15 April 1991 REPLY TO QUESTIONS AND COMMENTS

1. What Items are Acceptable in Household Domestic Refuse?

Kitchen wastes: vegetable matter, putrescent matter including old food, bones, fish, meat and fat.
Household wastes: tissues dust and cinder or ash.
Garden wastes: prunnings, grass cuttings, weeds and old plants.

1a Segregation of Wastes?

The method by which this is achieved must be satisfactory to all parties involved. However before a scheme is finally decided it will be necessary to make a proposal for our feasibility study. The following is one such proposal:-

- Household domestic waste will be disposed of in three bags.

  Green Bags: for vegetable, food, putrescent matter, garden waste, dust and cinder.
  White Bags: for paper and cardboard,
  Black Bags: for anything else ie metal tins, plastic and glass.

Collection of wastes will occur weekly for green bags, and on alternate weeks for white and black bags. Thus two sorts of waste will be collected every week.

Ofcourse the details of the existing waste collection and disposal practices need to be known in detail before any new system can be designed.

2. Sewage or Sewage Sludge?

Sewage sludge at between 4% to 10% dry matter will be drawn off the primary settlement tank.

3. Acceptable level of impurities?

The implication of impurities in the source material are two fold. The first consideration would be the affect of impurities on the performance of the anaerobic digetion process, where:-

- Benifitial impurities are:-

  Iron, cobolt, nickel, molybdenum, tungsten, selinium and sulphide.
  Optimum sulphide content from 1 to $25 mgl^{-1}$

Detrimental impurities are:-

Adverse sulphide content from 100 to 150mg^{-1}

Salt Toxicity:-

cation	concentration mg^{-1} stimulatory	moderately inhibitory	strongly inhibitory
Sodium	100-200	3500-5500	2000
Potassium	200-400	2500-4500	12000
Calcium	100-200	2500-4500	8000
Magnesium	75-150	1000-1500	3000

Note: these do not allow for synergism and antagonism caused by the presence of more than one cation.

Ammonia and ammonium Ion Toxicity:-

Benifitial as source of nitrogen but toxic above 150mg^{-1}

Heavy Metal Toxicity:-

Where in order of toxicity: Zn=Cu=Cd>Cr(vi)=Cr(iii)>>Fe

However the presence of sulphide can raise the toxic threshold by forming insoluble metal sulphides.

Methods of removing toxicity inhibition include:-

- Removal of the toxic influent, ie do not accept that waste.
- Dilution of the toxic influent.
- Addition of antagonists to identified toxins.
- Precipitation of toxins.

Alternatively, as the source material (influent) is secured from a relatively small and fixed area (4 to 7Km radius) the source of toxic wastes may be identified and alternative arrangements made for the disposal of the waste.

The second consideration is the permissable impurity level in the waste derived products at the end of the process.

- Impurities in the Settlement tank liquid discharge:-
  These would remain the same as for normal sewage works.

- Impurities in the Biogas:-
  Hydrogen sulpdide and water vapour. Existing combined heat and power units, (CHP), include models specifically designed for running from biogas.

- Impurities in the Digested Solids and Liquids:-
  It is intended that the solids are composted and marketed in the horticultural and agricultural market. The marketing strategy for these products will depend upon the impurities present. For more information we can contact:-

-The Ministry of Agriculture, Fish and Food.(MAFF)
-The Agricultural Development and Advisory Service.(ADAS)
-The Agricultural Research Council.(ARC)
-The Water Research Council.(WRC)
-The Organic Advisory Service, Elm Farm Research Centre, Hamstead Marshall, Berkshire,RG15 OHR, 0488 58298
-The Soil Association,86Colston St. Bristol,BS15BB, 0272290661
-Long Ashton Research Station, Long Ashton, Bristol, BS1 89AF 0272 392181 research into Willows as biomass fuel and suitability of refuse derived compost as a horticultural medium.
-Henry Doubleday Research Assocoiation.(HDRA) National Centre for Organic Gardening, Ryton on Dunsmore, Coventry, CV8 3LG

4. Quantities of Waste Stored and Nuisance Prevented?

At this stage in the project it is difficult to estimate accurately the quantities to be stock piled. But for a first estimate we may assume:-

-2 to 3 weeks worth of domestic refuse to be held in the process at any one time. Including some in the reception, some in shredding, some in mixing and in holding tanks before digestion, some in digestion and some in fibre separation.
I have assumed a two week reception storage capacity for all wastes including contingencies. The following assumptions were then used to estimate the storage area required:-
- waste density 500kg/m^3
- storage depth 2 metres
- storage method by movable concrete clamps.

The actual storage requirement will be affected by the following:-
- Overall size of the digester and hence optimum feed rate.
- Seasonal factors in supply of a waste, for example: Autumn for agricultural crop residues, (mainly straw), and for food processing wastes. And Winter and Spring for livestock slurries from housed intensive livestock production.

