Falkland Islands Government

FALKLAND ISLANDS WASTE DISPOSAL

Appendices

February 1998

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Appendices

February 1998

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APPENDIX A

MARKETS FOR RECOVERED MATERIALS AND PRODUCTS

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MARKETS FOR RECOVERED MATERIALS & PRODUCTS

1. MARKET FUNDAMENTALS

1.1 Introduction

Each of the principal recyclable - or "secondary" - materials is subject to a complex international market in which demand and value are governed by economic and industrial forces.

In many cases, secondary materials are consumed together with primary materials - as in the combination of molten steel and ferrous scrap used in an integrated steelworks. They may be used as an alternative to primary material - as in the case of higher grades of waste paper which can be substituted for virgin wood pulp. They are also employed substantially as basic feedstocks - as in the manufacture of packaging boards, the production of secondary aluminium ingots for die-casting, or in steel making employing the scrap-intensive electric arc process.

The importance of secondary materials as basic inputs is rising - as in the manufacture of newsprint and the steadily increasing proportion of steel produced in electric arc furnaces.

Although governed fundamentally by the requirements of consuming industries, demand and value are also influenced by factors that arise in the primary commodity markets.

In general, demand for secondary material rises significantly when supplies of primary material are in very great demand and so become expensive. Secondary values also increase, and may sometimes virtually equal the price of primary material. Such over-heated market situations are likely to be brief and end when the primary sector settles back to normality.

Secondary materials are cheaper than the primary equivalent, offer significant energy savings in use, and do not require the considerable technological infrastructure of primary material production. Thus they represent an important economic advantage that is especially attractive to developing nations anxious to compete in markets dominated by major companies in the developed world.

The competitive position of secondary materials can be endangered when the price of the primary equivalent falls to a point close to the total cost of collecting and processing recyclables. Such circumstances usually arise during economic recession and, although temporary, may seriously impair the position of secondary producers. The impact will be much more pronounced in sectors with an immature market structure; the development of plastics recycling has been inhibited in this way.

A prolonged decline in the real cost of a primary material can effectively eradicate an area of recycling. For example, in the post oil crisis period of the 1970s, it was economic to recycle lubricating oil to the original specification. The steady fall in the real cost of primary oil, however, gradually made unsubsidised recycling to lubricant generally uneconomic, consequently most recovered oil is now used as a fuel.

Until comparatively recently, the environmental benefits of recycling, in reducing the amounts of waste for disposal, have been regarded as a valuable side effect of an activity undertaken only if commercially viable. However, political intervention in recycling in response to greater public awareness of and concern for environmental issues, has disrupted some of the markets for secondary materials and could dislocate others. This involves both national and supra-national policies.

In some countries, notably Germany and to a lesser extent some parts of the United States, government policy has concentrated on collection of recyclable materials, while neglecting the necessity of creating a demand for what has been collected. This has given rise to substantial surpluses of recovered paper, board and low-grade plastics which in recent years have had a depressive effect on international markets already weakened by economic recession.

Low-grade waste paper and board has been supplied to consumers in Germany and to the German export market at extremely low or even negative prices. Availability of such very cheap material collected at public expense has tended to reduce recovery in countries that are net importers of waste paper, and where domestic waste paper collection is dependent on standard commercial considerations.

The conflict between what may be termed the "economic" and "environmental" approaches to recycling can be very damaging. In its report *Packaging and Packaging Waste*, published in October 1993, the British House of Lords Select Committee on the European Communities made this comment:

"We have concluded that the political drive to recycle anything and everything has become a matter of political dogma unsupported by rational environmental or economic thinking."

The established world markets for secondary materials are threatened by further dislocation. This arises from the UNEP Basel Convention, of which one of the objectives is controlling the export of hazardous wastes from developed to developing countries. Under the Convention, trans-frontier movement of recyclable wastes classified as hazardous is due to cease in January 1998. In principle, this would bring to an end trade in items such as discarded lead-acid batteries and many non-ferrous residues which represent important industrial feedstocks. However, lack of adequate definitions of what constitutes "hazardous" and widespread misunderstanding of the technicalities of the Convention, are leading various non-OECD governments to prohibit imports of recyclable wastes entirely, or to impose severe restrictions.

Recyclable materials were categorised as waste by UNEP, the OECD and the European Union, partly in an attempt to stop what is known as "sham recycling". This involves the movement of dangerous wastes across boundaries for dumping under the guise of being intended for recycling.

It is now appreciated by these organisations that to treat all recyclable materials as though they were worthless wastes causes genuine problems, especially in view of the "proximity principle" which stipulates that wastes should be dealt with as close as possible to the point of arising. There is a wide measure of agreement that a distinction must be drawn between "wastes for final disposal" and "wastes destined for recovery".

The issue is further complicated by an OECD measure to regulate all trans-frontier movements of recyclables between member states. A three-tier colour-coded system provides a "green" category subject only to controls normally applied in commercial transactions. Materials in the forms of sludge, powder, dust or "solid items containing encased hazardous waste liquids," are on an "amber" list requiring more rigorous control. A "red" category brings together hazardous substances which can be moved across national boundaries only with written consent. Under the colour code system, movements between OECD and non-OECD countries made after 6 May 1994 require bilateral agreements, but very few such agreements are in place.

1.2 Key Considerations

As can be seen from the introductory observations above, recycling carries substantial business risks and requires considerable knowledge of diverse commodity markets. Companies engaged in this sector generally achieve viability by handling a range of materials of varying levels of profitability from sources in industry and commerce. In many cases, these materials will be source-segregated. Where this is not the case, separation technology is an integral part of the company's processing system.

Municipal Solid Waste represents the outer fringe of the range of potentially recyclable materials, as it consists of mixed, often contaminated residual materials that have previously failed to attract the interest of the commercial sector. Any potential market value tends to be low - sometimes nil or even negative - while costs of handling and separation are high.

Against this background, and given the comparatively volatile nature of many of the markets into which recovered materials have to be sold, it is virtually impossible to achieve a stable income from MSW recycling. High disposal costs and other considerations may make this area of recovery desirable, but it is likely to be carried out at a cost rather than a profit.

The market attributes of each of the major secondary materials sectors are examined in turn below.

1.3 Market Attributes

1.3.1 Paper and Board

Unlike metals, paper and board can be recycled no more than three or four times before the fibres break down irrevocably. Technological advance is enabling a much wider range of waste to be employed in making a wider range of products. For health and hygiene reasons, however, it remains essential that waste paper is segregated as close as possible to source so that it is free of contamination from mixed refuse.

In 1995, the world paper and board industry consumed 117 million tonnes of waste paper in producing 278 million tonnes of new product. The scale of increase in use of secondary fibre can be seen in Table A1[1].

Table A1: World Consumption of Waste Paper (M tonnes)

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
59.7	65.1	70.6	76.1	81.1	84.1	90.6	95.8	99.2	106.8	117.0

The countries of Asia account for the strongest growth in world paper and board output, and are the leading importers of waste paper - about 6.5 million tonnes in 1995.

Global demand for recycled fibre is developing at roughly double the rate of paper and board production. Thus prospects for the waste paper market appear to be very good. But it is in the waste paper sector that politically-motivated environmental policies are having greatest impact.

The rise of "public policy" collection of waste paper from MSW, which began with packaging grades and is now moving into tissue, printing and writing papers, has resulted in the availability of surpluses at very low cost. For a period in 1994/95, these surpluses were absorbed by an upsurge in demand which then receded - with a severe impact on all waste paper prices. The surpluses continue to overhang the world market, which can swing from under-supply to over-supply and back again within the movement of a few percentage points. The market is governed ultimately by demand for the products of the paper and board industry. As this demand is cyclic, the existence of inflexible volumes of waste paper from public policy collection is all the more disruptive.

There is no doubt that the world paper and board industry will continue to use more recycled material and that recovery rates can be raised to meet that need. The problems lie in co-

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1 *Pulp and Paper International Yearbook*, Bureau of International Recycling

ordination of supply and demand, and in achieving some measure of price stability, with traditional commercial recovery having now to operate in parallel with public policy collection which is subsidised, directly or indirectly.

Alternative markets

Various alternative markets for paper and board exist, as described below.

Animal bedding

Shredded newspapers are used successfully as a substitute for straw in bedding for horses, cattle, pigs and other animals. The product is biodegradable and can therefore be composted. Colour printed magazines must not be used as these may contain inks that could be injurious to animals if eaten. Furthermore, as they often consist of high-gloss paper, bedding would be slippery. Stapled publications must be avoided as the staples can give rise to injury.

Thermal insulation

Processed waste paper has been used extensively to provide an economical form of thermal insulation in buildings. The raw material is shredded into fragments which are treated chemically to resist fire and rot. The product is a loose, fluffy material which is normally fed between the joists of a roof space by means of a pneumatic delivery hose from a container vehicle parked outside. This cellulose insulation can also be spray-applied to the underside of a factory or warehouse roof. Such an application is of particular relevance to the Falkland Islands.

