MICHAEL AXISA, LAY LAY Co Ltd

PA 5731/98 & PA 1124/97
Pig & Rabbit Breeding Farms
San Leonardu
Zabbar

PRELIMINARY STUDY:
PROJECT DESCRIPTION

FOR AN
ENVIRONMENTAL IMPACT ASSESSMENT

July 2003
PA 5731/98 & PA 1124/97
Pig & Rabbit Breeding Farms
San Leonardu
Zabbar

Preliminary Study:
Project Description

July 2003
Adi Associates

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Philip Grech
Joseph Buhagiar

Kevin Morris
ENVIRONMENTAL IMPACT ASSESSMENT

PRELIMINARY STUDY: PROJECT DESCRIPTION

INTRODUCTION

1. The Planning Authority requires the preparation of an Environmental Impact Assessment for the sanctioning of a pig breeding farm (PA5731/98) and the extension of a rabbit breeding farm (PA1124/97) in San Leonardu, Zabbar. Neither farm is currently operational.

2. The EIA calls for the preparation of a detailed project description, including the number of head, operational / management practices, buildings, landscaping, and waste disposal methods.

3. In discussing the nature of the project with Mr. Axisa and his architect, it has become apparent in respect of the pig breeding farm that the previous scale of the operation and management / operational practices are no longer acceptable or sustainable under current legislation and government policy. In addition, even to maintain currently accepted pig husbandry practices, the buildings could require substantial modification or, where surplus to requirements, demolition.

4. The rabbit breeding farm comprises a large roofed over space and a number of disused rooms that the client wishes to bring into the operational area of the farm.

5. The buildings of both farms have been cleared of all farm-related equipment and to all intents and purposes are disused shells.

6. There could be considerable opportunities to upgrade the facilities to the benefit of both the owner operator and the environment.

SCOPE OF STUDY

7. The purpose of this preliminary study is to ascertain the optimal size and operational practices for each farm and to provide sufficient data for the compilation of the project description and subsequent environmental impact analysis. It may be necessary to develop a number of building options and management strategies for evaluation.
8. The specific requirements are:
   - Outline the legal framework and policy within which pig and rabbit breeding farms currently operate and could be required to operate in the event that Malta becomes a member of the EU.
   - Broadly outline the environmental constraints pertinent to the site
   - Establish the optimal farm size for the site by reference to the number of breeding sows / does or other parameters as appropriate.
   - Identify for each option uses for the existing structures: buildings, water reservoirs and slurry troughs, indicating the need for new construction, modifications and demolitions as appropriate
   - Identify for each option the appropriate equipment and management procedures for the handling of wastes, odours and noise, having regard to the health of the farm and its operational ease
   - Indicate the physical viability of each option
   - Indicate the financial feasibility (including staffing) and market outlook of each option

9. In formulating the pig farm layout and management strategies in particular, in view of its considerable size, it would be appropriate to consider bioremediation, the use of gases within the facilities for heating and electricity generation for use on the farm, the reclamation of water for re-use within the farm and the treatment of the solid wastes with a view to recycling. Such considerations should indicate whether the proposed technology is widely used and where, and an evaluation of the risks involved in the introduction of such technology to Malta.
THE LEGAL AND POLICY CONTEXT

10. In the course of the Study the EU amended its Directives on pig husbandry, laying down the minimum welfare standards for the protection of pigs. These requirements will become law for all new, re-built or brought into use facilities after January 1 2003 and will apply to all current facilities after 2013.


DIR 2001/88/EC

12. This Directive includes a number of parameters that affect the design and management of the piggery. The requirements cover minimum floor area per pig, floor surfaces, prohibition of tethering sows and gilts, pig accommodation standards, provision of manipulable material, feed and feeding systems, and the use of individual pens. It also requires the person attending to the pigs to have received instruction and guidance on the provisions of the Directive.

DIR 2001/93/EC

13. The general conditions of this Directive cover noise exposure, lighting, physical and thermal comfort, access to manipulable material, floor design, feed frequency and access to water, prohibition (subject to a number of exceptions) of procedures intended as an intervention carried out for other than therapeutic or diagnostic purposes, size and condition of boar pens, treatment of sows and gilts against parasites and the provision of nesting materials before farrowing, piglet protection in farrowing pens, weaning periods, and group housing.

14. These two Directives will enter into force as from the day of accession. Although Malta had initially requested a transitional period to adapt to the original directive on the welfare of pigs, in the course of negotiations Malta withdrew its request. Subsequently, the Directives and the ensuing amendments will enter into force as from accession.

APPLICATION OF EU DIRECTIVES TO PIGGERY DESIGN AND MANAGEMENT IN MALTA

15. The principle factors affecting the design of the piggery are:

- Piglets are to be weaned at 28 days or later, and
- Pigs must have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities, such as straw, hay, wood, sawdust, mushroom compost, peat or a mixture of such, which does not compromise the health of the animals.
- Space standards apply to pigs at the various stages in the rearing cycle
**Weaning**

16. The change in minimum weaning periods from 21 to 28 days will largely affect the balance between the space required for farrowing and weaners, as well as the care and attention needed for the very young weaners. The sow farrowing index would decrease from 2.4 to 2.3 litters per year.

17. The Annex to Directive 2001/93/EC provides for piglets to be weaned at 21 days if they are moved into specialised housings which are emptied and thoroughly cleaned and disinfected before the introduction of a new group and which are separated from housings where sows are kept, in order to minimise the transmission of diseases to the piglets. Although the characteristic of specialised housing are not defined, it is taken to mean nursery facilities with adequate heating, floor insulation, rich feed and water with additives such as electrolytes, glucose and iron. For the purposes of the Piggery design a 28 day weaning / 2.3 litters per year per sow is assumed.

**Manipulable material**

18. The EU Directive will mean a major change in the way that piggeries are built and managed in Malta. Bare concrete floors with underlying cesspools commonly used throughout Malta will not meet the EU requirements. The Directive lays down that pigs must, as indicated above, have access to manipulable material. In practice, this means that pigs will need to be kept in larger pens with an adequate supply of straw-like material / sawdust / mushroom compost / peat / wood etc. Although the Directives require farrowing sows to be provided with suitable nesting material during the week before farrowing, an allowance is made in situations where the slurry system makes it impractical. In such circumstances, and for practical purposes a mat would suffice.

