure costs, additional variable costs include nutritional analysis (including advice by a nutritionist), extra labour costs associated with managing the mixing system and the need to separate and dispose of packaging material. Where materials are prone to degradation (short shelf life) they may need to be stabilised to preserve their food value and palatability. This may require antioxidants in high fat ingredients or acids. Acids can be used simply to lower the pH and arrest spoilage bacteria or can be used specifically to prevent fermentation (sorbic acid) or to eliminate specific pathogens (formic acid for salmonella) – see Appendix B. Manufacturing food waste can be fed to a variety of classes of pigs but this very much depends on the nature and volume of what is available. Products like bread, milk and confectionary can be fed to all classes of stock including breeders, and

the intake of these products can be up to 90% of their daily ration. There is a need to leave some room for a balancing supplement to correct the amino acid, mineral and vitamin aspects of the total diet. Some materials are self-restricting by their solids content (e.g. whey at 3-5% solids), their salt content (dog food), palatability or nutrient imbalance.

5.2.2 Procurement

One advantage of using recycled food waste for pig feed is that a wide variety of food waste products may be utilised. In particular, liquid food waste can be taken advantage of which other livestock industries do not use. Initiation of supply by either grower or waste provider allows both parties to take advantage of opportunities where they arise, so each pig producer has quite different experiences of products. The pig producers identified that there are no guarantees of quantity or quality when using food waste, and this can lead to much greater logistical management and nutritional planning than if a standard feed were used. If managed poorly, this variability could lead to decreased pig production by reduced quality and nutrition of the feed. The procurement of food waste suitable for pig feed at close distances to farms is highly competitive and for this reason, commercially confidential. The concerns of the growers interviewed indicated that although there may be sufficient liquid food waste volumes for some farmers to take advantage of this lucrative system, in general the supply is limited.

5.2.3 Risks

The major risk posed by the use of recycled food waste is the potential for contamination. Potential contamination was identified by growers as being:

- Nutritional, from unexpected food content and potential effects to the pigs.
- Physical, from inappropriate handling by staff at the processing facility allowing large contaminants including metal or plastic objects to end up in the waste.

No licences are currently required as long as swill feeding legislation is obeyed. The risk posed by uncertainty of content (from meat and chemical contamination) in the food waste can be reduced by raw material declarations provided by the waste producer. Risks posed to the pigs by variation in ingredients of the food waste consignments are managed by regular consultation with a nutritionist. There is some risk of dietary upset posed by feeding recycled food waste to sows, therefore different food wastes are targeted at different age groups within pig production.

5.2.4 Other benefits

Aside from cost benefits from the growers, recycling food waste as a pig feed source was identified by growers as having a positive public perception and aiding their reputation. Some of the growers further support this method of feeding due to the environmental benefit of reducing landfill waste.

5.3 Economic Analysis

This section provides high level economic analyses of the costs and benefits for the development of two distinct food waste feeding systems: (i) Manufacturing – use of food processing waste as described earlier in existing piggery liquid feeding systems; and (ii) Commercial – theoretical treatment and feeding of food waste from supermarkets. Note that the analyses include assumptions for a range of variables that have been constructed from limited available information. Therefore, the results should be used for guidance purposes only, including the need for further research to obtain more robust data for the analyses.

5.3.1 Manufacturing: on-farm liquid feeding system

This option involves the installation of an on-farm liquid feeding system capable of handling the range of food waste products from processing plants as described earlier. The scenario described is largely based on the experience of producers interviewed who have installed such systems and who have arrangements with food processors to regularly obtain waste products. Their experiences are described more fully in Appendix A and Appendix B.

The modelled scenario assumes that food waste is obtained free of cost from food processors who also pay for the cost of transport from factory to farm. This is not an uncommon practice for processors because they avoid otherwise paying costs to dispose of the waste to landfill. The model uses whey as an example waste product and assumes it is fed to 500 sows, and that the whey comprises 11% of the dry matter (DM) content of the overall pig ration. The remaining 89% of dry matter is supplied via proprietary pellets. This wet/dry feeding system is compared to a conventional dry only feeding system, where sows obtain 100% of DM via pellets. The overall daily ration is assumed to be 6 kg per sow per day (21 tonnes DM per week for the overall farm) which is the same for each of the two feeding scenarios. Table 5 includes the assumptions adopted for key variables for the ingredients used in the different feeding systems.

Table 5 Pig fee ration assumptions

Feed system	$/tonne delivered	DM%	$/tonne DM	% DM in ration
Dry (pellets)	$400	90%	$444	89%
Wet/dry (whey)	$0	7%	$0	11%

Additional assumptions for the liquid feeding system are listed in Table 6 below, including a requirement for installing four storage tanks at a total cost of $50,000 and an integrated, computer controlled liquid feeding system costing $150,000. These assets are assumed to have a 15 year useful life. It is further assumed that there is no change in other daily operating costs, including labour, between the liquid feeding and more conventional dry feeding systems.