Moulded fibre products

Egg boxes and fruit trays made from selected pulped waste paper are widely used throughout the world, but the scope is widening. Protective packaging for fragile or sensitive products has been usually provided by expanded polystyrene – a material that is extremely bulky, is difficult to dispose of, is not biodegradable in landfill, has often employed ozone-damaging gases in manufacture, and is increasingly unpopular with environmentally aware members of the public. Moulded pulp can provide similar protection, with packaging designed specifically to contain any product with safety. The manufacturing process is relatively simple and is environmentally-friendly. The product is biodegradable, combustible or recyclable.

An important market for moulded fibre exists in the medical field where there is a rising demand for disposable products - originally in the interests of hygiene and convenience, but now of critical importance in guarding against the spread of AIDS. Bowls and trays for swabs, syringes and many other essential uses in hospitals and surgeries can be produced economically and efficiently from secondary pulp which is ultimately incinerated with safety. Bedpans and urine bottles are also being produced by this means, and there is undoubtedly scope for inventive development.

Historical prices for different types of recovered waste paper in the UK are given in **Sub-Appendix A1**.

1.3.2 Ferrous Metals

Ferrous scrap is a raw material used in most steel-making processes, but is of critical importance in the electric arc process in which the furnace charge is frequently 100% scrap. This extremely efficient process represents a rising proportion of total world capacity - now almost one third. It has the attraction of not requiring investment in coking plant and blast furnaces to produce iron from ore. Although electric arc production is employed increasingly in Europe and North America, it is the natural process for countries relatively new to steel making - such as those concentrated in the Far East and Pacific Rim. Yet as these nations, such as Taiwan or South Korea, have no historically long-term industrial base, they depend on considerable imports of scrap.

According to the International Iron & Steel Institute, in 1994, the world steel industry consumed 335.6 million tonnes of scrap, international trade accounting for the provision of 77.5 million tonnes. About 45% of world steel output was derived from scrap.

Of the increasingly important producers in South East Asia, South Korea ranked sixth in the world with output of 36.8 million tonnes, 3.1 tonnes more than in the previous year. It was the second largest importer of scrap with 5.0 million tonnes.

Prices of ferrous scrap are determined strictly by the law of supply and demand, national values generally being driven by the world export market. The United States represents the largest single scrap market in the world and exports up to 10 million tonnes of secondary ferrous material a year. Germany ranks second in exporting with 7 to 8 million tonnes.

An upsurge in US domestic demand will reduce the export outflow, and have a major upward impact on prices, as many of the steel industries in the Far East (e.g. Taiwan and South Korea) are major users of North American scrap. However, steelworks in importing countries will frequently make their final purchasing decision on the basis of exchange rates, concluding a contract in Europe or North America according to the strength of the US dollar, the German mark, or pound sterling. To be traded internationally, ferrous scrap must conform to accepted specifications - usually those of the United States.

A study by the Economic Commission of the United Nations (1995) quantified the established trend in scrap availability towards greater recovery from obsolete sources, and a decline in secondary material generated as a by-product within steelworks. Although arisings from various forms of engineering and metalworking production declined in the Western world in the 1970s and 1980s, this is being largely counteracted by growing arisings in the developing world as more countries become industrialised.

Recent prices for different types of ferrous scrap in the UK are given in Sub-Appendix A1.

1.3.3 Non-ferrous Metals

As it is concerned with metals such as copper, aluminium, brass and zinc, the non-ferrous market involves much higher values than the ferrous market. Prices are based on values set by the leading terminal markets of which the most important by far is the London Metal Exchange (LME).

To the classic influences of physical supply and demand must be added sales or purchases by national strategic reserves (the USA's is the most important)), position-taking by the most influential market players, mining company strikes or threats of strikes, political developments in key primary producer countries, speculation, and - now of very serious consequence - the involvement of financial institutions which regard the commodity markets as just another area of investment.

Although the LME's prices are for refined grades that include both primary and recycled metal, the Exchange has a special contract for ingots of secondary aluminium cast to a standard specification. Both LME, and Comex in New York, set daily prices on a spot (cash) or three months supply basis. The two quotations will rarely be the same, the forward price being influenced by a multiplicity of considerations of which sentiment is by no means the least.

A further influence on non-ferrous values is the inability of primary producers to react swiftly to changes in physical demand. The gestation period of new investments in primary production capacity is long, with the risk that new facilities are likely to come on stream when an upturn in demand has receded. Furthermore, investment in primary production is extremely expensive, and thus mining companies are very cautious about expansion unless they are convinced that the market will readily absorb additional output. Equally, they are very reluctant to make production cutbacks in response to recession, partly for risk of losing market share to competitors.

Prices of non-ferrous scrap are likely to be around 20% below those quoted on the LME, but physical supply and demand will erode or enhance that difference.

The gradual decline of metal-using industries in the developed countries has led to a fall in availability of high-quality scrap generated from manufacturing, which requires little processing. There is thus greater dependence on recycling metal (both non-ferrous and ferrous) from obsolete products, which involves higher transport and processing costs.

Scrap remains in good demand because it offers a price advantage to consumers, and also savings in energy input. For example, there is a 95% saving in energy when an aluminium ingot is produced from scrap rather than primary material.

The major secondary non-ferrous metals are copper and its alloys (e.g. brass), aluminium, lead, zinc and tin. Precious metals are also recovered, e.g. from plating and other process solutions, and from obsolete computer equipment which includes gold and/or platinum electrical contact points.

A variable proportion of the metallic content of a car consists of non-ferrous metals - apart from aluminium engine blocks, on average about 3%. The adoption of catalytic converters (standard in the USA, Japan, Scandinavia, Switzerland and Austria, and required on new vehicles throughout the European Union since 1988) is leading to new opportunities in recovery of the platinum, rhodium or palladium employed as a catalyst.

After a generally buoyant period in 1994/95, the world non-ferrous market has been affected by sluggish economic performance in many industrialised countries, and the slower pace of the so-called Tiger economies of the Far East. Sporadic "dumping" of secondary metals by the formed Soviet-bloc countries to secure hard currency remains an overshadowing factor. The first quarter of 1997 showed signs of gradual improvement.

An interesting feature in the recovery of non-ferrous metals is the content of aluminium in household waste. The greatest proportion is to be found in aluminium cans for carbonated beverages. The beverage industry, however, is extremely reactive to changes in technology and cost in its choice of packaging materials. As a consequence of the high aluminum price during 1995 and improvements in tinplate can technology, a number of companies, notably Coca-Cola, took the decision at the beginning of 1997 to switch from aluminum to tinplate cans. As a consequence, the proportion of aluminium in household waste is likely to be lower in the future.

Recent prices for different types of non-ferrous scrap are given in Sub-Appendix A1.

1.3.4 Plastics

Markets for recovered plastics are very much less well developed than those of ferrous or non-ferrous metals, largely because plastics have been in significant use only since the mid-1950s. Furthermore, their application is often concentrated in short-term uses such as packaging, and in small combinations with other materials. Apart from growing use in car manufacture, and to some extent in building, they do not arise in easily recyclable post-user quantities, as is the case with metals or paper.

World production of primary plastics has expanded from under 10 million tonnes in 1960 to a current estimate of 100 million tonnes. Giant multinational petrochemical groups have dominated this massive growth in production of materials which, in general, offer the dual benefits of cheapness and outstanding utility. With a low economic incentive to recycle, it has been extremely difficult for the necessarily small recycling operations to make headway against the eagerness of the petrochemical groups to increase primary market share.

Unlike metals, plastics do not retain all aspects of their quality or strength characteristics when recycled. Mechanical strength is generally impaired and surface appearance is inferior.

During the last 10 to 15 years, there has been a steady rise in utilisation of scrap material generated in the manufacture of plastics products, which was at one time often landfilled. In many cases this has become a closed-loop process, with manufacturers reusing their own scrap.

The precise nature of a plastic and freedom from contamination are vital to successful recycling. Wherever possible, recovery is restricted to material of known specification and origin. This becomes particularly difficult with the multiplicity of plastics entering the domestic waste stream as individual, usually small, items of extremely low value.

Various German sources estimate the subsidies required to support recycling of post-consumer plastics in the West at between US$ 180 and US$ 700 per tonne.

Problems of Cost

The difference in cost between primary and secondary plastics is a major obstacle to recovery. As a result of widespread economic recession, the price of primary plastics was low for several years, with the result that the cost of collecting and reprocessing used materials frequently exceeded the price of the superior virgin product. A typical price ceiling for secondary material is 80% of the primary price.

The criteria of consistency of supply of material of known origin and established polymer are at least achievable from industrial and commercial sources. Post-user car battery cases, bottle crates, photographic film cassettes, garment hangers, telephone handsets and instrument cases, are examples. In all such instances, the redundant products pass through a limited number of firms and thus material is available in volume from known sources.

Among the high-value plastics, such as ABS, from which computer, laser printer, facsimile transmitter and photo-copier cases are made, recycling is generally economic. There are increasing instances of closed loop approaches to recovery of these materials by some of the major manufacturers (e.g. Hewlett Packard), with materials from dismantled equipment being shredded under closely-controlled conditions and the recovered polymer employed in the manufacture of new equipment.

A further area of viable recycling is polyethylene sheet which is widely used for the protection of goods, often shrink-wrapped on pallets. In established practice, this material can be granulated, melted, and pelletised at a UK cost of about £255 per tonne. Washing and drying will then add £175 per tonne, probably rendering the process uneconomic. Thus, only material that is uncontaminated - even by paper labels and considerable over-printing - is generally viewed as economically recoverable.