19. The introduction of manipulable material implies the adoption of a straw (or other similar material) based production and housing regime wherever possible / practicable; sows, gilts, and weaners to rearing pigs would utilise this ‘dry’ system. This will have a profound effect on the layout of the piggery, the management practices, and the sourcing of straw or other similar material.

**Housing and floor area requirements**

**Weaners & rearing pigs**

20. The unobstructed floor area available to each weaner or rearing pig kept in a group, excluding gilts after service and sows, must meet the requirement in Table 1

<table>
<thead>
<tr>
<th>Live weight (kg)</th>
<th>m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 10</td>
<td>0.15</td>
</tr>
<tr>
<td>Over 10 up to 20</td>
<td>0.20</td>
</tr>
<tr>
<td>Over 20 up to 30</td>
<td>0.30</td>
</tr>
<tr>
<td>Over 30 up to 50</td>
<td>0.40</td>
</tr>
<tr>
<td>Over 50 up to 85</td>
<td>0.55</td>
</tr>
<tr>
<td>Over 85 up to 110</td>
<td>0.65</td>
</tr>
<tr>
<td>Over 110</td>
<td>1.00</td>
</tr>
</tbody>
</table>
**Gilts & Sows**

**Floorspace & housing**
21. The total unobstructed floor area available to each gilt after service and to each sow when gilts and/or sows are kept in groups must be at least 1.64m$^2$ and 2.25m$^2$ respectively. When these animals are kept in groups of less than 6 individuals the unobstructed floor area must be increased by 10%. When these animals are kept in groups of 40 or more individuals the unobstructed floor area may be decreased by 10%.

22. Sows and gilts shall be kept in groups during a period starting from 4 weeks after the service to 1 week before the expected time of farrowing. The pen where the group is kept must have sides greater than 2.8m in length. When less than 6 individuals are kept in a group the pen where the group is kept must have sides greater than 2.4m in length.

23. The construction of or conversion to installations in which sows and gilts are tethered is prohibited.

**Manipulable material**
24. Sows and gilts shall have permanent access to manipulable material that is clean, dry and not harmful to the pigs.

**Farrowing sows & piglets**
25. There are no predetermined space standards for farrowing sows. It is noted, however, that protection must be provided for the piglets, and there must be sufficient space for piglets to suckle without difficulty.

**Boars**
26. Boar pens must be sited and constructed so as to allow the boar to turn round and to hear, smell and see other pigs. The unobstructed floor area available to an adult boar must be at least 6m$^2$. Where pens are also used for natural service the floor area available to an adult boar must be at least 10m$^2$ and the pen must be free of any obstacles.

**Flooring surfaces**
27. Flooring surfaces shall comply with the following requirements:

- **Gilts after service and pregnant sows**: a part of the area required in para 21 above, equal to at least 0.95m$^2$ per gilt and at least 1.3m$^2$ per sow, must be of continuous solid floor of which a maximum of 15% is reserved for drainage openings;

- **When concrete slatted floors** are used for pigs kept in groups:
  - the maximum width of the openings must be:
    - 11 mm for piglets,
- 14 mm for weaners,
- 18 mm for rearing pigs,
- 20 mm for gilts after service and sows;

  - the minimum slat width must be:
    - 50 mm for piglets and weaners, and
    - 80 mm for rearing pigs, gilts after service and sows

**Feeding**

*All pigs*

28. Sows and gilts kept in groups must be fed using a system which ensures that each individual can obtain sufficient food even when competitors for the food are present.

29. To satisfy their hunger and given the need to chew, all dry pregnant sows and gilts must be given a sufficient quantity of bulky or high-fibre food as well as high-energy food.

30. All pigs over two weeks of age must have access to a sufficient quantity of fresh water or be able to satisfy their fluid intake needs by drinking other liquids.

31. Feeding and watering equipment must be designed, constructed, placed and maintained so that contamination of the pigs' feed and water is minimized.

**MALTESE LEGISLATION AND POLICIES**

32. In the Maltese context the following legislation and policies will affect the design and management of the piggery:

- LN 8 of 1993: Environment protection (Sewer Discharge Control) Regulations
- LN 86 of 1980 Swine keeping Regulations
- Structure Plan for the Maltese Islands

33. LN 8 essentially prohibits the discharge of untreated piggery slurry into the urban sewerage systems. All slurry will need to be treated to urban sewage quality or better before discharge.

34. LN 86 regulates the slaughtering quota per piggery. Although the Applicant is no longer in possession of such quotas, it is assumed that the operator will conform to this legislation as appropriate. LN 86 also requires that the piggery be at least 100m away from any other piggery, and 200m from an inhabited area or a feedmill.

35. The Structure Plan is relatively silent on piggeries. It calls for a generic improvement in agriculture, and requires that new agricultural buildings be acceptably located with regard to noise, smell and effluent impacts. (AHF1 and 5 refer). It is noted that Structure Plan Policies such as BEN 1 and 2 only apply to urban areas. However, the site appears to be located on the margin of an area of agricultural value within a Rural Conservation Area. Structure Plan Policies relating to conservation of good quality
agricultural land, scenic value, and archaeology / ecology are therefore relevant. These will be addressed as part of the EIA as required by the ToR.

**ENVIRONMENTAL CONSTRAINTS AFFECTING DESIGN**

36. In the absence of the baseline studies, (which will be undertaken as part of the EIA once the general piggery construction and operating parameters have been established), it is not possible to be definitive about the environmental constraints or the degree of risk involved. However, in scoping the EIA it is apparent that the key environmental constraints are possible effects of the piggery on hydrology, ecology, cultural heritage and the effects of noise and odour on nearby sensitive land uses, including residents.

37. The primary concern regarding ecology is how flora and fauna downstream of the Site (including marine) may be affected if untreated pig slurry was deposited on the fields, or if it should inadvertently escape from the site.

38. Such discharges are also of concern to hydrology; the site may overlie the aquifer recharge area. Deposition of untreated slurry onto the fields may affect the aquifer and increase the levels of nitrates. The recently formulated Nitrate Protection Zone policies will also be relevant.