Table 6 Liquid feeding enterprise assumptions

Item	Value	Unit
Sows	500	No.
DM per sow per day	6	Kg
Total DM per week	21	Tonnes
Liquid feed supply system capital costs		
Storage tanks (x4)	50,000	$
Feeding system	150,000	$
Feeding system asset life	15	years
Discount rate	7	%

The relative costs from the wet/dry and conventional feeding systems were modelled over a 15 year timeline, with installation of the liquid feeding system occurring in year 1. The difference in relative costs between the two systems were calculated for each year and discounted to calculate the Net Present Value (NPV) and Internal Rate of Return (IRR) from the investment. The results (Table 7) suggest that after the additional outlay of $200,000 the producer will save $53,387 each year in feed

costs, resulting in a NPV of $138,156 over 15 years and the IRR of the investment is 22%. These results show that in this scenario installing the wet feeding system is clearly worthwhile. Table 7 also presents some breakeven values for selected variables. These indicate the following:

- Cost of whey, including transport: the investment is positive for whey purchase and transport costs of up to $12.20 per tonne
- Cost of proprietary pellets: the investment is positive even if proprietary pellet costs are $230 per tonne
- Liquid feed supply system costs: the investment is positive up to a liquid feeding system cost of $297,000.

While based on real examples, it should be noted that the above results rely on the following assumptions:

- Consistent supply of whey, obtained at zero cost to the producer (although the breakeven analysis indicates a positive return on investment above zero cost for whey).
- No difference in running costs (labour, electricity, maintenance) between liquid feeding and conventional feeding systems.

No difference in nutritional value between DM supplied via whey and conventional pellets (or if there are differences these can be adjusted for in pellet selection, without impacting on overall price and sow performance will remain the same)

Table 7 Economic analysis – liquid feeding of manufacturing food waste

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Wet/Dry Feeding system															
Capital and feed costs															
Whey tanks x4	$50,000														
Feeding system	$150,000														
Feed cost (conventional)	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947
Feed cost (whey)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total feed cost	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947	$431,947
Salvage value															$ -
Conventional feeding system															
Feed cost	$485,333	$485,333	$485,333	$485,333	$485,333	$485,333	$485,333	$485,333	$485,333	$485,333	$485,333	$485,333	$485,333	$485,333	$485,333
Difference in costs between wet/dry and conventional feeding systems (partial budget)															
Additional capital costs	-$200,000														
Feed savings		$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387
Total	-$200,000	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387	$53,387
NPV	$138, 156														
IRR	22%														
Breakeven whey cost	$22.50														
Breakeven pellet cost	$230														
Breakeven feeding system cost	$297,000														

5.3.2 Commercial: collection and treatment of supermarket food waste

This option involves the development of a processing plant capable of accepting a large quantity of a range of food waste products (wet and dry) from a commercial source (e.g. supermarket(s) located in large regional areas), removing packaging or other physical contaminant, treating/processing at temperature to remove disease risks to pigs and drying/pelletising the product (moisture content about 12%) so that it is suitable as a feed source for pigs in combination with proprietary pelleted feeds.

Supermarket food waste has the potential of containing RAM and would therefore require treatment to the Australian Standard for the Hygienic Rendering of Animal Products to remove the risk of the final product containing viruses (e.g. FMD virus) and the consequences of disease outbreaks in the pig and other livestock industries that would cause significant economic harm.

Unlike the above on-farm liquid feeding system example, this type of arrangement does not exist in Australia so this analysis is theoretical. However, the significant volumes of food waste from the commercial sector makes the proposition worth considering (see earlier discussion in section 5.1.4 "Food waste in Australia").

Assumptions for a commercial food waste treatment plant

While there are no examples of treatment plants in Australia as described above, there are treatment plants that process organic waste to produce compost and the main capital and operating components and costs of these systems can be adopted to provide an estimate of the likely feasibility of a commercial food waste system for the production of pig (or other livestock) feed. The following details of a DiCOM System waste treatment facility in Sydney have been used to develop assumptions for this scenario. The features of the DiCOM System are outlined in Table 8 below.

Table 8 DiCOM System waste treatment plant features

Feature	Description
Operation	The system combines a multiple separation process that recovers recyclable materials, glass and grit from Municipal Solid Waste (MSW) to produce a clean organic fraction. This fraction is treated using a patented advanced hybrid biological process within a closed vessel. The sequential batch process is automated, ensuring optimal performance and consistent quality.
Throughput	75,000tpa modules, with 25,000tpa multiples
Inputs	All MSW; green waste; source separated food organics; some Commercial & Industrial (C&I)
Residence time	21 day process cycle: 5 days loading phase and aerobic pre-conditioning; 7-11 days anaerobic phase; 3-7 day aerobic curing phase; 2 day unloading phase
Net energy	1,700MWh consumption, 3,700MWh gross production
Other outputs	AS 4454 compliant compost (27,000tpa) and various recyclables outputs (4,150tpa)
Diversion rate	75-80% is the benchmark target
Capital cost	75,000tpa process capacity, approx. $35-40m
Competitive target cost	Once landfill cost reach $90/t (operating cost $30/t processed).
Footprint	2,000 m2 for 75,000tpa capacity; each additional 25,000tpa module requires additional 500 m2

Source: Alternative Waste Treatment (AWT): Australia's waste future. www.insidewaste.com.au, March/April 2010

Based on the features of the DiCOM System, GHD adopted the following values for a range of variables for the economic analysis for this scenario.