Secondary polyethylene pellets are used in the manufacture of crates, buckets, bowls, sacks and bags, usually with a proportion of virgin material to improve mechanical strength and appearance. Other applications include damp-proof membrane for use in the construction industry, agricultural sheeting, and as extruded sections to provide protective cover for electric cables where these are buried below street level.

Polypropylene is extensively recycled from lead-acid battery cases and also from sacks (often used to pack fertilisers and seeds for the agricultural industry).

Polyvinyl chloride (PVC) waste generated by industry is recycled into products including pipes, packaging, and window frames, nearly always in combination with primary material. Its main arising as a post-consumer product is in mineral water bottles - especially in France, where granulated PVC is included in some road surfacing materials.

Polyethylene terephthalate (PET) is also used for bottles - usually of carbonated drinks - but is much harder than PVC and has a very high quality surface appearance. It is extremely light and is most commonly employed for bottles of 1.5 to 2 litres. It can be recycled - notably as fibre-fill insulation in cold-weather clothing - but collection frequently proves to be prohibitively expensive.

Because different polymers do not make mechanically-sound bonds between them, the recycling of plastics mixtures remains an unsolved technical problem. Companies in various parts of the world have developed processes for the production of crude extrusions from mixed plastics which have been used as fence posts or for making furniture for public parks. The product tends to be unattractive, has often proved unreliable, and has rarely established a realistic market. The failure rate among these firms has been high.

So-called "compatibilisers" are polymers with the capacity to form chemical bridges between various standard plastics molecules. Thus a sort of plastic alloy is created. These materials are being used for a variety of special applications, usually involving high-value plastics. Compatibilisers tend to be too expensive for general use, but they are undergoing development and in time their application is likely to become more widespread. Whether they will ever be cheap enough to enable recovery of mixed plastics from the municipal waste stream is a matter for conjecture.

Sorting Mixed Plastics for Recycling

As plastics recycling is being driven in some countries by environmental policy rather than economic viability, a market has developed for mechanised sorting systems.

A typical system will force containers (often flattened to prevent roll) into a single line on a conveyor. A scanner identifies the polymer and/or colour. The bottle is conveyed until it reaches the appropriate exit point where it is blown off by a jet of air. Such a plant is in use at Sompting in West Sussex. Shredded plastics can be segregated by sink/float systems which operate on the basis of differences in specific gravity between polymers. This approach offers the advantage of integral washing, but low energy, labour and other costs would be essential to any hope of achieving commercial viability.

Recycling to Chemical Feedstock

Development of recycling plastics to polymer feedstock or fuel is concentrated in Germany under an optimistic plan adopted in 1994 with the objective of virtually eliminating exports of mixed plastics from the state-backed packaging recovery system by 1997. Political and legislative pressure is forcing the major petrochemical combines to invest in feedstock recycling which, it is increasingly accepted, can be carried out only in large-scale plants. It is forecast that, by the turn of the century, subsidised chemical feedstock recycling will account for more than 75% of plastics recovery in Germany. At present, economic recovery by this route appears to be a matter of hope for the future.

1.3.5 Glass

On average, about 60% of the glass manufactured in the industrialised countries is devoted to packaging - whether returnable or non-returnable. In some countries, where large quantities of glass are used for packaging and indigenous primary raw materials are scarce, recovery can be a commercial proposition. The importance of the wine industry in France and Italy, for example, ensures a good demand for green, brown and colourless (known as "flint") glass.

Brown glass also has a strictly limited application in the manufacture of glasspaper, the raw material frequently being obtained from breakages in bottling plants.

Recovery of used flat glass, generally from building or glazing contractors, is usually a distinct operation, as this material is reused only in the manufacture of new flat glass.

In essence, one tonne of waste glass, known as "cullet", replaces 1.2 tonnes of sand, limestone and soda ash, which are the primary raw materials used in glass-making. There is also an energy saving which is estimated at around 150 litres of fuel oil for every tonne of glass produced.

Under the right conditions, therefore, glass recovery can be profitable. The primary materials, however, are inexpensive, while the costs of collecting and transporting cullet can become a serious burden. Colours must be reliably segregated, and contamination - especially of ceramics - poses technical problems. The presence of metals, such as caps or security rings around bottle necks, can damage the glass making furnace.

1.3.6 Textiles

The vast economies of scale of modern textile production have largely eclipsed the regeneration of used fibre into new fabric. In general, it is in the very low wage economies that "pulling" of discarded cloth into fibre for respinning is now undertaken on an appreciable scale.

Recyclable textiles are sorted according to fibre and also to colour to avoid problems of dyeing in subsequent manufacture of fabric.

Felt manufacture remains a viable outlet, with the product still used as carpet underlay, but more widely for sound-deadening and insulation applications in the automotive and other industries.

Cuttings from the manufacture of new garments are regenerated to some extent, but are more often shredded and used as filling or flocking in upholstery or bedding. Post-consumer fabrics are also employed in the latter applications in some parts of the world.

Absorbent fabrics, such as cotton and linen, are used in considerable quantities throughout the world as industrial wiping cloths, the engineering industry being a major consumer. Raw material is obtained from hospitals, hotels and other organisations using bed linen in quantity; from charity collections and to a gradually increasing extent from collection banks placed in car parks and other public spaces. Non-woven fabrics made from primary materials and industrial-weight paper towels manufactured from recycled fibre represent very serious competition to the traditional textile wiping cloth.

Cotton and other pulpable fibres are used in making the finest grades of paper - especially bank notes and documents that must be preserved for very long periods. Cuttings from the manufacture of cotton sheets and other forms of bed linen are likely to be used for this purpose.

The by-products and wastes generated in the processing of cotton, wool and synthetic primary fibres are recovered on a considerable scale, but represent a specialist sector which falls outside the accepted confines of textile recycling. Such materials do not often enter the disposal stream.

The most important area of textile recovery is now used clothing - and footwear - which tends to be collected in the richer countries of the world, graded according to weight and fibre content, and exported to nations where many of the inhabitants cannot afford to buy new garments. There is an increasing demand in some of the former communist countries of East Europe, either as a result of declining incomes, or because this is the only practical way of acquiring Western fashions at an affordable cost. The "recycling" of used clothing and footwear frequently involves financial risk, as many of the consumer countries have very low reserves of hard currency and may halt payment for long periods.

At the upper end of this market for reusable clothing is the small but highly profitable sector devoted solely to the recovery of "period" or once-contemporary fashions that are sought after by trend-setters in North America, West Europe and parts of South East Asia.

1.3.7 Wood

Recovery of wood has usually been undertaken only in response to local demand, but to some extent sourcing is becoming more widely spread. This is especially the case with wood for chipboard manufacture and the production of horticultural mulches (see below).

Used pallets are recovered for reuse, if on a limited scale which seems open to a certain amount of expansion. Repair of damaged pallets is sometimes undertaken where this can be achieved at low cost. Similarly, graded timber recovered from construction waste meets local but often limited demand, particularly in developing countries.

Where uncontaminated wood waste arises in regular quantities from industrial processes, it is used for chipboard manufacture and to some extent pulping by the paper and board industry.

Although wood used to produce charcoal may be described as waste, it is more generally a by-product of primary wood-consuming industries. Other sources of timber are employed, but relatively narrow criteria may have to be met if the process is to be economic and is not to generate unacceptable levels of waste.

In some countries local markets have been developed for wood chips as a mulch for ground cover in parks and other public areas where there is planting. Although wood shavings and sawdust are used for animal bedding, shredded timber can cause injury and its use is not favoured.

Contamination by timber preservatives and paint from wood used in the construction industry can cause a problem both for use as a mulch.

1.3.8 Municipal Waste-Derived Soil Conditioners/Growing Media

Compost produced from mixed MSW or similar wastes, while it does have some plant nutrient value, is not really a fertiliser to be compared, or to compete, with conventional industrial or natural organic fertilisers - it is rather a *low-grade soil conditioning agent* which helps to improve the soil structure and moisture retention capacity and contributes modestly, but not negligibly, to soil fertility. The viability of producing compost from mixed MSW depends crucially on:

- being able to produce a compost product of consistently good quality, odour-free, relatively clean of contrary matter, such as fragments of glass or plastics, and without elevated levels of heavy metals or other contaminants;

- developing sufficient long-term outlets for the compost product.

These conditions have been difficult to achieve in practice with mixed waste composting systems.

Potential areas of compost application include:

- landscaping e.g. park and sports ground development and maintenance, highway maintenance;
- special cultures e.g. mushroom growing;
- horticulture and agriculture, especially on intensively-used land;
- forestry, tree nurseries;
- land reclamation, restoration and erosion control;
- other specialist uses such as biological filters for odour control.

There is ample research available to demonstrate the beneficial properties of compost produced from MSW in improving soil quality and productivity. Nevertheless, there is often a considerable degree of consumer resistance to using a waste-derived product which must be overcome if MSW compost is to be marketed successfully as an acceptable alternative to "natural" soil conditioners. Consumer attitudes in some countries have also been adversely affected by the poor quality of compost produced by some plants, and by concerns about product contamination particularly by heavy metals. Even though most of the metal compounds contributed by compost are either not available to, or are not taken up by plants, in situations where food crops are produced on compost-treated land, attention needs to be paid to the heavy metal content of the compost, the soil and the resulting produce.