39. The primary concern about cultural heritage is the possible effect of the piggery on the nearby ecclesiastic ruins.

40. Noise and odour may affect the residents of Xghajra / Zabbar some 600m – 700m away from the Application Site.
Figure 1: Piggery Layout

1. Screening Tank
2. Aerobic Digestion
3. Anaerobic Digestion
4. Second Anaerobic digestion
5. UV Filter

All sewers 150mm Ø ceramic laid at 1 in 100
THE PIGGERY

DESIGN CONCEPT
41. The design of the piggery is based on
   • Meeting EU standards for pig protection and environmental quality
   • No increase in the buildings or floorspace extant on site
   • Retention and reuse of existing buildings
   • Free flow of air between buildings
   • Ease of vehicular access to and between buildings
   • Self containment and self-reliance

42. A number of concepts that are congruent with the EU Directives and Maltese legislation and policies have been explored on the basis of a 400 sow / 5700 head piggery utilising all or most of the buildings currently extant on the site. All systems will adopt the all-in / all-out philosophy, and in accordance with EU Directives all weaner, sows and gilts, boars and fatteners will use a dry straw-based production system; farrowing and piglets on a dry area / mat with frequent / continuous slurry flushing. The consideration of utilising the traditional slurry pit and pumping or more radically different concepts is ruled out by the need to meet the Directives and local legislation. Variations that affect piggery layout and overall management are therefore limited to feed handling, slurry / waste management, and climate control.

Overall layout
43. The concept provides for two separate piggeries operating within the Application Site boundaries. Gestation and farrowing occupy the buildings at the extremes of the site, and the fatteners are accommodated in the central buildings. The middle buildings, housing bioremediation (vermiculture), plant and equipment, straw storage, and quarantine unit will serve to separate the two operations. See Figure 1.

44. This two-in-one system will provide for a very efficient farm, and opens up the possibility of cross-fertilisation between the herds.

Use of buildings
45. The buildings are labelled from A to J from West to East.

Block A: Section A1 & A3

<table>
<thead>
<tr>
<th>Herd</th>
<th>Sows (gestation):</th>
<th>Gilts:</th>
<th>Boars:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>136</td>
<td>16</td>
<td>4</td>
</tr>
</tbody>
</table>
Slurry system: Gestation: dry with straw  
Feeding system: Mechanical  

**Section A2**  
| Herd | Sows (farrowing): 18  
Piglets: 180  
Slurry system: Wet with mats / some straw  
Feeding system: Mechanical |

**Block B:**  
**Sections B1 & B3**  
| Herd | Sows (farrowing): 40  
Piglets: 400  
Slurry system: Wet with mats / some straw  
Feeding system: Mechanical |

**Section B2**  
| Herd | Weaners: 624  
Slurry system: Wet with mats / chopped straw  
Feeding system: Mechanical |

**Blocks C & D**  
| Herd | Fatteners: 920 each  
Slurry system: Dry straw with muck-out as required  
Feeding system: Mechanical |

**Block E**  
| Herd | None  
Bioremediation: Composting / vermiculture / mushroom growing |

**Block F**  
**Section 1**  
| Herd | Quarantine: 3 boars & 33 gilts  
Slurry system: Dry straw with muck-out as required  
Feeding system: Mechanical |

**Section 2**  
| Herd | None  
Straw storage: Capacity for 1000 bales (432m$^2$ or 30m of linear block space)  
Plant & machinery storage: Total of 175m$^2$ allocated as required |
### Backup feed storage

**Workshop**

### Section 3

<table>
<thead>
<tr>
<th>Herd</th>
<th>Fatteners: 300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slurry system</td>
<td>Dry straw with muck-out as required.</td>
</tr>
<tr>
<td>Feeding system</td>
<td>Mechanical</td>
</tr>
</tbody>
</table>

### Block G

<table>
<thead>
<tr>
<th>Herd</th>
<th>Fatteners: 800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slurry system</td>
<td>Dry straw with muck-out as required.</td>
</tr>
<tr>
<td>Feeding system</td>
<td>Mechanical</td>
</tr>
</tbody>
</table>

### Block H

#### Section 1

<table>
<thead>
<tr>
<th>Herd</th>
<th>Sows (farrowing): 47</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Piglets: 470</td>
</tr>
<tr>
<td>Slurry system</td>
<td>Wet with mats / chopped straw</td>
</tr>
<tr>
<td>Feeding system</td>
<td>Mechanical</td>
</tr>
</tbody>
</table>

#### Section 2

<table>
<thead>
<tr>
<th>Herd</th>
<th>Weaners: 480</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slurry system</td>
<td>Wet with mats / chopped straw</td>
</tr>
<tr>
<td>Feeding system</td>
<td>Mechanical</td>
</tr>
</tbody>
</table>

#### Section 3

<table>
<thead>
<tr>
<th>Herd</th>
<th>Fatteners: 168</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slurry system</td>
<td>Dry straw with muck-out as required.</td>
</tr>
<tr>
<td>Feeding system</td>
<td>Mechanical</td>
</tr>
</tbody>
</table>

### Block I

<table>
<thead>
<tr>
<th>Herd</th>
<th>Sows (gestation): 140</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gilts: 10</td>
</tr>
<tr>
<td></td>
<td>Boars: 4</td>
</tr>
<tr>
<td>Slurry system</td>
<td>Dry straw with muck-out as required.</td>
</tr>
<tr>
<td>Feeding system</td>
<td>Mechanical</td>
</tr>
</tbody>
</table>
Table 1: Summary of herd distribution

<table>
<thead>
<tr>
<th>Block</th>
<th>Sows</th>
<th>Gestation</th>
<th>Farrowing</th>
<th>Boars</th>
<th>Piglets</th>
<th>Weaners</th>
<th>Fatteners</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>16</td>
<td>136</td>
<td>18</td>
<td>4</td>
<td>180</td>
<td>-</td>
<td>-</td>
<td>354</td>
</tr>
<tr>
<td>B</td>
<td>-</td>
<td>-</td>
<td>40</td>
<td>-</td>
<td>400</td>
<td>624</td>
<td>-</td>
<td>1064</td>
</tr>
<tr>
<td>C</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>920</td>
<td>920</td>
<td>-</td>
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<tr>
<td>D</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<td>920</td>
<td>920</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>F</td>
<td>33</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>300</td>
<td>336</td>
</tr>
<tr>
<td>G</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>800</td>
<td>800</td>
<td>-</td>
</tr>
<tr>
<td>H</td>
<td>-</td>
<td>47</td>
<td>-</td>
<td>-</td>
<td>470</td>
<td>480</td>
<td>168</td>
<td>1165</td>
</tr>
<tr>
<td>I</td>
<td>10</td>
<td>140</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>154</td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td>276</td>
<td>105</td>
<td>11</td>
<td>1050*</td>
<td>1104</td>
<td>3108</td>
<td>5713</td>
</tr>
</tbody>
</table>

SLURRY MANAGEMENT

46. Slurry output from a 5,700 head farm is substantial. The total output is expected to be about 8,500 m³ per year. See Table 2.