Table 9 Assumptions and variables for a theoretical commercial food waste treatment plant

Variable	Value	Unit
Electricity price	81	$ per mWh
Gas price	8	$ per Gj
Electricity required to separate 1 tonne of packaging	0.075	mWh per tonne
Labour required to remove 1 tonne of packaging	4	hours
Gas required to remove 1 tonne of water	5.815	Gj per tonne
Cost to dispose of separated packaging	200	$ per tonne
Cost to dispose of removed moisture	0	$ per tonne
Transport cost	0	$ per tonne in
Purchasing cost	0	$ per tonne in
Labour cost	25	$ per hour
Staff numbers	10	No.
Staff salary (average)	70,000	$ per annum
Plant overheads	500,000	$ per annum
Capex	40M	$
Plant life	20	years
Dried feed meal sale price	250	$ per tonne
Discount rate	7%	Per year

Based on the above assumptions, the plant operating costs, revenue and profit per year are provided in Table 10. The calculations show an annual profit of approximately $4.5 million earnings before interest and tax (EBIT).

Table 10 Annual operating and overhead costs and return of a theoretical food waste treatment plant

Item	Packaging	Moisture	Food	Total
Cost of energy to separate food component				
Composition of supermarket food waste	10%	40%	50%	100%
Tonnes per annum	7,500	30,000	37,500	75,000
Cost to separate packaging or remove moisture ($/tonne separated or removed)	$106	$47		
Cost to dispose of removed packaging or moisture	$1,500,000	$0		
Annual cost	$2,295,563	$1,395,600		$3,691,163
Plant operating costs				
Transport				$0
Purchase costs				$0
Staff costs				$700,000
Other overheads				$500,000
Total costs (food component + operating)				$4,891,163
Annual revenue				
Feed meal sale price ($/tonne)				$250
Revenue from sale of feed meal				$9,375,000
Profit (EBIT)				$4,483,838

The economic analysis of the food waste processing plant and breakeven values for key variables are shown in Table 11. The NPV and IRR are moderately positive indicating the feasibility for the scenario. However, the relatively narrow margins between the breakeven and baseline prices for the pig feed sale price and plant capital cost variables indicate that the feasibility is sensitive to changes in these variables.

Table 11 Economic analysis of food waste treatment plant

Item	Value	Baseline
NPV	$5,928,158	
IRR	9%	
Breakeven pig feed sale price	$234/tonne	$250/tonne
Breakeven plant capital cost	$46M	$40M
Breakeven operating costs	$10.7M	$4.9M

Care is needed in the application of the economic analysis because of the following:

- The analysis is theoretical, although the assumptions are based on actual processing of food and other organic waste in Australia.
- There is an assumption that the resultant pig feed following processing is equivalent in nutritional value to a proprietary pelleted pig feed of equivalent dollar value ($250/tonne).
- The purchase and transport costs of food waste to the plant are set at zero on the assumptions that these costs would be equivalent to the avoided cost of sending the waste to landfill.
- It is assumed that the heat treatment of the waste is equivalent to the required treatment of RAM under the Australian Standard for the Hygienic Rendering of Animal Products to avoid livestock disease risks.

6. Discussion

The findings of the research in relation to the procurement of sufficient volumes, effectiveness and costs of treatment, contaminant removal, distribution networks, regulatory approvals required and cost compared to traditional sources is summarised in Table 12 and Table 13 below. Table 12 summarises the strengths, weaknesses and opportunities for the pig industry of the potential to expand the current use of food waste materials as a component of pig feed diets. Table 13 provides a comparative analysis of the feasibility of the three food waste streams examined for this project and the potential future direction in relation to the pig industry.

Table 12 SWOT analysis of key issues

Issue	Strengths	Weaknesses	Opportunities
Availability (procurement volumes)	•A wide variety of food waste products may be utilised. • The pig feed market can take advantage of liquid food waste which other livestock industries do not use.	• Variability in supply volumes and sources utilised requires frequent nutritional analysis. • Variability in supply can cause unforeseen costs from handling and incorporating the waste into a useable form. • Variability in supply has the potential to decrease pig production by reduced quality/nutrition. • Liquid food waste from manufacturing and commercial sources is a highly competitive market and overall may not pose a high potential for wide-scale adoption.	• Potential sources of more consistent product not all explored, particularly from commercial sources such as vegetable waste from Coles. • Domestic food waste opportunities currently not used at all, with potential for large-scale infrastructure set-up to allow sorting and heat treatment of household waste to tap into this huge supply. • Larger organisations producing waste may have potential for reporting/in-house analysis to reduce the workload for growers if this method of recycling becomes more widely adopted. • Potential for partnerships between organisations producing food waste and pig producers such as at Rutgers University (see 5.1.3).
Product treatment (effectiveness and cost)	• Packaging of recycled food source can be recycled and sold on to recover some costs.	• Acid supplements may be required which can negate the cost advantage of using recycled product. • Significant capital input required to establish infrastructure allowing food waste recycling inputs. • Potentially significant additional labour costs required. • Some packaging is difficult to handle.	• Larger scale heat treatment to dehydrate recycled food would require significant investment and centralised management but could allow multiple waste producers and pig producers to maximise efficiency of logistics and make other sources of food waste safe for use, however some concerns were raised that it would not be cost effective for pig producers compared to livestock producers.
Contaminant removal	• Raw material declarations can be provided to reduce risk of chemical residues and uncooked meat.	• Some risk is posed by contaminants that are difficult or impossible to remove (plastic). • There is the risk that some contaminants may be incorporated due to the lack of	• Increased adoption and awareness of food waste as pig feed may help personnel in factories to view the food waste resource as valuable, reducing contamination from poor handling.