Historically, in Europe, the market prices for compost produced from mixed MSW have been low and certainly far from sufficient to cover the costs of production. This has inevitably meant that the costs of a composting operation have had to be supported by one, or a combination, of the following methods:

- payment of a viable "gate charge" for receiving the wastes;
- payment of a direct grant or subsidy of some kind;
- through a public authority undertaking to buy most or all of the output of the plant at artificially high prices.

A relatively recent development is the application of anaerobic digestion (AD) technology to the processing and recovery of mixed MSW. In addition to biogas (methane), this approach aims to produce a *high-grade growing medium* suitable for horticultural use. In Europe, this "horticultural product" is being promoted as an "environmentally-friendly" alternative to natural peat products. The development of AD as a method for recovering mixed MSW is being driven mainly by two factors:

- rapidly increasing prices in some areas for disposing of MSW to landfill;
- the restrictions (for environmental reasons) which are being placed on the exploitation of natural peat.

In the UK, for example, exploitable reserves of peat are expected to be exhausted within the next 20 - 25 years. The developers of AD systems are hoping to obtain prices for the "horticultural product" which are comparable with those for natural peat and peatmoss. The results of test marketing in the UK suggest that the "horticultural product" should be able to command considerably higher prices than those for low-grade soil conditioners.

1.3.9 Aggregates

Wherever supplies of natural aggregates are available, there has been little incentive to recycle construction and demolition rubble other than for infill. This is especially true of the UK. However, since 1992 the European Union has been studying these wastes as part of its Priority Waste Streams Strategy, and it is clear from this and other work that there is vast scope for recycling.

One of the best examples of current successful recycling is in The Netherlands where sand is available, but there is a shortage of gravel. It is estimated that the 11 million tonnes of masonry waste generated annually could meet 25% of demand for aggregates. There are 55 fixed crushing and screening plants in The Netherlands and more than 100 mobile plants with a combined capacity of about 10 million tonnes. Recovery is estimated at some 8 million tonnes. Specifications have been introduced for recycled aggregates, and 20% is now permitted in the coarse component of new concrete. Fines and soil from the screening operations are used in the upgrading of reclaimed land – a very important activity in The Netherlands.

Lack of quotable standards for recycled aggregates has no doubt acted as a disincentive in Britain and many other countries, users being unable to ensure that unwanted materials were excluded. Yet British Standard 6543 *Guide to use of industrial by-products and waste materials in building and civil engineering* was published as long ago as 1985 and appears to have had very little effect.

Exploitation of natural deposits is increasingly contested by the public on environmental grounds, and outright opposition to recycling by aggregate and quarrying interests is less evident than in the past. Ironically, however, companies trying to establish recycling plants complain of strong public opposition to their planning applications and a lack of sympathy among local authorities. In 1995, the UK Department of the Environment published on behalf of the Building Research Establishment *Use of waste and recycled materials as aggregates – Standards and specifications* (HMSO), which may stimulate demand for these materials. The task, however, could be seen as one of marketing as much as winning acceptance.

1.3.10 Batteries

Recovery of lead-acid batteries - as used in motor vehicles - has traditionally depended on the commercial value of the lead. However, more rigorous environmental and other controls on the handling of this metal have combined with little growth in its price to put the future of traditional recovery practice in question. An individual lead-acid battery is worth no more than 50p, and many scrap merchants have ceased to deal with them.

Within the context of EU and UK policy, recovery of lead-acid, nickel-cadmium and mercuric oxide batteries is seen as a matter of producer responsibility. In Scandinavia this approach has resulted in a significant increase in the recovery rate of lead-acid batteries, the costs of collection and subsequent recycling being supported by a levy on the purchase price of new batteries.

So far, UK lead-acid battery producers have committed themselves to a 90% recycling rate based on the assumption that the value of the lead and the already effective recovery of polypropylene battery cases will underpin a system that will have their active backing.

The battery industry has resisted collection of dry batteries other than through local authority Civic Amenity sites, arguing that the proportion of heavy metals employed is declining steadily.

Large nickel-cadmium batteries are being recycled economically. Technology for processing small ones exists and a plant has been set up in France. Collection, however, is only viable with a subsidy.

1.3.11 Oils

Oil is a supremely recyclable commodity as its molecular structure is undamaged when used as a lubricant. The degenerated additives, dirt and metal particles can be removed, and the oil refined to A1 standard. Re-refining of oil was carried out successfully in Britain in the 1970s and early 1980s. Century Oils, then the largest independent manufacturer of lubricants in the UK, marketed re-refined oil widely and demonstrated its guaranteed quality by sponsoring a racing car that used only the recycled product. Many re-refining processes, however, produce hazardous residues which present major disposal problems.

The declining real cost of hydrocarbon products and the increasing expense of disposing of process residues reduced the economic basis of re-refining to a point when, around 1986, it was no longer possible to cover costs.

Re-refining has continued in Finland, Germany, France and Italy, as well as a number of states of the USA, thanks to subsidies viewed as being in the public interest. In New Zealand, re-refined oil is used in government vehicles, and major fleet operators are encouraged to support the market by entering into agreements with re-refiners for the supply of the recycled oil and its return for processing at the end of its useful life.

Since the end of commercial scale re-refining in Britain, oil has continued to be recovered for other existing purposes. In the absence of few reliable statistics, it appears that on an annual basis, around 100,000 tonnes is used in-house by industry as a fuel. Up to 225,000 tonnes may be reclaimed for use as a fuel, and up to 30,000 tonnes laundered and blended with primary oil for a variety of fairly non-critical industrial lubricating purposes. An unknown quantity is used as a preparation in some forms of road surfacing.

Orcol, reputed to be the largest oil recovery firm in Britain, made a tentative return to re-refining in Britain in 1994 using two distillation processes. It has since quadrupled its original output of 20,000 litres a week and supplies the product to various fleet users which return the oil when it is no longer usable. It remains to be seen whether this presages a revival of re-refining in Britain.

Technology of Oil Recovery

Re-refining begins with removal of water, sludge and solids, followed by distillation to remove light hydrocarbons. In the past this was followed by treatment with activated clay which generated a residue that had to be disposed of at high cost, especially if strong acid is used as the dewatering agent. In more recent installations, vacuum distillation tends to be employed.

Laundering involves removal of water, sludge and solids, followed by distillation to extract exhausted additives. The output is usually blended with primary oil for use in industrial applications where high-grade lubricant is not required. The process can be applied to a limited range of feedstocks of known specification.

Reclaiming is a cleaning process limited to the removal of water and filtration to extract solids. Unlike laundering, it can cope with a diversity of feedstocks provided they are not contaminated by solvents – always a risk with supplies from unsupervised garage forecourt containers and Civic Amenity sites. The product is used as an industrial fuel, e.g. in boilers and space heaters (with burners designed for the purpose), and in heating prepared roadstone in highway surfacing.

The Market for Recovered Oil

Transport fleet operators have been used to selling used sump oil to a reclaimer for a few pence a gallon, but this practice is becoming rare. Oil is now usually removed at no charge, or for a fee. From the fleet operator's standpoint, the incentive is not to make money but to avoid the cost of disposing of a difficult material. In the UK, material containing as little as 1% of used motor oil is now classified as a "special" (hazardous) waste. Control is necessary to ensure that solvents and other liquids are not deposited in waste oil storage tanks. The presence of such substances can be dangerous, and will usually render the oil useless.

Steadily rising atmospheric emission standards pose a considerable threat to the use of reclaimed oil as a fuel, and it is questionable whether many of the companies engaged in this sector could upgrade their processes sufficiently to meet higher criteria. It is possible that these firms could be replaced by more sophisticated operators provided additional revenue could be obtained from, perhaps, a producer responsibility levy scheme.

The UK Waste Management Licensing Regulations are increasing oil reclaimers' costs and inevitably rebound in charges made for collection of waste oil. Application of producer responsibility looks increasingly likely in this sector, if only to avoid increased unauthorised dumping. A report by the UK National Environmental Technology Research Centre for the Department of Trade & Industry suggests that some form of levy is necessary to support the current level of recovery, let alone increase it.

Re-refining remains the best added-value route for oil recovery, and had the revolution in oil values created by the major oil-producing states in the 1970s persisted, re-refining would now be commonplace. A public policy based on producer responsibility could no doubt make it commonplace. It does entail significant economies of scale.

1.3.12 Solvents

Many industrial solvents share with oil the risk of causing serious pollution. Their recycling is reasonably well-developed, and many users in industry have increasingly adopted in-house recovery facilities, often using convenient modular plants. Solvents are also recycled by specialist companies, usually working under a "closed loop" contract with users. Under this system, the recycler removes contaminated solvent for filtration and distillation, and returns it to the same user to a guaranteed specification. Successful recycling of solvents depends to a large extent on the segregation of feedstock at source, as the material must be of known specification and the contaminants reliably identified. It also involves significant economies of scale.