Table 2: Slurry output

<table>
<thead>
<tr>
<th>Block</th>
<th>Gilts</th>
<th>Sows</th>
<th>Gestation</th>
<th>Farrowing</th>
<th>Boars</th>
<th>Piglets</th>
<th>Weaners</th>
<th>Fatteners</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total head</td>
<td>59</td>
<td>276</td>
<td>105</td>
<td>11</td>
<td>1050*</td>
<td>1104</td>
<td>3108</td>
<td>5713</td>
<td></td>
</tr>
<tr>
<td>Slurry m³ / pa</td>
<td>2</td>
<td>2</td>
<td>5.6</td>
<td>2</td>
<td>-</td>
<td>0.52</td>
<td>2.12</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total slurry</td>
<td>118</td>
<td>552</td>
<td>588</td>
<td>22</td>
<td>-</td>
<td>574</td>
<td>6589</td>
<td>8443</td>
<td></td>
</tr>
</tbody>
</table>

* Slurry included with sows

47. The introduction of manipulable materials into pig rearing necessitates two types of slurry management:

- A dry system where the solids are retained in the straw; liquids are absorbed or drain into the collection system for treatment in the wet system
- A wet system where straw is either minimal or not available; liquids and solids drain into a collection system for treatment

48. Most of the farm will be run on a dry system, the exception being farrowing sows and piglets and to a certain extent weaners. Any straw supplied to these animals would be insufficient for a dry system (the straw required for a dry system would be too deep (22 – 30 cm) for small animals to move about on. The liquid effluent sourced from the wet system and that which drains from the dry system will be treated to a standard suitable for discharge of the liquid part into the domestic sewerage system, or for recycling within the farm. It would also be suitable for irrigation. The solids resulting from the treatment facility will require further bioremediation in order to render it suitable for reuse, or it could be disposed of at a controlled landfill. The further use of the solids is addressed later in the description.
Waste Alternatives

**Alternative A**

- **Farrowers & piglets**
  - Wet slurry
  - Screening
  - Digester
    - Second class water
    - Flushing
  - Aerobic Anaerobic UV sterilisation

- **Weaners**

- **All other pigs**
  - Liquid effluent
  - Straw / Manipulable materials / solid part of slurry
    - Precompost (60 - 80°C)
      - Mushroom compost
      - Packed & inoculated
        - Grow & harvest mushrooms
          - Feed to pigs
          - Recycled to pens
          - Recycled to vermicomposting
        - Spent mushroom compost

- **Soil conditioner**
  - Vermicompost
  - Irrigation
Alternative B

Farrowers & piglets

Wet slurry → screening → Digester

Aerobic Anaerobic UV sterilisation

Second class water → Flushing

Irrigation

Sludge

Precomposting → Vermicomposting

Straw / Manipulable materials / solid part of slurry

Sell as soil conditioner
**Slurry collection & treatment**

*Wet collection & treatment*

49. The wet area collection system, to be used in the areas where there is little or no use of straw, comprises a U-shaped trough at one end of the pig pen towards which the pen floor drains (slopes). The trough will be covered with plastic slats which will prevent the bulk of straw entering the system. The troughs are connected to main collectors which convey the slurry to the bio-remediation facility. The system will be flushed regularly using treated effluent supplemented with either mains or runoff water as required.

50. All the main pipework is 150mm in ceramic pipes to resist the high strength sewage of the pigs, laid at 1 in 100 slopes. The levels are the pipe inverts and ground levels at the manholes. (See Figure 1)

51. As to recirculation water; the pipework will need about maximum 50% return to keep the flow fairly smooth; the flow is rather small and would probably be dry during the nights. Thus half the production would be available for irrigation (i.e., sufficient for growing 3 tumoli of tomatoes) and could save significantly on pumping the effluent to the distant sewers.

52. In addition to the effluent resulting from the pigs, washwater is also collected and treated. The water consumption and washwater arisings in each block are shown in Table 3.

**Table 3: Water arisings by block**

<table>
<thead>
<tr>
<th>Block</th>
<th>Annual Water Consumption m³/yr</th>
<th>Washwater m³/d</th>
<th>Total wastewater output m³/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>569</td>
<td>1.56</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>757</td>
<td>2.07</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>829</td>
<td>2.27</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>831</td>
<td>2.28</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>831</td>
<td>2.28</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>270</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>721</td>
<td>1.98</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>1110</td>
<td>3.04</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>398</td>
<td>1.09</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>5485</td>
<td>15.03</td>
<td></td>
</tr>
</tbody>
</table>

53. A total of approximately 5,500 m³ of foul water will be need to be treated each year. The figures include total slurry arising from farrowing sows, piglets and weaners. The solid fractions arising from the remainder of the herd is included in the straw handling.
Treatment

54. In view of LN8 it will necessary to treat the pig slurry to render it fit for disposal in the domestic sewage system or alternatively for use in the flushing system or irrigation. This means that the BOD₅ of pig slurry which typically 8000mg/l, must be reduced to less than 350mg/l, which will be achieved through a process involving screening, and anaerobic & aerobic digestion. The process proposed will reduce BOD₅ by 90% to 280mg/l and result in the production of about 1 35m³ of stabilised sludge. See Table 4. The latter would be added to the composting / vermiculture process or disposed of in a landfill. The treated water will be further sterilised thorough a UV filter to render it fit for use as flushing water or for irrigation.