		care taken over the waste product.	
Distribution networks	• Initiation of supply by either grower or waste provider allows both parties to take advantage of opportunities where they arise. • Transport is often paid for by the waste producer.	• If transport costs go up, it may become more cost effective for waste producers to landfill food waste than recycle it for pig feed.	• Identification of high pig production areas and consistent waste supplies could be utilised to create distribution centres or centralised systems to maximise transport efficiency.
Regulatory approvals	• No licences are currently required as long as swill feeding legislation is obeyed.	• If recycled food waste became more widely adopted in the industry it could pose a risk to the industry's reputation if growers do not self-regulate diligently.	• Governments may decide to alter swill feeding legislation to allow greater advantage to be taken of recycling food waste.
Application	• Some recycled food waste may be used at any class of pig growth for up to 90% of the pigs' diet.	• Some risk of dietary upset is posed by feeding recycled food waste to sows.	
Adoption of food waste systems broadly	• Generally positive public perception of recycling food waste benefits grower's reputation. • Environmental benefit (diversion of landfill) gained by recycling food waste. • Reduced feed cost for growers.	• Limited awareness of potential reduces opportunities initiated by organisations which produce food waste. • Increased management, monitoring and logistics places additional burden on growers.	• Heating or cooking systems could make potentially meat-contaminated waste streams safe. • As food waste is becoming more and more in the public eye, the incentives and willingness to recycle may drive a concerted effort to recycle food waste for pig feed.

Table 13 Summary of feasibility of three food waste streams

Issue	Manufacturing (food processing waste)	Commercial (supermarket waste)	Household (domestic waste)
Source	Food waste/surplus from food processing factories, including out of specifications for the market. Wide range of products from dairy processing plants, milling industry (grains, malt), bakeries, fish processing, brewing and distilling and pet food wastes.	Food waste component from supermarkets, green grocers and food services (restaurants). Requires separation from non-food components and treatment to be suitable as a pig feed.	Food waste component of municipal solid waste (MSW) (or similar) requiring separation from non-food components and treatment to be suitable as a pig feed.
Supply chain, distribution	Food processing source → farm	Commercial source (e.g. supermarket) → treatment plant → feed pellet manufacturer(optional) → farm	Household waste (potentially including separation of food component) → municipal waste centre → treatment plant → feed pellet manufacturer(optional) → farm
Volume	High but unknown volumes, subject to commercial-in-confidence arrangements between processors and producers to protect ongoing supply.	High volume of raw material – approx. 350,000 tonnes per year in NSW alone (see Table 3).	High volume of raw material – approx. one million tonnes per year in NSW alone (see Table 3).
Treatment, incl. contaminant removal	Generally no treatment required. Some products require removal of packaging (wrapping and cans). Packaging materials can be recycled.	Separation of physical contaminants and non-food components followed by heat treatment. Non-food components can be composted, packaging recycled. Risk of contamination with RAM.	Separation of physical contaminants and non-food components followed by heat treatment. Non-food components can be composted, packaging recycled. Risk of contamination with RAM.
Regulatory approvals	None	EPA approval for use of industrial waste, approval that treatment meets Australian Standard for the Hygienic Rendering of Animal Products. Local Government development approval for treatment plant.	EPA approval for use of industrial waste, approval that treatment meets Australian Standard for the Hygienic Rendering of Animal Products. Local Government development approval for treatment plant.
Capital costs	On-farm liquid feeding system ~$200K per farm	Treatment plant $35-40M	Treatment plant $35-40M
Economic return	High: 22% IRR (high confidence due to the system being operational)	Marginal: 9% IRR (low confidence due to extrapolation from non-pig feed systems)	Not calculated
Overall risk (GHD assessment)	Low: for existing producers Medium: for new entrants (stranded asset if producers lose access to feed source)	High: disease risk, uncertainty of treatment costs, yield and nutritional quality of pig feed, uncertainty of price received for pig feed output	High: disease risk, uncertainty of treatment costs, yield and nutritional quality of pig feed, uncertainty of price received for pig feed output

Future Outlook	Likely potential for expansion to new users as the costs of landfill increase and benefits of food waste in a liquid feeding system are promoted. Existing users will endeavour to protect their current sources of supply.	Volume of food waste from supermarkets is likely to increase and there is potential to explore opportunities to value add waste to avoid landfill costs, with outputs including livestock feed as well as garden compost. The impetus for treatment of food waste will be driven more by corporate social responsibility issues rather than demand from the pig industry. A pilot treatment plant needs to be constructed to establish proof of concept.	Volume of food waste from supermarkets is likely to increase and there is potential to explore opportunities to value add waste to avoid landfill costs, with outputs including livestock feed as well as garden compost. The impetus for treatment of food waste will be driven more by corporate social responsibility issues rather than demand from the pig industry. A pilot treatment plant needs to be constructed to establish proof of concept.