1.3.13 Electricalical and Electronic Scrap

In the UK and EU, it has been established that a producer responsibility initiative is required to promote recovery in this sector. According to the UK Centre for Exploitation of Science & Technology (CEST), 6 million items of electronic equipment incorporating materials worth £50 million are landfilled in Britain annually. In response, the Industry Council for Electronic Equipment Recycling (ICER) was established in 1992 by various manufacturers, service providers and major retail groups to develop a voluntary recovery system. Progress has been slow, and several leading manufacturers have indicated that they will respond only to legally-enforceable recovery. Some of the original members of ICER have broken away to form their own voluntary network.

ICER has sponsored a repair and recovery centre in West Sussex, where battery and mains powered electrical and electronic equipment is reconditioned (where possible) and donated to schools. Such products are collected in the Worthing "grey box" scheme. The scheme has been established on an experimental basis and it does not appear to be economic.

The commercial incentive to recover many types of electronic equipment has declined significantly with the miniaturisation of such products. For example, large mainframe computers contained appreciable amounts of precious metals in a multiplicity of switches and contact points. Desktop PCs contain precious metals, but only in very small amounts.

Precious and various non-ferrous metals are reclaimed by specialist companies, usually operating on a large scale. However, there is now a trend towards the dismantling of redundant computers, printers, photo-copiers and similar types of equipment to recover reusable parts, reclaim metals where only this is appropriate, and to ensure recycling of the high-grade plastics from which the cases are made. These operations may be carried out in very close collaboration with the producers of the original equipment who utilise recovered components and direct the plastics into their own manufacturing systems.

1.3.14 Toner Cartridges

Most parts in the mechanism of a toner cartridge, used in photo-copiers and laser printers, have a lifespan considerably in excess of the toner filling. Provided the photo-sensitive drum which is the critical component in transferring the image is not scratched or damaged by excessive exposure to light, it can be reused.

The companies which carry out recycling competently, dismantle or partially dismantle the cartridges, depending on their condition, and replace any parts that are worn. They then refill the cartridge with toner and seal securely the port between the toner store and printing mechanism. This seal has to be removable by the user, but if it fails during storage or transit, toner will spill out when the cartridge if fitted.

The reputation of recycled toner cartridges is still recovering from firms which marketed cartridges at less than 50% of the original sales price, and merely refilled them with toner through a hole drilled in the top or side. Performance was poor and frequently led to expensive problems when toner spilled into the mechanism of a photo-copier or laser printer.

Several major names in the toner cartridge sector, such as Xerox, Canon and Hewlett Packard, have responded to the bad image of recycled cartridges by making their own arrangements for the return of exhausted units. Various independent companies are also engaged in this service.

In theory, used toner cartridges should not enter the waste-stream, as the recycling specialists try to conclude supply-and-return agreements with users in any volume. But where users don't bother, or small quantities are involved, units will stray. There is a demand for them and it is usually possible to obtain at least £2 or £3 each on the basis of a minimum number.

1.3.15 Tyres

Remoulding/retreading represents a well-developed, profitable market for tyre recovery. It offers considerable cost savings, especially for users of large, special-purpose tyres such as those fitted to earthmoving equipment. Used tyres are also traded to the less developed areas of the world, where they are often fitted to vehicles without further preparation. The tread may be "re-cut" in an effort to extend the life of the tyre, but the effect is to weaken what remains of the tread.

Inner tubes and conveyor belting are recycled, and there is a small international market in these materials.

In tyre manufacture, vulcanisation is employed to cross-link the hydrocarbon chains that form the rubber and construct an elastic three-dimensional network. This process is hard to reverse, chemically or physically, and available systems have been expensive and energy intensive. Total or partial devulcanisation is still under development, but at present there are major obstacles to the large-scale use of recovered rubber with primary (unvulcanised) rubber in tyre casings. In the past, vulcanised rubber crumb was used in the manufacture of carpet underlay, but this degenerates over time, eventually into a thick layer of fine black dust. It has been largely superseded by plastics which offer superior durability and performance.

Rubber reclaim - usually the surface grindings generated in retreading - is used in surfacing children's playgrounds and sports areas where resilience is required. It has also been used in road surfacing as it offers attractive elasticity benefits. The drawback is that it reacts to heat, and generates an unpleasant odour. Reclaimed rubber also has outlets in the manufacture of mats, or as soles and heels for shoe repairing; to make solid tyres, bicycle pedals, tips for walking sticks and crutches, vehicle fenders, and domestic waste bin lids.

Tyres can also be treated by pyrolysis, a process of decomposition by heat, which produces oil and other substances, including hazardous non-recyclable residues. The process is expensive and still the subject of research and development.

In some countries with major fishing interests, tyres have been used to construct artificial marine reefs to encourage growth of fish stocks. This has proved successful, although there have been problems in anchoring the tyre structures permanently to the sea bed.

Increasingly, it is considered that old tyres are best used (usually shredded) as a fuel to produce energy. Their calorific value is comparable with that of fuel oil and significantly higher than that of coal. Volume is reduced, steel reinforcement can be recovered as scrap, and the remaining product is sterile. Emissions of dioxins and other potentially harmful substances can be controlled to extremely low levels.

In the UK, a plant to produce up to 23 MW of electrical energy from the combustion of used tyres has been constructed and was operating until recently. This plant is currently closed due to technical problems believed to be associated with lower thermal efficiency than forecast. An alternative market exists in using tyres as an energy source for cement kilns. In this case, they can be combusted whole but this requires special feeding equipment and can lead to a lack of control of the rate of heat release. An alternative is to shred the tyres so that they can be pneumatically fed into the kiln with the pulverised coal main fuel.

2. MARKETS IN THE FALKLAND ISLANDS

The very small size of the Falkland Islands economy means that there are likely to be very few markets for recovered materials. The major possible exceptions are:

- Oils as fuel
- Paper for insulation or possibly animal bedding
- Wood and occasionally metal for reuse by others
- Compost as fertiliser/soil conditioner

3. OVERSEAS MARKETS

3.1 Introduction

For the Falkland Islands to gain access to overseas markets for recovered materials, it will be necessary to send them by ship. The best connections are with the UK, to and from which ships travel regularly. It may also be feasible to ship to South America.

The cost of shipping is the major problem. If normal commercial rates are paid, the relatively low value of recovered materials will normally be more than offset by the shipping costs. There is, however, one possible option which could enable materials to be shipped to the UK at little or no cost apart from the port handling charges. This is by taking advantage of the shipping arrangements of the military. The military ship materials to the Falkland Islands in containers and these containers frequently return to the UK empty. Their shipping costs are nevertheless paid for. It should be possible to negotiate with the military to send recovered materials back in their containers at a relatively low cost.

Initial enquiries indicate that this might be possible, but we have not pursued the matter further for fear of damaging FIG's negotiating position.

Metal scrap, waste paper and board, and glass are the principal materials which might be collected in the Falkland Islands for recycling overseas. With the exception of paper which might be processed into insulation or animal bedding, no consumption capacity exists on the Islands. Shipping is the critical cost factor in this trade, and might create conditions under which most recyclable materials are cleared for a charge or at best accepted free. The only exception would be the higher-priced non-ferrous scrap such as copper, brass and aluminium.

3.2 Paper and Board

The value of waste paper and board is governed by changing conditions in international markets. As has been noted in A1.3.1 above, the world market for waste paper is overshadowed by the availability of material collected not in response to normal market forces, but as a result of public policy. Apart from infrequent and usually short-lived peaks in demand from the paper and board industry, this situation keeps the commercial value of waste paper very low.

3.3 Metals

As recycling of metals is essentially unaffected by 'public policy' collection, prices rise and fall in response to international market movements.

The market for aluminium is an interesting one. The UK market price for scrap aluminium is around £500 per tonne. The British Alcan plant at Warrington, Cheshire, however, offers a relatively fixed price of about £750/tonne in an effort to promote the recycling of aluminium from cans so that they can be seen as an environmentally friendly product. This plant is purpose designed for the processing of can scrap into new cans and therefore has some advantages over conventional aluminium recovery. If access could be achieved to this plant making use of shipping by the military, the recycling of aluminum cans might actually earn some revenue.

The proportion of aluminium cans, however, is currently on a downward trend, as explained in section A1.3.3.

A specific opportunity for non-ferrous metals may exist in the near future. There are substantial quantities of ferrous metal scrap in South Georgia. It is possible that a "one-off" mission to South Georgia may take place to collect this material. If this is the case, the ship, with appropriate equipment, might be able to visit the Falkland Islands at the same time. If this the case, it would be necessary to identify all appropriate scrap metal in advance and to make appropriate arrangements so that it can be easily collected.

3.4 Tyres

Tyres may have some value in the UK, either for retreading or as a fuel source for cement kilns.

3.5 Oil

The military ship oil back to the UK or to other military bases for reprocessing at the present time. It might be possible to send oils from the civilian community in a similar manner. The value of the oil as a fuel on the islands, however, will probably make this unnecessary.

3.6 Glass

Colour segregated glass fetches an average price of around £30/tonne in the UK.