55. Details of the waste collection system are shown on Figure 1.
## Table 4: Summary of bio-remediation of slurry

<table>
<thead>
<tr>
<th>Inputs:</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>From derivations:</td>
<td></td>
</tr>
<tr>
<td>Total water output:</td>
<td>15.03 m³/d</td>
</tr>
<tr>
<td>Total Nitrogen: (TKN) =</td>
<td>3.19 g/l</td>
</tr>
<tr>
<td>From Sewerage Master Plan:</td>
<td></td>
</tr>
<tr>
<td>BOD₅=</td>
<td>8000 mg/l</td>
</tr>
<tr>
<td>Suspended Solids=</td>
<td>15000 mg/l</td>
</tr>
</tbody>
</table>

### Process:

#### a Screening:
3cm bar vertical screen on say 200mm inlet: tank 1m wide x 2m long

#### b Anaerobic digestion:
- Theoretical Tank volume = 90.17 m³
- proportions: b/L:: 1:2 or 1:4
  - Breadth: 3.5 m
  - Length: 10.5 m
  - Depth: 2.5 m
- Provided Volume= 91.88 m³
- Efficiency:
- Removal
  - BOD₅= 65% 2800 mg/l
  - Suspended Solids= 75% 3750 mg/l

#### c Aerobic Digestion

**1st stage**
- Allow 30 hours retention
- Minimum Tank volume = flow x Time/24 = 18.79 m³
  - Dimensions
    - Breadth: 3.5
    - Length: 3.5
    - Depth: 2.5
- Provided Volume= 30.63 m³
- Return Sludge: 30%

**2nd stage**
- settling time 1.5hrs
- Minimum Tank Volume = flow x Time/24 = 0.94 m³
  - Dimensions
    - Breadth: 1.5
    - Length: 1.5
    - Depth: 1
- Provided Volume= 2.25 m³

### Output:

This returns seed sludge by airlift pump to aerobic digester. Stabilised sludge to be removed 3 times a year about 135m³/year - For re-use/disposal at landfill

### Efficiency:

Removal
- BOD₅= 90% 280 mg/l
- this would be acceptable for discharge to sewers (<350mg/l BOD₅)

### Summary:

<table>
<thead>
<tr>
<th>Layout</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>15.03 m³/d</td>
</tr>
<tr>
<td>Inlet</td>
<td>200 mm diameter</td>
</tr>
<tr>
<td>Screening tank</td>
<td>1m x 2m plan 0.5m deep</td>
</tr>
<tr>
<td>Aerobic</td>
<td>3.5m x 10.5m plan 2.5m deep</td>
</tr>
<tr>
<td>Anaerobic</td>
<td>a 3.5m x 3.5m plan 2.5m deep</td>
</tr>
<tr>
<td>Anaerobic</td>
<td>b 1.5m x 1.5m plan 1m deep</td>
</tr>
<tr>
<td>slopes are 1/116</td>
<td></td>
</tr>
</tbody>
</table>
Dry system

56. The dry system is introduced as a result of the strict EU criteria regarding the availability of manipulable material. Manipulable material may comprise straw-like material / sawdust / mushroom compost / peat / wood. This will generally build up to about 25cm deep before the open is emptied. When the pigs are first introduced to the pen it is envisaged that the pen will be covered in about 7cm of material such as mushroom compost and a bale of straw will be placed in the centre of the pen. The pigs themselves will distribute it throughout the pen as they play with it / eat it etc.

57. The dry system drainage will be set up in a manner similar to the wet system, with the exception that the solid component of the slurry will by and large remain within the manipulable material. Some of the liquid part will be absorbed and some is expected to drain into the trough for treatment. Undoubtedly the level of solid material will build up, and as it does so it will be covered with additional manipulable material or if it becomes too mucky will be mucked out. Under the all-in / all-out management strategy, the pens will be mucked out and thoroughly cleaned each time they are vacated.

58. The mucked out material will be subject to bioremediation as described below.

Manipulable material requirements

59. On the basis of piggeries using straw-based system abroad, it is estimated that the piggery would consume about 9,000 bales of straw material each year\(^1\). Although such material is widely produced in Malta it is principally consumed by the dairy industry and to a much lesser extent by other animal farms and some mushroom growers. It is noted that there have been occasions in the past when the local supply was insufficient to meet demand and straw was imported. It is assumed, in the absence of a market survey, that none of the current production would be available to the piggery and that alternative sources would need to be secured.

60. In order to identify possible alternative supplies we have considered increasing the land under straw, the use of wood shavings, sorghum, mushroom compost and seagrass as well as importation.

Additional land brought under cultivation for straw

61. This would be a viable option if unused / under utilised land were to be reinstated. It runs the risk of reducing the land under winter crops.

Wood shavings

62. This option would need to be used in conjunction with another material such as straw in a ratio of 1:3. Although not considered to be a problem, supply sustainability has not been established. Use of wood shavings, however, will affect the bioremediation process. As discussed elsewhere in this description, vermiculture will play a pivotal role in bioremediation. The toxins and other chemicals in wood shavings (including preservatives) are likely to detrimentally affect the worms, and

\(^1\) A bale is nominally assumed to be 60cm x 60cm x 120cm.
unacceptably elongate the bioremediation process. If wood shaving have to be used, it is suggested that their use be limited to that part of the pen where the pigs regularly urinate instead of covering the entire floor area of the pen. The wood shavings could then be collected and composted separately from the straw muck bedding.

**Sorghum**

63. To be grown under contract farmers. Sorghum is a summer crop that can be grown after the straw (wheat) has been harvested. It will require irrigation, and two crops can be grown in a season. It is noted that the land surrounding the piggery would be ideal for such purposes if it were irrigated with surplus treated water arising from the piggery. About 24ha would need to be cultivated in order to yield 9000 bales. Additionally, the seeds of the sorghum plant, if harvested separately, would be a valuable food source for the pigs, or for sale to the poultry industry.

64. The main disadvantage to the use of sorghum is that the straw has potentially abrasive properties and will need to be finely chopped in order to avoid abrasion to the pig's skin. Furthermore, sorghum straw would be unsuitable for use with Farrowing Sows and young Weaners. Field trials would be necessary to establish sorghum's suitability and what pre-distribution treatment would be required.

**Mushroom compost**

65. Spent compost from the mushroom industry could be one alternative that appears to be well tolerated by pigs and serves to supply them with additional micronutrients such as iron. The pigs love the fresh earthy smell and the compost will supply them with useful micronutrients and some vitamins as well. There is a strong association abroad between mushroom farming and piggeries.

**Dried seagrass (Posidonia)**

66. Posidonia oceanica recovered from beaches as part of Government’s beach cleaning programme, if cleaned and dried may be used in conjunction with other manipulable materials such as straw and mushroom compost. Further research and trials would be necessary to establish its suitability. It is understood that there are substantial quantities available each year.