7. Implications & Recommendations

This project is a feasibility study into food waste recycling (both commercial and domestic waste) for use in Australia as pig feed, with a particular emphasis on procurement of sufficient volumes, effectiveness and costs of treatment, contaminant removal, distribution networks, regulatory approvals required and cost compared to traditional sources.

The study included an analysis of three different categories of food waste:

1. Manufacturing (food processing) waste – waste products from dedicated food processing plants
2. Commercial waste – waste from supermarkets, green grocers and food service outlets
3. Domestic (household) waste – generally the household component of Municipal Solid Waste (MSW) stream.

The potential for using human food waste as a source for pig feed varies considerably depending on the source of the waste. The manufacturing (food processing) stream has a high economic return but is restricted by the fact that only a limited number of food processing companies and pig producers are participating. Participants are highly protective of the waste stream because of the need to ensure ongoing supplies, and this is likely limiting the expansion of this food source supply to additional pig producers. However, there is likely to be potential to expand the current number of operators (food processors and pig producers) through an awareness campaign that highlights the avoided landfill costs to processor and economic benefits of a cheaper pig feed source to pig producers.

The commercial food waste stream (supermarkets etc.) shows a positive (although marginal) economic return from the treatment of food waste as a pig (or other livestock) feed, although the analysis is theoretical and is based on assumptions for treatment that are unproven. The advantage of this stream is the high volume of potentially suitable waste and the increasing desire by the sector to avoid disposing the valuable resource to landfill. An important risk is the presence of RAM in the food waste and the need to have a treatment that eliminates the risk that this material could harbour diseases such as FMD.

The household waste stream is similar to the commercial waste stream, except that the risks of this source in terms of economic returns and disease risk are amplified. Despite this, the sheer volume of food waste means that the source is likely to be a potential contributor to pig (or other livestock) feed, but only after the proof of concept for the manufacturing sector has been provided.

The following recommendations available to APL as a result of this study include:

1. Raising awareness of the potential economic benefits of using manufacturing food waste to both food processors and pig producers with a view to expanding the number of participants who could take advantage of the opportunity. At the same time, there will be a need to protect the commercial-in-confidence arrangements of exiting participants.
2. In conjunction with the supermarket sector, consider investing in the construction a pilot food waste treatment plant to take advantage of the desire to avoid consigning waste to landfill and at the same time demonstrating the technical and economic feasibility of this concept.

Caveats

The analyses are presented on the basis of providing guidance on the merits of utilising different sources of food waste into pig rations. Due care is required when interpreting the outcomes, especially

if individual businesses wish to incorporate food waste into their existing systems. In particular, the following need to be considered:

Certain food wastes (e.g. good quality whey) are relatively easy to use. Others (e.g. packaged products, high mineral/salty products) require additional consideration and may incur additional costs and labour requirements. Note however that there are examples of these products being successfully used, including instances where producers may need to be paid to take these wastes.

Depending on the relationship between the source of food waste products and the pig producer, some supply chains could include middlemen/brokers who may aggregate, blend and de-package wastes. Additional costs for these services would need to be considered.

The cost of transporting low dry matter content products means that distance from sources needs to be considered in costing.

Conversion of conventional feeding systems to liquid waste feeding systems is likely to be more difficult and costly compared to installation in new farms.

The benefit:cost for individual producers would need to consider the above, however the breakeven economic analyses completed for this project indicate the potential benefits of using food waste in circumstances where costs are higher than those assumed for each of the base cases.

8. Intellectual Property

No new commercially significant developments, patents or licences were produced in the course of this research.

9. Technical Summary

Two advances of information were developed in the course of this research.

1. GHD developed an economic model to enable a benefit:cost ratio analysis to assess current food waste use as a source of pig feed. Further economic modelling allowed an assessment of the potential for broader food waste recycling, using food from supermarkets as a potential pig feed.
2. A comprehensive survey was conducted, collating information from the pig industry with experience using food waste as pig feed in current industry operations. This information includes feedback from producers and practical considerations of usage at the farm level (Appendices A and B).

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11. Publications Arising

No publications were produced or are intended to be produced, arising from this project.

12. Legal Disclaimer

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GHD has prepared some preliminary cost estimates set out in Chapter 5 of this report ("Economic Analysis") using information reasonably available to the GHD employees who prepared this report; and based on assumptions and judgments made by GHD under the assumptions outlined in that section. The Economic Analysis has been prepared for the purpose of providing a basis of comparison between potential of different waste sources and must not be used for any other purpose. The Economic Analysis is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Economic Analysis and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that any specific pig feeding system can or will be undertaken at a cost which is the same or less than the Economic Analysis.

13. Appendix A – Pig producer responses (combined)

The following table reflects the answers of three pig producers experienced at using recycled food waste as pig feed. Where similar views were expressed these have been combined.