4. CONCLUSIONS

Markets may exist in the Falkland Islands for:

- Oils as fuel
- Paper for insulation or possibly animal bedding
- Wood and occasionally metal for reuse by others
- Compost as fertiliser/soil conditioner

If transport costs can be held down, markets may exist in the UK for:

- Metal cans, particularly aluminium
- Glass
- Tyres

Sub-Appendix A1 - UK Materials Prices

Recovered paper prices: 1990 to 1997 (£ per tonne)

	1990		1991		1992		1993		1994		1995		1996		1997
	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	
Computer paper	180	180	150	140	130	140	155	145	145	170	260	320	230	150	130
Container	40	40	26	28	25	24	24	17	17	58	50	150	60	28	16
News and mags	33	30	28	30	30	30	26	28	24	50	65	170	50	40	13-25
Mixed papers	30	23	20	18	12	12	12	10	10	44	42	87	35	18	0
Softwood primary pulp (US $)	840	790	660	540	520	600	460	415	450	630	750	925	860	550	500

Ferrous scrap prices – April 1996 to April 1997 (£ per tonne)

	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Grade 1 Old steel	41	53	45	42	39	37	37	31	33	33	36	37	37
Grade 5c Loose light steel	21	28	25	22	18	16	16	12	12	12	18	18	19
Grade 10 Light cast iron	55	59	59	55	53	52	52	45	46	44	47	47	49

Non-ferrous scrap prices – April 1996 to April 1997 (£ per tonne)

	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Mixed copper	1180	1290	960	895	915	860	895	850	910	950	965	1040	1005
Aluminium – old rolled	510	520	480	460	460	450	410	400	410	440	510	540	510
Aluminium cans – baled	745	745	745	700	700	700	700	700	700	700	750	750	750
Lead	360	380	350	340	230	340	320	285	275	285	260	290	270

APPENDIX B

WASTE MANAGEMENT PROCESSES AND TECHNOLOGIES

Appendix B WASTE MANAGEMENT PROCESSES/TECHNOLOGIES

Appendix B

Waste Management Processes/Technologies

1. WASTE SEGREGATION

1.1 Introduction

Wastes require segregation when different processes are appropriate for different portions of the waste stream. The most common reason for segregation is to enable certain materials to be recovered for recycling or composting. In addition, however, certain wastes may have potentially dangerous properties - notably hazardous wastes and healthcare wastes - and will need more complex, and therefore costly, processes to render them less harmful. The segregation of these wastes first of all ensures that they can receive the appropriate treatment and secondly minimises the quantity of waste that must be subjected to such treatment.

It will be seen from section B2 that the recovery of materials from wastes once they have mixed is complex, expensive and not very efficient in terms of actual vs. potential yield. Consequently, if materials can be segregated *before* they are placed into a mixed waste stream the task of the waste manager - and therefore the cost of the process - is much reduced and simplified. In addition, not only may cost be saved but also the degree of cross contamination between wastes will be reduced, thus leading to a cleaner material which reduces the need for further treatment before the recycling process and may also result in a higher quality recycled product.Furthermore, the practice of segregation at source can alert waste producers to the amount and value of their waste and stimulate waste minimisation.

The need for segregation will be determined by the type of process that is selected for treatment and disposal of the wastes. Segregation for its own sake is clearly of no economic or environmental value unless it can increase the economic or environmental performance of a subsequent process.

Segregation has two possible implications - its financial cost and the cost to the waste producer, which may be financial or in terms of convenience and personal effort. The latter may affect the success and public response to any proposed segregation scheme. Each of the options has therefore been evaluated from these two points of view. The characteristics of each are first described, together with comments on their convenience to waste producers

1.2 Household Wastes

There are a wide variety of options that can be employed for the segregation of wastes in the home. A small quantity of items might be discarded by the householder but reused by another person. This is a particularly popular practice in the Falkland Islands, probably more so than in many other communities. Nevertheless, valuable though this may be for social and economic reasons, it will make little impact on the waste management problem. It should nevertheless be encouraged and appropriate provisions made for it to continue.

With regard to the success of segregation systems for household waste, there are two key ratios which are relevant. The first is the participation rate - which describes the proportion of householders who participate actively in any segregation scheme. The second is the capture rate, which measures the proportion of the potential yield of any given recyclable which is actually segregated. The former will be influenced by the convenience of the scheme to the householder. The second will depend on the nature of the individual recyclable materials - some materials being easier to segregate than others, due to the ease of handling, storage and the degree of contamination with, for example, foodstuffs.

A number of the more significant segregation options are discussed below.

1.2.1 Segregation of Bulky and Other Wastes at a Civic Amenity Site

The Role of a Civic Amenity Site

In the UK, Civic Amenity (CA) sites are an important component of waste management. Their main purpose is to provide the public with a place for the free disposal of excess and bulky household wastes. They also serve as "Bring" recycling centres.

There could be a benefit in providing a CA site in the Falkland Islands. For a population the size of the Falkland Islands, one such site would be appropriate. A range of containers could be made available for different recyclable materials. People would also be free to dispose of other wastes into containers. The range of wastes for disposal includes "DIY" materials, garden wastes, car oils, old batteries and defunct white goods.

A persistent problem in the UK has been to prevent trade waste producers from using the service free of charge by posing as householders. Without control, very large quantities can be brought. In Kent, for example, over 200,000 tonnes per year is deposited at 15 CA sites during 4 million visits - an average of 50 kg per visit. This is the equivalent of more than 130 kg per person per year and almost certainly includes significant quantities of trade and commercial wastes.

It would be difficult to justify the provision of a CA installation in the Falkland Islands anywhere except in Stanley. There, subject to space being available, a facility could be provided to which people could bring wastes for disposal, scavenging and recycling. The advantages should include an improvement in safety standards and minimising public exposure to the landfill operation which, even if carried out to the best standards, is never an attractive sight to the untrained eye and only leads to complaint.

1.2.2 Scavenging

In many parts of the world scavenging of various kinds is common and, in practice, ineradicable. In the Falkland Islands, it appears to be a part of the culture. In some less developed countries, it is common for scavengers to collect their findings together for a visiting dealer to inspect and offer cash for what he wants. Unsold materials are either kept for another occasion or returned to the landfill. When new landfill sites are under development, the layout includes an area set aside for scavenging, in an attempt to achieve some order.

In the UK such a process is frowned upon, largely on the grounds of health and safety. There have been many fatal accidents on landfill sites in the past, caused by reversing vehicles. Broken glass and other objects can also cause injury. Sometimes, however, an alternative system is available. At CA sites the operator, who has won a tender to do the work, is entitled within the terms of his contract, to remove and sell whatever materials he wishes. He would not be permitted to remove items from the recyclables containers. In the Falkland Islands, we would not recommend such a system, but would propose that scavenging took place at a CA site rather than on the landfill.

1.2.3 Separation of Bio-wastes

In continental Europe, it is becoming increasingly popular to collect "bio-wastes" - kitchen food wastes and garden wastes, sometimes known as "VFG" (vegetable, fruit and garden wastes) - separately, to provide a feedstock for composting processes.

The first option is to use these materials for home composting. This is addressed in section B3.3. The alternative is to collect them separately from the household, for centralised composting or treatment. Because such wastes tend to be moist, potentially odorous and attractive to flies and vermin, the normal method is to use a two container wheeled bin system, with one bin for the bio-waste and the other for the residue. Twin-compartment bins also exist, although they require specialised collection vehicles and are costly.

If each bin is collected on alternate weeks, as is frequently the practice in continental Europe, the additional costs are relatively small - over and above the cost of a single bin mixed MSW collection. The conventional view is that fortnightly collection of biodegradable waste can give rise to odours and an excessive fly problem. The container manufacturers argue, however, that with well fitting lids of the kind now available, this is no longer a problem. Several local authorities in the UK are now carrying out tests on this system, some for as long as four years, and are very pleased with the results. One authority is anticipated to extend the system to 12,000 households shortly. Many container manufacturers are prepared to offer support for trial schemes of this nature.

1.2.4 "Bring" System for "Dry" Recyclables

"Dry" recyclables are the recyclable materials in household waste other than bio-waste. Recyclables can be separated by two methods: the "bring" system and the "collect" system.

The problem with "bring" systems is that the response from the public is limited, unless they are placed at very high density, such as 1 for 500 people (New Forest DC, UK) or within 100 metres (Adur DC, UK - for households not receiving separate collection). Such a density would not be a problem in the Falkland Islands, although it is more difficult to achieve in larger communities.

In the UK, Collection Authorities estimate that a maximum of 15% of the household waste stream can be attracted to "bring" systems. In Adur, where 28% of the population is served by the "bring" system at high density, the recycling rate for this part of the population would appear to be 8.5% of the total waste stream, so the 15% parget may be optimistic.

There are minor variations in the type of container that can be used at "bring" sites but this is less important than questions of location, scope and scale. In the UK, there are two types of "bring" site in normal use. One comprises a collection of relatively small (1100 litre or thereabouts) containers designed to receive different kinds of recyclables. The other type is a larger installation, normally associated with the Civic Amenity (CA) sites, where containers of 12 m^3 or larger are provided.

1.2.5 "Collect" System for "Dry" Recyclables

The alternative is one of a range of "collect" systems, whereby the recyclables are collected directly from households. There are a number of options, which are described below. Convenience for the householder, and therefore the participation rate, tends to be greater with "collect" systems than the "bring" system. One impinges on the other, however, and it is generally neither helpful nor economic to use both systems for the same material. If the "bring" system locations are provided at sufficient density to be convenient for the majority of users, then the increase in participation rate by offering a "collect" system may not be economically or environmentally justifiable.