Special storage to avoid nuisance (smell and vermine)
- Basically solids to be mixed with sludge as soon as possible.
- Depending on further discussion on specific health hazards, (as identified by our COSH investigation for the site), then for example domestic refuse may be stored straight away in hoppers.
- Generally the equipment and floors should be kept clean, the site neat and tidy, the grass kept short, and possibly a dog kept on site.

5. Techniques for Mixing, Feeding and Transfering the Process Products between the various units?

Generally:-
- slurries: pumps, ie rotor pumps, chopper pump.
- solids: conveyor belt/flight of buckets, tractor shovel, screw pumps.

The techniques used will also depend on what equipment is supplied by the supplier of the digester and their recommendation.

6. The Digestion Period?

The 15 days quoted was an estimate based on consultation with Farm Gas ltd.

The digestion period will depend on the types of wastes to be digested. To complicate matters further there are also variables like the 'solids retention time' and the 'hydraulic retention time'. In other words solids can be recycled through the system.

In an existing system the operators had to adjust the variables to develop the maximum efficiency.
Pretreatment of the solids also has an affect:
- Both shredding the solids, ie 20cm for straw, 2cm!
or pre-mixing the solids and liquids to allow hydrolysis and liquidification of the solids to occur.

7. What is required to utilise the Methane?

Gas storage and CHP are required, and both these items are supplied by the digeter supplier, ie Farm Gas.

For the CHP units the maintenance is normally carried out by the manufacturer. The cost of this essential maintenance is between 24 and 36 pence per hour in service per 50Kw of capacity installed.

8. Costs and problems in Marketing the Compost end product?

The separated solids may be sold direct to a compost manufacturer for them to compost and market. Alternatively it might be composted on site and then either sold in bulk or marketed independently. The first two options are advised.

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The process of anaerobic digestion will destroy all pathogens and weed seeds, and therefore steralisation will not normally be required. The exceptions are:-

- After laboritory analysis toxic bacteria or viruses are found.
- When agricultural waste with a viral infection is utilised. Then farmers practising mono-culture with the same crop as that from which the virus originared will not except the product.
- Steralisation may be by chemical or thermal means and will produce a higher value compost.

Storage of separated solids will be in clamps or hoppers.

Composting will be by tunnel aerated windrows, using digested liquid to maintain moisture content.

9. Labour Requirement for the scheme?

An estimate for the RAF Watisham scheme is, (837tpa DM), :-

direct labour	man hours			cost at
	per tDM	%	actual	£7/h
solids in	.067	6	56	392
shredding	.414	39	346	2422
digestion	.084	8	70	490
solids separation	.250	23	209	1463
compost	.211	20	177	1239
CHP	.041	4	34	238
Sub Total	1.070	100	892	6244
Management	at 50% of time			£20/h
	0.535		446	8938
Total			1338	£15182pa

Skill Required?

The level of expertise required for the scheme will be low. However, with experience of running the plant the work efficiency will increase, and therefore the employee will aquire essential skills.

As this plant is so small the work, including the manegerial work should be carried out by a single employee, or shared with any existing sewage works employee.

Some of the maintenance required is specialised, and these cases the contract maintenance is inluded in the maintenance cost.

10. Net Present Values at a 5% Test Discount Rate?

First the costs and revenues will be presented, note several variables have been changed from the first viability.

Associated Costs:-
- -waste collection, assume same as existing costs.
- -waste disposal cost, this will be less as the quantity for landfill will be redused by the organics being taken out. (See Associated revenues)
- -waste processing:- (for author, see 2km year4)

costs	capital	running
reception		
clamps	200	2100
loaders	15000	
tanks	4200	
shredding		
shredders	15000	555
digestion		
digester	115000	2955
separation		
separater	400	100
handling unit	1000	
composting		
compost shed	5000	300
fans	800	
CHP	16500	590
Sub Total	173100	6600
		+ labour 15182
Construction(20%)	34620	
Design(15%)	25965	
TOTAL	£233685	£21782
plus: 10year replacement capital	£48700	

Associated Revenues:-

Savings:

-sludge disposal, assume £10/tonne for 1970T @10%DM	19700
-refuse disposal, @ £7/tonne for 276T organics	1938

Products:

-compost, 50%DM @ £40/tonne for 602 tonnes	24105
-electricity, @ 5pence per kwh for 282487kwh	14124
-heat, assume half sold @ 2p/kwh for236034kwh	4720
-fertiliser, assume quarter sold @ £.84/t for 2168T	1821
TOTAL	£66408

Scrap, every 10 years @ 30% £14610

10. cont.

Net Present Values at 5% discount rate, based on 100% equity.

The centalised waste processing scheme will be compared with a conventional sewage works, as this is what is planned for the site in any case. For this the capital cost will be assumed to be half the processing plant cost, ie 0.5 x £233685 = £116842 . And the operating costs for the conventional sewage works will be assumed to be half the labour, quarter the running cost, and the sewage sludge and refuse disposal costs; ie £7591+£1650+£19700+£1938 equals, £30879pa.