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2 Sorghum is adapted to a wide range of environmental conditions but is particularly adapted to drought. It has a number of morphological and physiological characteristics that contribute to its adaptation to dry conditions, including an extensive root system, waxy bloom on the leaves that reduces water loss, and the ability to stop growth in periods of drought and resume it again when conditions become favorable. It is also tolerant to waterlogging and can be grown in high rainfall areas. It is, however, primarily a crop of hot, semi-arid tropical environments with 400 – 600 mm rainfall that are too dry for maize. It is also widely grown in temperate regions and at altitudes of up to 2300 m in the tropics. Sorghum can be grown successfully grown on a wide range of soil types. It is well suited to heavy Vertisols found commonly in the tropics, where its tolerance to waterlogging is often required, but is equally suited to light sandy soils. It tolerates a range of soil pH from 5.0 – 8.5 and is more tolerant to salinity than maize. It is adapted to poor soils and can produce grain on soils where many other crops would fail. [http://www.icrisat.org/text/coolstuff/crops/gcrops2.html](http://www.icrisat.org/text/coolstuff/crops/gcrops2.html)
Importation

67. Importation has the advantage of superior quality in that it is usually more water absorptive since it is left standing in the field for a considerably longer time before being harvested. However, importation could introduce problems of health risks associated with diseases abroad.

Storage of manipulable material

68. About 5 month’s supply of straw (or sorghum) could be stored in Block F (area 48.6m x 9.7m x 3.6m high), and substantial storage would need to be sought off-site. The buildings proposed for the rabbit farm could be considered; they have the capacity to store about 12,000 bales. Alternatively, the building adjacent to the eastern boundary could be used; it has a capacity of 6250 bales if stacked to 4.8m high. (area 562m$^2$). It is unlikely that MEPA would consent to storage on the roof of the piggery, and furthermore such storage would impact on air circulation and piggery cooling.

BIOREMEDIATION

69. The organic waste generated by the piggery must be safely handled not only to avoid environmental problems but if possible, to extract some environmental benefit.

Alternatives

70. Consideration was given to the use of the slurry in gas production and possibly the generation of electricity or heating. Investigations showed that an economical unit would require a 10-fold increase in stock numbers.

71. A multi-stage closed loop bioremediation system is proposed. It comprises

- Treatment of the liquid waste and part of the solid waste in an aerobic/anaerobic digestion system to reduce its BOD and COD to produce flushing / irrigation water, or for discharge (of the liquid) into the public sewers. Annual waste water production is about 5,500m$^3$, although about 50% could be recycled for flushing thereby substantially reducing water requirements. The solid fraction will result in the production of about 135m$^3$ of sludge. This will be subject to further treatment in order to turn it into a saleable product.

- Treatment of the solid slurry and bedding (amounting to between 3000 – 4000 m$^3$) together with the sludge as follows:
  - vermicomposting system for the sewage sludge
  - pre-composting of the bedding/solid slurry to create mushroom compost
  - utilisation of the bedding for the mushroom growing industry, followed by collection of spent material, composting and vermicomposting.
  - pre-composting of the bedding/solid slurry followed by integrated vermicomposting of the sludge and pre-composted bedding.
  - storage for direct fertigation/ field fertilisation
72. The outputs from this will be

- vermicompost and worm casts for agriculture and horticulture (income)
- worm biomass for the poultry/ fish rearing industry (income)
- mushroom growing (income)
- increased humus and reduced fertiliser input for fields
- mushroom compost to supplement straw and other manipulable materials
- second class water for flushing and irrigation

**Volumes to be treated**

73. The annual volumes to be treated are summarised in Table 5. Detailed calculations are included in Appendix 1.

<table>
<thead>
<tr>
<th></th>
<th>Volume M$^3$</th>
<th>Weight (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedding initial</td>
<td>5184</td>
<td>300</td>
</tr>
<tr>
<td>Slurry</td>
<td>4150</td>
<td></td>
</tr>
<tr>
<td>Stabilised sludge</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td><strong>Total for bioremediation</strong></td>
<td><strong>5000 – 6000</strong></td>
<td><strong>3000 - 4000</strong></td>
</tr>
</tbody>
</table>

**IMPLEMENTATION: REQUIREMENTS, ENVIRONMENTAL AND ECONOMIC BENEFITS**

74. In order to implement the entire scheme it is likely that the piggery, the neighbouring store and the proposed rabbitry would be required. Additionally, consideration should be given to re-excavating the former slurry pits for use as mushroom growing tunnels.

75. Three alternatives are proposed

- a): Vermicompost the stabilised sludge from the aerobic / anaerobic digesters and sell the vermicasts as soil conditioner, b): precompost the solid part of the slurry / straw / manipulable materials at a high temperature to produce mushroom compost, c) recycle the mushroom compost to the pens as manipulable material, the vermiculture system, greenhouse growing medium, and for sale

- a): Precompost the slurry / straw / manipulable materials, b) vermiculture with sludge, c) sell product

- a): storage of effluent for direct fertigation / field fertilisation
76. The total period for completion of the mushroom growing operation (Alternative A) will be slightly longer than the time for pre-composting for the vermireactor but it can be made to overlap since the operation can be adjusted to handle the material available for composting. The advantage of this system over Alternative B is that a dead time of 5 weeks pre-composting prior to vermicomposting will be converted into an economically useful time and create a new resource.

**Alternative A:**

**Stabilised sludge remediation: Vermicomposting**

77. Up to 80% of the sludge arising from the aerobic / anaerobic digester system (output 135m$^3$) will be converted into worm casts through a process of vermicomposting. The remaining 20% will be used in the pre-composting phase of the bioremediation of the straw / solids arising from the dry farming system. One of two systems could be used in the vermicomposting of the sludge: a continuous vermireactor or a windrow system.

**Earthworms**

78. Although locally available species (genus Allobophora) are suitable they are not necessarily the most efficient. The most efficient earthworms for bioremediation (cited in the literature) are Eisenia Foetida (Red wrigglers) and Eudrilus eugeniae (African night crawler). The latter is a very voracious feed-consuming earthworm which is not likely to be present in Malta and the import of which is unlikely to gain approval. The former is a widely distributed north temperate climate species that appears to be present locally (imported for fishing bait and pet fish food) but its presence and status in Malta needs to be confirmed. Eisenia foetida is the earthworm of choice in most vermicomposting systems worldwide. Estimates given below are for this species. The rearing of Eisenia foetida may require MEPA approval in view of its impacts on biodiversity.