What has been demonstrated in the UK is that both "collect" and "bring" systems are practicable and can divert wastes towards recycling. What is unconfirmed, and this is also often the case in the UK, is that such schemes stand satisfactorily in economic terms.

It is important to recall that the impetus behind all these schemes in the UK is the Government's policy for recycling. Councils must are obliged to produce plans with a target of recycling 25% of household wastes. There is no such requirement in the Falkland Islands, where it remains possible to apply overall logic rather than adopt an empirical target.

Collect systems involve variations of waste storage in "Box", "Bag" and "Bin". Most of these are summarised in the following paragraphs.

The Box system

The "Box" method, requires householders to select, but not sort, their recyclable wastes, put them together in the box and place it at the kerbside for collection. The collection may be carried out once a week or once a fortnight.

The boxes are available in various sizes from 11.5 litres to 54 litres. The largest is appropriate for an average family but more than one is sometimes required. There tends to be a loss of boxes though damage or misappropriation of around 3-5%.

"Blue Box"

This system, originally developed in the USA, is probably the longest running method used in the UK for storing and collecting mixed dry recyclables. A newly developed specialised separate collection vehicle is used in Adur District in the UK. This vehicle has five separate compartments for three colours of glass, mixed cans/plastic and paper. The collectors separate the materials from the blue box and place them in the relevant compartment. There is a reject compartment for small quantities but if the blue box is improperly used it will be left unemptied. The recyclables can be delivered directly to a depot whence the different materials can be separately discharged and subsequently loaded for despatch to the purchaser. The cans and plastic require further sorting at an MRF.

The vehicles are expensive and large and the carrying capacity limited. However, it would be better to look to a more economical approach which can achieve the same diversion rate of recyclables from household wastes.

"Grey box"

The Grey Box is similar in design and is used in the same way by the householder. The difference, as used by Worthing BC, is that collection of recyclables and mixed MSW is carried out using a single compartmentalised collection vehicle. The vehicle has three compartments for paper, cans/plastic and mixed MSW. Glass is not collected and goes to a "bring" system.

This method is much cheaper than Adur's "Blue box" system for recyclables collection but discharge must be at an MRF for sorting prior to sale. It is also necessary for the vehicle to visit the waste disposal site before resuming collection.

The Separate bag system

Where a plastic bag collection system is used, recyclables may be segregated by placing them in a separate bag. This is usually colour-coded (e.g. green or blue) or, better still, a clear bag, so that the quality of the segregation can easily be evaluated by the collector. A variant analogous to the "blue box" system involves the use of separate coloured bags for each class of recyclable.

There are four alternative collection methods:

- Bags may be collected on a separate collection round.
- Bags may be placed in a trailer behind the refuse collection vehicle.
- Bags may be placed into separate compartments of a two compartment collection vehicle.
- Bags may be loaded into the normal refuse collection vehicle.

In the last case, the bags need to be of a heavier gauge, to minimise bursting. When the vehicle discharges at the delivery point (transfer station, landfill or other treatment plant), the recyclables sacks are hand segregated and fed to a hand picking MRF (see section B2). This system will be introduced shortly in Bedfordshire. The type of collection vehicle is important for such a system, in that some compaction machinery has a greater propensity to damage bags than others. Some damage rate is inevitable but it is claimed that, with care, 70% of bags can be recovered intact.

Since the Falkland Islands have now moved to the use of wheeled bins, a bag system would not be appropriate.

Separate Wheeled Bins

Where a wheeled bin system for MSW collection is used, such as in the Falkland Islands, separation can be achieved by using two bins - similar to that described for bio-waste in section B1.2.3 above. A three-bin system could be used to separate all three waste streams. If each bin is collected on alternate weeks, the additional costs (over an existing wheeled bin system) are relatively small.

Wheeled bin collection systems are also more expensive in general than plastic bag systems, because the vehicle productivity is reduced due to the time taken by the bin lifting equipment. We believe that vehicle productivity may be reduced by as much as 25%, although crew size may be reduced, so that overall costs are perhaps 10% higher. It has also been suggested that, in the UK, the quantity of waste which arises for collection by local authorities also increases - by as much as 25%. This is partly due to the increased amount of garden waste that is placed in these large bins but mainly as a result of diversion of wastes either from Civic Amenity sites or from trade waste. Trade waste producers are likely to take advantage of the capacity of these bins to reduce or eliminate their trade waste charges.

Two-compartment Wheeled Bins

Separation of materials can be achieved using a single wheeled bin divided into two compartments. Some time ago there was enthusiasm for these two-compartment bins but this has reduced considerably. Leeds and Exeter Councils employed them for a few years but now only Test Valley DC are continuing to use them. It now appears that they will shortly discontinue their use.

In these bins, two types of waste, such a mixed recyclables or bio-waste and residual waste, can be collected at the same time using only one bin instead of two, thus reducing the cost of bin provision. The collection vehicle is also divided into two compartments, so that the contents of each part of the bin are separately contained in the vehicle body. The compartments can be separately discharged at different types of waste management facility.

The disadvantages of the scheme were:

- Quantities of the different types of waste are unequal
- Householders, despite colouring and labels, tended to confuse the purposes of the bin divisions
- Only one bin could be lifted at a time, compared with two on a conventional vehicle
- The vehicles were more expensive.

1.2.6 Some Comparisons of Household Waste Segregation Systems

Table B1.2.1 on the next page shows some measures of segregation experience from Germany. These results are particular for towns in Germany and so results cannot be transferred without special assessment, but they are indicative of what might be achieved using different combinations of "collect" bins and "bring" containers.

Table B1.2.1: German Experience of Segregation Systems

Segregation System	Per capita production (kg/year)	Class of waste (container)	Materials	Weight fraction %
Communal bin scheme only	360	Disposal (Communal 1100l Eurobin)	mixed	89
		Dry recyclables (Communal 1100l Eurobin)	paper	5
			glass	5
			metal	1
Two bins/household	300	Disposal (240l wheeled bin)	mixed	23
		Dry recyclables (240l wheeled bin)	mixed glass, paper, metal	77
Three bins/household	407	Disposal (240l wheeled bin)	mixed	42
		Dry recyclables (240l wheeled bin)	mixed paper, glass and metal	16
		Bio-waste (240l wheeled bin)	garden and kitchen	42
Three bins and nearby bring site	380	Disposal (240l wheeled bin)	mixed	58
		Bio-waste (240l wheeled bin)	garden and kitchen	22
		Dry recyclable (240l wheeled bin)	paper only	14
		Recyclable (Communal 1100l Eurobin)	metal	8
		Recyclable (Communal 1100l Eurobin)	glass	8
Two bins and nearby bring site	320	Disposal (240l wheeled bin)	mixed	48
		Bio-waste (240l wheeled bin)	garden and kitchen	30
		Recyclables (Communal 1100l Eurobin)	paper	8
		Recyclables (Communal 1100l Eurobin)	glass	8
		Communal stack	cardboard	6

The following is a comparison of the advantages and disadvantages of "bring" and "collect" systems.

- Both can be successful in diverting waste, but the "collect" method is more expensive per tonne.
- If a "bring" system is well established, the cost of adding a "collect" system may well increase total recyclable quantities but the marginal cost is likely to be high.
- If the objective is to maximise the quantity of recyclables, a "collect" system is more likely to succeed.

- If a "bring" system is well established, it will be relatively expensive to replace it with a "collect" scheme.

- The method of collecting in bags is quick for collectors at the point of pick up (except where bags are placed in less accessible locations). The least disruptive way of introducing a "collect" scheme would be to make use of one of the systems based on bags. Several communal pick up points have been established by custom. Communal 1100 litre bins could be put at these sites and used for mixed or segregated wastes.

- Problems for the "collect" system using bags are that they can be unsightly in town areas whilst awaiting pick up, some loss of recyclables is likely due to breaking bags, and there is some risk of damage by scavenging animals.

- If separate collections are to be used, the householder must be made aware of the routine of pick up, which should be changed as little as possible.

1.2.7 Hazardous Household Wastes

Some materials discarded in household waste are regarded by some as "hazardous". Batteries, of which about 5% contain toxic heavy metals are perhaps the most notable and schemes have been put in place in many countries for their collection for recovery or safe disposal. An EU directive requires the provision of separate collection and recycling facilities for rechargeable batteries - which tend to contain the heavy metals. Recycling facilities do not currently exist in the UK but are available in France. There is little doubt that, if batteries can be removed from household waste before it is landfilled, incinerated or composted, an environmental benefit is achieved. This might be achieved by a mandatory producer responsibility scheme - at no cost to the FIG.

There may also be a number of other materials in household waste which, in some countries, are regarded as hazardous and are segregated. Examples are paints, solvents, household chemical such as bleach, shoe polish, pesticides and pharmaceuticals. These materials arise in relatively small quantities and the degree of environmental damage that they cause in a landfill or incinerator when mixed with normal household waste is probably overstated. What is certain is that, if they are segregated - and therefore concentrated in one place - they will form a hazardous waste and will require expensive treatment - probably incineration, which may cost as much as £1,000/tonne. In addition, providing a dedicated collection service for such materials could cost a similar order of magnitude.