Table 14 Compilation of pig producer answers

Question	Details
What types of food waste have you used as a feed source for your pigs (please list as many as possible)? For all remaining questions please choose the top three food waste types you commonly use (if you have three).	Pet food (e.g. dog biscuits), fish fillet/fish finer waste (fish & breadcrumbs & oil), dairy products (e.g. liquid whey, cheese), lollies, spreads, hazelnut husk, liquid sugar, molasses, chocolate/chocolate sauce, canned fruit, biscuits, bread
Are you required to have any licenses in place for the use of recycled food waste as a pig feed source?	No
Do you know the nutritional content of each source (e.g. dry matter %, protein %, energy) and does it vary for each delivery?	Periodic tests are completed to guide nutritionist in the design of diets Varies for each delivery and supplier
How often do you have the material analysed?	Varies – from quarterly to rarely for nutrient content, and daily for dry matter content
Do you use professional nutritional advice on how to handle these materials?	Nutritional advice is sought on how to best utilise products to achieve optimal diet
How do you use any stabilising additives e.g. antioxidants, acids etc.?	Varies - acid supplements are sometimes used to limit fermentation, although decision is based on whether the costs of additives could outweigh the value of the products
How do you handle recyclable packaging?	Mostly packaged and sold to recyclers (includes paper, plastic and steel from tin cans)
Is there any guarantee of the volume/weight available and nutritional content provided by the waste producer? Do you know of any risks with the food waste you accept?	No guarantees on quantity or quality from factories Raw material declarations reduce risks of chemical residues, uncooked meat etc. Most risks are due to unforeseen costs incurred in handling and incorporating wastes into the diets
What class/age of pigs do you feed with this food source, and what % of their daily intake does the food source represent?	All classes of pigs (sows, weaners, growers & finishers) although some avoid feeding to sows because of implications if there is a dietary upset) Percentage of diet varies from 10% and up to 65% of daily dry matter intake
How frequently is the food source available (e.g. daily, weekly, monthly)?	Varies with products and can be irregular. Some food sources daily and some weekly
Is the supply initiated by you or by the waste producer?	Varies, but generally bilateral
How is this food source transported, who organises and pays for the transport, what is the travel distance and what is the cost ($/tonne)?	Factories generally organise and pay for transport, but varies
Is the food waste a solid or a liquid, and do you modify it after arrival on farm?	Food waste varies from liquid (5% DM content) to solid All utilised in liquid feeding systems on farm
How is the food waste stored on farm and what mechanism is used to feed it to the pigs?	Stored in holding tanks and pits (with agitators if required) All connected to computerised formulation system to mix in correct proportions for the final ration

How much labour (hours) per day is required to prepare and feed the waste to pigs?	All farms use liquid feeding systems. Additional labours for incorporating food waste components varies but can be as low as one hour additional per day
What are the impacts on pig production from use of this food waste (e.g. improved growth rates, scour issues, other benefits or costs)?	There may be a slight decrease in pig production due to inconsistency of supply/nutrients/quality, however this is generally offset by cheaper feed costs
Have you experienced any other issues with this food source? (e.g. public perception, concerns around disease, regulatory issues etc.)	Mostly production issues/risks as described above Public perception is positive
Are there any recycled food waste types you used in the past which didn't work? What was the main issue?	Mainly with some packaging which is difficult to handle Some instances with unacceptable foreign material (e.g. plastics)
What recycled food waste types work the best for you?	Generally liquid wastes as the more solid wastes can be used by other livestock industries which can out-compete the pig feed market
What are your motivations for using recycled food waste as pig feed?	To reduce feed costs and also because of the benefits to the environment through avoiding sending products to landfill
What would you like to see the industry do in the future to be able to utilise food waste?	System to heat/cook general food waste, i.e. including meat products & make it safe for pigs to eat. This would stop restrictions, like on bakery waste that has bacon bits. That all food processor know that piggeries are an option. But it is very difficult and hard to consistently ensure the quality and safety of the product we are receiving. Great attention to detail is needed to get it to work well in a system which is why many farms have tried and gone back to the easier pre-milled style of feed. I can't see utilising food waste being viable. Using pigs as an environmentally positive option to landfill and charging to do it is all we've been able to make work.
Do you have any further comments/ relevant information you wish to add?	We have invested substantial capital into facilities to handle the products over the years. This is the main constraint to using by-products and probably the biggest hurdle to other producers. It is almost like a separate business due to the management, monitoring and logistics of the product and balancing it with other feeds. And the initial investment needed into the equipment which in some cases is hard to guarantee a return due to the unreliable nature of by-product suppliers.

14. Appendix B – Pig nutritionist response

The following table reflects the answers of one pig nutritionist experienced at using recycled food waste as pig feed.

Table 15 Compilation of pig nutritionist's answers

Question	Details
What types of food waste have you used as a feed source for your pigs (please list as many as possible)? For all remaining questions please choose the top three food waste types you commonly use (if you have three).	Milk industry wastes- whey, whole milk, cheese, yoghurt, ice-cream, DAF Milling industry wastes-- millmix, rice pollard, pulse offal, oat bran, oat hulls, malt combings, barley offal, wheat dust, hominy Food industry wastes-- bread, flour, dough, biscuits, bakery waste, confectionary(chocolate, sugar based lollies, caramel, popcorn), nutella, peanut butter, jams, canned fruits and juices, vegetable wastes, grape residues, potato wastes, mustard meal, corn steep liquor, fish fingers and batter, soup mix, coffee whitener, glucose syrups, soft drinks Pet food wastes- dry dog and cat products, textured soy components used in canned dog food. Brewing and distilling wastes - brewer's yeast, spent grains, molasses residues Other - egg and hatchery wastes Most foodstuffs have a feed value for animals (at a price) but some are unsuitable for pigs and are better directed to ruminants e.g. olive pomace, fruit pomace, brewers grains.
Are you required to have any licenses in place for the use of recycled food waste as a pig feed source?	Not aware of any licenses as such being required but strict compliance to the swill feeding legislation is mandatory as well as any environmental concerns about storage (seepage, runoff, odour, flies, scavenging birds, rodents). All have to be considered.
Do you know the nutritional content of each source (e.g. dry matter %, protein %, energy) and does it vary for each delivery?	It is essential for the user to know the nutritional content through analytical monitoring. The value in using by-products as alternative feedstuffs is dependent on them being able to supply the necessary nutrients and to do this we have to know what is in them as much as we do conventional materials. The problem is that these wastes are just that; they are not made to a specification but rather occur because they fall outside the normal specifications for all sorts of reasons. As such the supplier makes no claim to their nutrient content or the consistency of their analysis.