**Vermiculture System**

79. There is a choice between windrow systems and a continuous vermireactor. Both systems must be operated under full aerobic conditions at a temperature of between 15 –25 $^\circ$C and with high humidity (approaching 80 % within the medium).

**Vermireactor**

80. Vermireactors are like long (as long as possible), wide (1-1.5 metres), shallow trays filled gradually with waste for the earthworms to convert into worm casts. The process time varies according to the thickness of sludge added to the vermireactor. A vermicomposter involves addition of small quantities of feed and bedding material (e.g.., sludge) to the top and harvesting of vermicasts and other degraded components occurs from the base. The process is practically odourless and is usually carried out indoors.

81. The bedding system comprises an absorbent material such as paper or straw or soil (or limestone substitute such as Xahx), sand, sawdust layered structure and food added either as a very small amount (2 mm layer) on a daily basis or as a thicker layer
(2 cm) on longer cycles every 10 days. A similar amount of vermicasts are harvesting from the base. Shorter cycles may also be used. The reactors may be stacked on top of each other to reduce space but operating may become more time consuming unless mechanised.

82. Given 135m$^3$ of sludge per year, over 11,000 Litres must be consumed per month or around 3700 L every 10 days. This will require between 3 and 4 reactors measuring say 50m x 1m x 10 cm, depending on the length of space available. The reactors will also consume some bedding with pig solids as part of the reactor bedding or as a substitute of parts of it. It is better to feed little at regular intervals but the problem is that the more frequent the feeding, the greater the man-hours dedicated to the operation.

83. The reactors will need an inoculation rate of about 0.5 kg of worms per 900 cm$^2$ of reactor surface which is equivalent to around 1000 worms per 900 cm$^2$. Under the floor area proposed this would be equivalent to 2000 kg of worms. Such an amount need not be purchased but rather a starter batch of say 100 kg will be purchased and the rest reared on a cow dung slurry until the system becomes self sustaining.

Windrows

84. The windrow system makes use of windrows on a concrete floor and may be operated indoors and outdoors. The windrow system is very similar to conventional composting but with the addition of worms to enhance the process. It is noted that worms would be killed by the high temperatures involved in composting and may only be added once the bedding / slurry fermentation has stopped generating heat (at least 5 weeks, and the windrow has been well-turned to ensure that the fermentation process is complete.)

Returns:

85. Between 60 to 80 % of the sludge is returned in the form of worm casts which may be harvested, pulverised and sold as a soil conditioner. Given the 3700 L input every 10 days, this will amount to between 2500 - 3000 kg of worm casts in the same period. A further benefit may come from the degraded bedding, which may be passed through a 5mm screen and also sold as a soil conditioner. The other return is in the form of worms sold to the poultry industry or fish farming industry though the market for this is not expected to be very large especially since it still needs to be established. These returns should not be equated with economic benefit but more with an environmental benefit since this treatment will reduce problems of disposal. The expected returns from vermicasts cannot exceed Lm 5.00 per 100 kg which is approximately the price paid for a bag of good quality compost of similar size. Nonetheless, assuming that the entire production could be sold at this rate, an income of Lm450,000 – Lm540,000, might be realised.

Solid slurry with bedding and remediation – Mushroom compost production:

86. In Europe and America, waste and bedding arising from piggeries is composted and used on-site to grow mushrooms. The spent mushroom compost can then be used
as absorbent layer mixed with new straw bedding (mushroom compost is an EU-approved manipulable material) and fed back into the vermin-reactor process as a substitute bedding material.

87. The slurry / bedding / manipulable material will undergo a rapid 10 day accelerated pre-composting schedule to raise the temperature to 60 – 80 °C. (This process will help to eliminate potential pathogens in the straw based slurry compost.)

88. Once composted, the material is packed into trays and mushroom spawn inoculated. This operation must be carried out under controlled conditions of temperature and humidity and takes about 10 – 15 days to come to completion.

89. The mushroom compost is cased a left to produce mushrooms. Casing takes places under a controlled regime of temperature and humidity to encourage fruiting. The growth period to harvesting is about 10 days. The spent mushroom compost is pasteurised before further use. The total elapsed time for the mushroom growing alternative is 30 – 35 days, which compares well with the piggery 5 week cycle.

90. It is estimated that this process will produce 5000m³ of mushroom compost per year.

91. The spent compost is used for vermicomposting or returned to the pig sheds. There may be the added advantage that some of the cost of the straw for bedding will be covered by other mushroom growers if an agreement can be made for them to supply the fresh straw and in return they take an amount of mucked straw for their facility, returning the spent material after mushroom harvesting.

92. The advantages of this alternative are many and include:

• The amount of straw that will be required for bedding will be less than originally projected since spent mushroom compost will be partly recycled as bedding.

• The pigs love the fresh earthy smell and the compost will supply them with useful micronutrients and some vitamins as well;

• The waste resources will be converted into a saleable product;

• Any surplus mushroom production can be fed to the pigs;

• The system becomes a closed loop of use and reuse thus minimising problems of disposal.

• There is the additional advantage of reduced transport and handling costs of the spent bedding.

Alternative B:

Solid slurry with bedding and stabilised sludge remediation – Pre-composting and Vermicomposting

93. This involves processing the straw / manipulable material bedding / solid slurry that is removed from the pig pens at the end of each all-in / all-out cycle together with the sludge from the digesters. It is estimated that 5,000 – 6,000 tonnes of spent bedding
will need to be processed each year. This process also requires at least 20% of the sludge; it could process all of it.

94. There are two parts to the system: windrows for pre-composting the material and vermicomposting to complete the bioremediation.

95. The vermiculture part of the system is essentially the same as the vermicomposting system indicated above. However, instead of utilising trays that are 10cm deep, a 50 – 75cm deep tray system would be used.

96. The windrow pre-composting system precedes vermicomposting; it must complete before the introduction of worms (excess heat would kill the worms). Experiments have shown that where there is a bulkier organic material such as straw, a five week pre-composting cycle can help to degrade it sufficiently to receive the worms without harm. If the bedding is not pre-composted, then the chances are that the worms will use it rather slowly.