66.4 − 21.7 = 44.7

£000

year	discount factor 5%	CWP scheme cash flow	CWP scheme DCF	conventional sewage works cash flow	conventional sewage works DCF
0	1	(233.6)	(233.6)	(116.8)	(116.8)
1	0.952	~~66.4~~	63.2	(30.8)	(29.4)
2	0.907	~~66.4~~	60.2	(30.8)	(28.0)
3	0.864	~~66.4~~	57.3	(30.8)	(26.6)
4	0.823	~~66.4~~	54.6	(30.8)	(25.3)
5	0.783	~~66.4~~	51.9	(30.8)	(24.1)

	CWP scheme	conventional sewage works
present value of benefits	287.2	n/a
present value of costs	233.6	250.3
net present value	53.6	(250.3)
benefit: cost ratio	1.23:1	0:1
discount payback (years)	~~3.06~~ ↑ 5 or 6 years	n/a
internal rate of return % **	13	n/a

** note this IRR is for a 5 year period, but as the project should last for 50 years before a complete reconstruction the real IRR will be well over 20%

11. How and Who thought of the CRWP project?

The idea of CRWP was the authors.

It was identified as being something entirely missing from the waste processing , recycling scene, and therefore worthy of study. Thus it was chosen as my MSc Thesis title.

12. Considerations of the Thesis.

- The thesis was intended to provide guidelines and a reference guide for entrêpeneurs. The entrepeneur can develop a scheme both financially and technically by use of this thesis. Schemes need not be the same as variables differ between locations.

10. cont.

Net Present Values at 5% discount rate, based on 100% equity.

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present value of costs	233.6	250.3
net present value	53.6	(250.3)
benefit: cost ratio	1.23:1	0:1
discount payback (years)	3.96	n/a
internal rate of return % **	13	n/a

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12. cont.

- The need to make a detailed assessment of well tried and tested technology was not felt to be necessary.

13. Views of the Assessors of the Thesis?

My thesis was accepted on the second submission as it was unfinished at the end of my MSc course, which was when the first submission was due.

My assessors where:-
- Paul Douglass and Dr J Morris, both at Silsoe College, Cranfield Institution, Silsoe, Bedfordshire. MK45 4DT tel 0525 60428

They accepted my Thesis, but honestly I do not know their opinions on it. Other than that it was commented upon for being too large.

Please contact them, if not directly on their views on the thesis, then on some related matters with which they could be very usefull:-

- The possibility of the PSA giving a project title, for degree, MSc, or Phd, on for example: 'the agricultural implications of recycling nutrients to agriculture from society' or 'the affect of organic liquid fertiliser for all year round use on UK farming' or (as they are also overseas orientateda) 'CRWP as a grant assisted development option for developing Countries'

  And in each case we can offer to give project guidence, something I would be keen to help organise. The research and publicity could be benifitial for the PSA.

14. Further Information on the Specific Mechanics of the Process?

For experienced and technical advice on the digestion side of the process we should contact:-

- Charles Howard , of Farm Gas ltd on 0588 638577 at Industrial Estate, Bishops Castle, Shropshire SY9 5AQ

  They do not, as their name suggests, only deal with farms. They also have considerable experience with abbatoir and sewage sludge digestors. They are now also partners, or part of Anglian Water Company.

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14. cont.

Note that I resently met Mr M Everest, who is a business analyst for Anglian Water Commercial Developments. (more about this with the Milton Keynes Proposal.)

Regarding other parts of the necessary plant, I have several files full with technical information from various manufacturers But the detailed information about the intended location must be obtained before correct specification for the equipment can be drawn up. Then detailed selection of plant can be made.

15. Is a system at RAF Wattisham viable, and if so would the Author invest more of his time to establish a viable scheme?

The viability of the scheme needs to be better assessed. For this to be achieved the steps in section 1.3 p23 ('guidelines for setting up a CRWP enterprise') part ii, need to be carried out.

Yes, as I know the only real obsticle will be the communication and management problems for the scheme. Once a system that will work for all the parties involved is found, then the appropriate technology, when applied at the correct time, should produce a viable scheme.

I also understand that there might be a grant available from the DOE or ETSU for continuing this, or other, pilot scheme viability studies.

16. Would the Author Invest his own Capital in this, or a similar size Scheme?

I have already put much of my time and money into trying to get to a situation where I can help produce a viability study. To my mind it has all been worthwhile. I do not say that a CRWP scheme as has been described to date will be the solution. Any proposal will be based on more information than as yet I have seen.

The size of the RAF site may not necessarily restrict the quantity of wastes brought into the plant from the local area. I say this because in my opinion the quantity of waste currently proposed to be processed is too small. This will result in under utilisation of the majority of the equipment in the plant, which is already costed for smaller and relatively more expensive units. So if this flexibility is allowed then yes I would invest my own capital.