How often do you have the material analysed?	The frequency of testing is determined by the volume of product and knowledge of its precise composition (either a pure food substrate or a mixture etc.) For instance glucose syrup, whole milk, starch, flour etc. should be fairly predictable but blended products, especially if the components are very different, can involve a lot more variation. Smaller one-off parcels probably aren't worth testing but regular high volume products require adequate QA. Analytical testing is not cheap but it is important to know what you are dealing with. For that reason a good cross-section of materials should be tested each month for the critical components (moisture, protein, fat, fibre) as well as any particular aspects that could compromise animal performance e.g. ash (Ca, P, salt), antinutritional factors (glucosinolates, trypsin inhibitors, tannins, mycotoxins). The testing needs to be focused, judicious, cost conscious but with the aim of covering the attendant risks. More professional users have NIR facilities to screen the primary nutrient content and then just send out selected samples for amino acid assays, reactive lysine assays, trace mineral content or spoilage indicators.
Do you use professional nutritional advice on how to handle these materials?	Producers unfamiliar with by-product use should seek some guidance.
How do use any stabilising additives e.g. antioxidants, acids etc.?	Where materials are prone to degradation (short shelf life) they may need to be stabilised to preserve their food value and palatability. This may require antioxidants in high fat ingredients or acids. Acids can be used simply to lower the pH and arrest spoilage bacteria or can be used specifically to prevent fermentation (sorbic acid) or to eliminate specific pathogens (formic acid for salmonella). The application of these in liquid media is straight forward but in dry or semi-moist product it can be more problematic as surface spraying may not be adequate and some form of turning or mixing may be required. Where materials have a known short shelf life it is best to turn them over frequently so the logistics of delivery need to be coordinated with usage. Some milk products can be stabilised with hydrogen peroxide or formalin.
How do you handle recyclable packaging?	Recyclable packaging (paper, plastic, cardboard, glass, steel and plastic crates etc.) is generally washed and assembled for sale through an appropriate outlet. Paper, cardboard and plastic are sorted into compatible forms and then baled up in a compressor to facilitate efficient transport with no spillage. Solid crates are stacked and strapped on pallets and demountable palacons are folded down and stacked for transport back to the relevant factories they came from. As the returned containers or packaging material are intended for reuse they must be clean. Any material that can't be cleaned must be dumped - but the costs of this are prohibitive so it is avoided where possible.
Is there any guarantee of the volume/weight available and nutritional content provided by the waste producer? Do you know of any risks with the food waste you accept?	At best there are genuine intentions to forecast available volumes and nutrient content but there are few absolute guarantees. As these are waste products there is always a risk they may not be treated with due respect e.g. poor hygiene, broken glass or wooden packaging /wire and nails included in the load.
What class/age of pigs do you feed with this food source, and what % of their daily intake does the food source represent?	This very much depends on the nature and volume of what is available. Products like bread, milk, confectionary etc. can be fed to all classes of stock including breeders, and the daily intake can be up to 90% of their daily intake. There is a need to leave some room for a balancing