97. In order to accelerate the pre-composting system, successive layers of bedding and activated sludge will be used. A thin layer of stabilised sludge is sprayed onto the bedding material at frequent intervals as or it may be inoculated without the sludge. The windrow must be frequently turned on a 5 – 8 day cycle to ensure uniform composting throughout the pile and to avoid accumulation of undesirable gases from anaerobic fermentation.

98. In order to process 5,000 – 6,000m$^3$ per year plus 135m$^3$ sludge, (i.e., 600 m$^3$ of bedding/solid slurry per 5 week cycle), it is estimated that the pre-composting stage will need to comprise a windrow measuring 400m x 1.5m x 2.0m (or for example 5 x 75m runs). The vermicomposting system would require as similar amount of runs, albeit stack if necessary.

### Alternative C

**Direct fertigation / field fertilisation**

99. This is possibly the easiest option but carries the greatest environmental burden in that the fertiliser load including those of some micronutrients such as copper may in the long run prove deleterious. By EU regulations, open /field storage is prohibited. The pig slurry must be collected and stored inside holding tanks to prevent leakage and contamination of ground water, until such time that it can be applied to fields. If this option is used, besides the expense of building the tanks themselves, there are a number of problems that need to be resolved. First and foremost, the size of the fertiliser storage facility must be substantial to take the amount of slurry and/or sludge generated. Second the emissions associated with decomposition of the urine into ammonia. Third there are limitations as to the amount of slurry that can be applied which should not exceed 2.5 tons per tumolo or slightly less than 25 tons per hectare. The fourth limitation is the amount of odours generated during the application period and possibly during storage. Fifthly, EU Regulations on the Nitrate protection zone could affect the utility of this. For these reasons, this option should only be resorted to as an emergency step ie a small storage facility should be
constructed for contingency purposes only if the alternative systems suggested fail and until such time that the normal operations can be restored.

**BUILDINGS, VENTILATION, FEED SYSTEMS AND OTHER CONSIDERATIONS**

100. The development of the 400 sow piggery is based on the retention of the existing buildings without substantial modification. As they stand, however, they are not ideally suited to providing adequate ventilation, cooling or when necessary heat conservation.

101. It is envisaged that indoor temperature stability will be achieved through the use of ventilation stacks, shading and where necessary forced air ventilation. While these are matters to be addressed more fully at the detailed design stage, in outline the system would comprise shade tree planting in the spaces between the building blocks, chimney stacks on the roof of each block to vent the air and openings near the ceilings to draw in cooler air. If necessary, the ventilation could be assisted by fans.

102. It is envisaged that the feed system would be semi automatic; being fed mechanically from feed silos at the end of each block. Water would be available in each pen for on demand drinking.

103. All buildings within each farm unit would be interconnected by all-weather connections, i.e., a covered, fenced concrete walkway. In some instances, the walkway connects to a pig pen; the latter would need to be vacated for the occasions that it is used as a thoroughfare. (This is most likely to be during the all-in / all-out changes and would not be a problem.)

**THE RABBIT FARM**

104. Under the scheme described above, considerable space will be required for the off-site storage of manipulable materials. In view of the difficulties arising from the legislation regarding rabbit farm layouts, and in particular set backs from roads and third party properties which would mandate the demolition of the existing buildings, it is proposed that the site and existing buildings of the proposed rabbit farm be utilised as a back up / support for the piggery, including use for the storage and processing (if required) of manipulable materials.
APPENDIX A

ESTIMATES OF QUANTITIES

Quantity estimates for composting: Bedding
- 9000 bales of straw are estimated to be the annual requirement.
- 3000 bales of wood shavings# are additionally required
- TOTAL 12,000 bales

Assuming 0.6 x 0.6 x 1.2 m³ volume and 25 kg dry weight per bale
- Total Bedding Storage Volume: 12,000 x 0.432 m³ = 5184 m³
- Dry Weight of Bedding: 12,000 x 25 kg = 300,000 kg or 300 metric tons.

Quantity estimates for composting: Slurry Solids
Pig slurry has been calculated as being composed of 60 % solids (faeces) and 40% liquid (urine). At production the following volumes (extrapolated from liquid fraction volumes of slurry) will be produced by the facility reared on bedding material:

- Gilts    – 177 m³
- Gestating Sows – 662 m³
- Boars    – 33 m³
- Weaners  – 861 /2.3 = 374 m³
- Fatteners – 9883 /2.3 = 4296 m³ Initial = 5542 m³

Since the pigs will consume some of the straw, the amount of solids in faeces at production is expected to be slightly higher. Pig faeces are by nature of a semisolid to liquid consistency and volume and weight reductions are expected as the faeces dry. Some of the water present will be absorbed by the straw/wood shavings and some will evaporate in the drying process. Assuming a:

- 10 % loss to evaporation = 554 m³
- 15 % loss to absorption = 831 m³
- Remaining Solids Volume = 4150 m³

Quantity estimates for composting: Stabilised Sludge
The aerobic/anaerobic digester of the wet slurry (estimated at over 8400 m³ per year) results in the formation of stabilised sludge. Volume of Stabilised Sludge = 135 m³
Quantities Available for Composting/Vermicomposting

- Initial Bedding Volume – 5184m³
- Initial Slurry Solids Volume – 5542m³
- Initial Bedding Weight – 300 tons
- Initial Slurry Solids Weight – 5500 tons

Volumes:

- Used Bedding Volume (30 % reduction after use and compaction) - 3600 m³
- Final Slurry Solids Volume – 4150 m³
- Stabilised Sludge – 135 m³
- Final volume when three components are mixed together between 5000 and 6000 m³. The total is not a simple addition due to filling of interstitial spaces in bedding.

Weight:

- Used Bedding Weight (original less 5 % eaten, plus 25 % liquid gain) – 350 tonnes
- Final Slurry Solids Weight – between 2500 and 3500 tons depending on water loss.
- Stabilised Sludge (wet weight per m³ of material, assumed at 1 tonne – 135 tonnes

Therefore we are looking at a facility which must handle a:

- total annual weight of 3000 – 4000 tons and
- total annual volume of 5000 - 6000 m³ organic waste.

NB. Wheat straw can be made to absorb more water if it is allowed to weather in the field before being harvested. However, the weathering process cannot be prolonged since the straw will then begin to lose its nutritive capability for mushroom growing.