	supplement to correct the amino acid, mineral and vitamin aspects of the total diet. Some materials are self-restricting by their solids content (e.g. whey at 3-5% solids), their salt content (dogfood), palatability or nutrient imbalance.
How frequently is the food source available (e.g. daily, weekly, monthly)?	The availability depends on the product. If they are regular by-products from a continuous processing operation they can be available daily. Other opportunities can be sporadic or one-off e.g. product coming out of date or rejected for human use. Freight arrangements can determine the frequency of delivery in that it may take several days to accumulate sufficient quantity to warrant the cost of a truck to deliver it, or the transport may need to be coordinated with a backload.
Is the supply initiated by you or by the waste producer?	Supply can be initiated either way. Most by-product users tend to approach potential sources and like to enter into supply agreements. Having registered their interest the user may be contacted by the seller when waste product needs to be placed to signal its availability. This is particularly so for unplanned manufacturing malfunctions or material going out of date.
How is this food source transported, who organises and pays for the transport, what is the travel distance and what is the cost ($/tonne)?	This is all part of the negotiation process. For quality materials that are regularly available and are attractive to a number of users there can be some competitive bidding involving payment for the product and with the user arranging and paying for freight. Where the product is a bit more problematic or the cost of disposal into landfill or the sewerage system is prohibitive, the source of the waste may prefer to give the product away and even subsidise or pay the full freight costs. Freight costs are generally whatever the going rate is and can be influenced by distance, the nature of the material (tanker, tipper, flat-top truck), the distance involved, the unloading facilities and the chance of a back load. While the transaction is entirely negotiable, at the end of the day it has to be an acceptable cost to the supplier (relative to alternatives) but arrive at the user at a cost which leaves some value and purpose in it as a pig feed.
Is the food waste a solid or a liquid, and do you modify it after arrival on farm?	Food waste comes in all physical forms and states of disrepair. If the product is dry and can be milled then it lends itself for traditional feed milling into mash or pellet feeds. If it is semi-moist or liquid it is best used in liquid feeding systems. So materials like milk, whey, yoghurt, ice cream, fruit juice etc. can be received into tanks and dispensed directly into the feed. Material like jam, custard, peanut butter, packaged milk etc. may need crushing and separation from the packaging using water and made up into solutions of known solids content, again for direct injection into liquid feed mixes. Some essentially dry (dogfood) or semi moist materials (mustard meal, fish wastes) can be placed in a pit and homogenised into a slurry by adding water or one of the other liquid components (whey, milk, diluted jam). These are then also available for incorporation in the liquid feed.
How is the food waste stored on farm and what mechanism is used to feed it to the pigs?	Storage methods vary with the products in question. Dry, free flowing material could be placed in silos or in flat storage sheds or concrete bays. Liquid materials can go into tanks and the semi-moist materials or difficult to handle material can be dumped in a pit and agitated with water to render them into a slurry. The storage form chosen needs to recognise the perishability of the product and facilitate use in a reasonable time period, with or without stabilisation, and to allow the storage vessel to be emptied and cleaned on a regular basis to maintain hygiene.

How much labour (hours) per day is required to prepare and feed the waste to pigs?	This is quite variable. Where liquid products (whey, milk, ice cream, yeast) are delivered by tankers into tanks on farm there is very little labour required at all. Where the material comes in small packets requiring emptying (biscuits, custard, yoghurt, bread, lollies) then labour demands can be quite high unless there is specialised equipment in place to do the de-bagging. Where the material comes in bulk and needs to be stored temporarily or placed in pits and homogenised with water then this also requires a degree of labour. Just the running of the liquid feeding system can be labour demanding, depending on its age and degree of automation. The labour requirement also depends on the scale of the operation (e.g. 100 v's 4000 sows) and as such is very farm specific.
What are the impacts on pig production from use of this food waste (e.g. improved growth rates, scour issues, other benefits or costs)?	The primary benefit of by-product feeding is reduced feed costs. There are generally no growth or feed efficiency benefits and actually performance may be variable and on average a little below conventional operations because of the variable nature of the ingredients utilised. When certain combinations of by-products are utilised they can create a degree of dietetic stress (high liquid, low fibre, high salt or osmotic tension) leading to looseness. The exercise can involve a lot of logistical hassles and some uncertainty re supply and the risk of product degradation if not utilised in a timely manner. So the cost benefit needs to offset all of this.
Have you experienced any other issues with this food source? (e.g. public perception, concerns around disease, regulatory issues etc.)	As long as facilities are in place to handle the products effectively and the piggery is not on public display (close to a road) there is little concern re public perception. But if there are recurring spills (which are not cleaned up promptly), accumulating empty containers, paper and plastic blowing around, large flocks of scavenging birds, rodent infestation, offensive odours etc., then there are likely to be complaints. The risk of disease transfer is not high but appropriate biosecurity and hygiene needs to be exercised to manage things professionally. The only regulatory issue which needs to be addressed is compliance with the swill feeding rules.
Are there any recycled food waste types you used in the past which didn't work? What was the main issue?	There are many instances of complications - some due to poor management and others due to inappropriate products. Disrespect for the waste at the collection point can see a lot of foreign material being included (glass, wood, wire, string, rubber bands, chemicals) which cause problems with the equipment or makes them unacceptable as a feed component. Delays in processing highly perishable materials can lead to major difficulties and some materials are just not suitable e.g. olive pomace and citrus pulp which are better directed to ruminant use.
What recycled food waste types work the best for you?	Milk products are usually the best value (regular supply, sound condition, reasonable shelf life, high food value, safe, consistent). Others that also represent good value are pet food waste, bakery waste and confectionary.
What are your motivations for using recycled food waste as pig feed?	The prime motivation is cheap feed and a lower cost of production. Some may propose an altruistic purpose of helping maintain the environment and preventing a waste of valuable resources into landfill, but this is generally secondary to the cost saving.
What would you like to see the industry do in the future to be able to utilise food waste?	It may be that the swill act has served its purpose and needs to be modified to allow more effective utilisation of the enormous pool of food waste which is currently condemned to landfill. There does need to be a disciplined professional protocol in place to facilitate this, and maybe it

	should fall to either government or licensed contractors to provide central processing facilities where materials could be marshalled, sorted and processed into consistent products that could be sold to approved piggeries. This removes the public health concerns and by producing feed mixes of known nutritive value would promote efficient recycling of this valuable resource.
Do you have any further comments/ relevant information you wish to add?	There is general agreement that we need to manage the world's food resources much better and at the same time take responsibility for a sustainable environment. It has also been stated that the food wasted in the western world would go a long way to covering the shortfall in the developing world. At a local level, the recovery of useful feed ingredients and their utilisation in human food production would help address these issues.