1.3 Trade, Commercial and Industrial Wastes

Segregation of recyclable wastes from trade, commercial and industrial wastes is often simpler and cheaper than for household wastes. This is because these types of waste tend to have a more limited spectrum of components - typically 3 or 4 major ones, as opposed to more than 12 in household waste. Furthermore, in household waste, the problem is further exacerbated by the contamination of one component by others such as liquids, sludges, or putrescible food waste which make the waste mixture difficult or unpleasant to segregate and may yield target components so contaminated as to be of unacceptable market quality.

In trade, commercial and industrial wastes, clean recyclable paper is frequently a major component and can be easily separated at the point of production in offices. Such a scheme gives the best possible chance for sales at better prices. In the Falkland Islands, potential for segregation may exist, but the quantity of paper is less than in many other countries and, as has been explained in Appendix A, recycling markets are difficult to access. Other materials which may have potential for segregation are:

- Wood
- Plastic
- Metals
- Electronic equipment
- Tyres

1.4 Construction and Demolition Wastes

In countries such as the UK, a good deal of focus is being aimed at the segregation of construction and demolition wastes. In the Falkland Islands, however, such materials are generally scarce and it is probable that most recoverable materials are already recycled. Nevertheless, the options are discussed below.

Segregation of the components of construction and demolition wastes can be carried out at source by providing separate containers for the waste materials. This does introduce some difficulty. There are many occasions when single material wastes arise for disposal but frequently, particularly during small building operations, the waste contains significant putrescible fractions. The provision of two containers can be awkward if space is limited and raise costs..

The alternative to segregation at source is segregation at the destination, be it a landfill or aggregate recycling plant, or at an intermediate sorting facility - where materials can be sorted using manual and simple mechanical methods. Once segregated, many of the materials will have some potential for recycling, as described in Section B 2.6. The scale of such an operation in the Falkland Islands might render it uneconomic, however.

Thus there is a range of possible destinations for construction and demolition wastes. Civil engineering and building businesses should know of the various outlets and plan their strategy accordingly. Any such strategy will have to recognise that quantities vary from year to year depending on activity in the construction sector. In peak years in the UK, quantities of construction and demolition wastes reached four times that of MSW. In the early and middle 90s there was so little construction activity that quantities of waste reduced to about half that of MSW.

1.5 Hazardous and Healthcare Wastes

Hazardous wastes require expensive specialised treatment and have the potential to cause significant harm to human health and the environment. They should always be segregated from other wastes, so that they can be treated in an appropriate manner. They may also require segregation between different hazardous waste types.

This may be done at source, but it may also be done at a central storage and sorting facility, if there are sufficient quantities to warrant its establishment.

Healthcare wastes also present a major risk to public health. In many countries, the "risk" wastes are segregated from non-risk wastes, which tend to be similar to MSW. The reason for this is the much higher cost of treatment of healthcare wastes. Alternatively if the quantity is small and especially if energy can be recovered from the treatment process (incineration), it may acceptable to incinerate healthcare wastes without segregation, thus avoiding a more complex management process.

At the present time, healthcare wastes are handled in plastic bags, similar in strength to ordinary refuse bags. It is likely that this will shortly become unacceptable in the UK, as a consequence of the European ADR regulations. Acceptable alternatives are either rigid plastic containers, wheeled bins to contain the bags or extra strength plastic bags. The last mentioned cost about 15p each. With a normal weight of about 5kg/bag, this will add a cost of £30 per tonne.

1.6 Suitability of Segregation for Different Waste Streams

Table B1.6 shows suitability which, for this purpose, measures practicability. In most cases the decision to segregate is an option. Exceptions are healthcare and hazardous wastes which really must be segregated to avoid later difficult, expensive or even dangerous consequences.

Table B1.6: Suitability of Wastes for Segregation at Source

Waste Type	Suitability
Household Wastes	✔
Trade and Commercial Wastes	✔✔
Construction and Demolition Wastes	✔✘
Manufacturing Wastes	✔✔
Hazardous Wastes	✔✔
Agricultural and Horticultural Wastes	✘
Healthcare Wastes	✔✔

1.7 Economics

A special situation exists in relation to segregation of household wastes in the Falkland Islands. The PWD has already purchase sufficient wheeled bins to permit each household in Stanley to have two containers. The additional cost of offering a source segregation system is therefore only the collection cost. Furthermore, since the collection vehicle has spare capacity and has also been purchased by the PWD, the additional cost is simply the cost of labour, diesel and a small allowance for maintenance.

In order to collect a second bin, it would be necessary to replicate the entire collection service. Assuming the collection of each bin were still made on a weekly basis (although it might be possible to change to a fortnightly collection - at least for non putrescible materials), the additional cost would be similar to the existing cost, say £3,500 per month or £42,000 p.a. This equates to an additional £62 per household.

This is substantially higher than would be acceptable in the UK, but, in absolute terms is not a very high figure and might be considered acceptable for the Falkland Islands.

A "bring" system, however, could be introduced for, say, glass and cans at a much lower cost, by the use of some additional 1100 litre containers. The additional cost of collecting from these, by using the existing collection vehicle would probably be no more than about £10,000.

1.8 Applicability in the Falkland Islands

In general, decisions as to whether or not to segregate wastes have to be taken in the light of other, more significant, factors. The treatment and disposal options might affect what to segregate and, for some materials, whether to segregate them at all.

1.8.1 Household Wastes

For Camp, a "bring" system is clearly the only practical possibility. The problem would then be the cost of transport of the materials back to Stanley for sorting and onward shipment. This will be discussed further in section B2.6.3.

In Stanley, a "bring" system is likely to be the least expensive way of segregating recyclables. Using two bins might also be practical but, since a bin system is already in operation, plastic bag and "box" systems are clearly inappropriate. or bio-wastes, however, the only practical alternative would be to introduce a two-bin system.

1.8.2 Trade & Commercial Wastes

Trade and commercial wastes are produced by the private sector. There are two ways in which the FIG may encourage further segregation.

A pricing strategy for disposal can be introduced to make segregation more attractive. This would have other ramifications, which are discussed in Section 10. One example would be to charge a higher price at the landfill for loads containing significant amounts of paper and board - provided a market can be established for such materials. This strategy might also be applied to other recyclable materials.

The second alternative is to offer encouragement to the private sector to become involved in recycling to make such segregation attractive. This is discussed in more detail in Section B2.6.2.

1.8.3 Construction and Demolition Wastes

The scarcity of construction materials in the Falkland Islands is such that most practical recovery is already carried out. We do not foresee any practical application for additional construction and demolition wastes segregation or recovery.

1.8.4 Hazardous Wastes

The quantities of hazardous wastes arising in the Falkland Islands are small. A simple storage and sorting facility would probably be useful, however. It could be operated by the PWD.

2. RECOVERY, REUSE & RECYCLING

2.1 Introduction

Materials become waste essentially for two reasons. Either their physical or chemical composition changes - usually by a form of biodegradation - or else they become mixed or contaminated by other materials. Some three quarters of MSW (and indeed most commercial and industrial wastes as well) fall into the latter category. If materials were not mixed and contaminated by each other they would, normally, be resources - with a use to which they could readily be put. MSW, among wastes, is one of the most heterogeneous mixtures of materials and, as a consequence, is one of the most difficult from which to recover useful materials or products.

In order to recover materials from waste, it is necessary to segregate or sort them. In the case of MSW, the sorting process can commence in the home at the point when they are about to become waste, but it can also take place later in the waste's life cycle, during or after collection or, in the extreme case, after deposit. Sorting of wastes after collection can be undertaken at a Materials Recovery Facility (MRF). The next section deals with MRFs. Alternative methods of recovery are addressed in the subsequent sections.

The process of sorting of wastes displays the typical economic characteristic of diminishing returns. Some materials are easier to sort than others, whilst some are virtually impossible to sort into useful products. The reasons for this may be caused by product design, the materials being inseparably mixed during manufacture, such as certain composite materials, or as a result of their method of use or disposal, for example when paper waste becomes contaminated by food or oil.

2.2 Processes for Materials Recovery

2.2.1 Characteristics

Overview

Recovery of materials from waste may be performed by a variety of mechanical methods or by semi-manual methods.

Where the input waste stream is fairly consistent and the components to be extracted are easily identified, then it is possible to construct mechanical equipment which will effectively extract a good percentage of the available selected materials. This approach, however, is capital intensive, requires substantial buildings to contain the equipment and is relatively inflexible in its operation.

The degree of technology applied at an MRF can be gradually increased over time, as the volume of waste and demand for recyclables increases.

An MRF can be conveniently located wherever waste is to be delivered. Where transfer stations are used, they make an ideal location, provided sufficient space is available - both for the sorting of the waste and also for the storage of the recovered materials. Mechanical sorting also is the normal first stage in some other processes for the treatment of MSW, for example, anaerobic digestion, composting and WDF production (see Section B3).

Manual Sorting

An alternative, proven, technique is to use manual sorting techniques which are less demanding in capital, require more modest facilities and which are more flexible and adaptable to changes in a potentially volatile market which may give preference to a particular material or component.

The human waste segregator working alongside a "picking belt" may be considered as:

- An optical detector capable of recognising various waste types
- A manipulator capable of selecting and removing material from the waste stream
- A programmable device which can be re-programmed to select a different waste component quickly by word of mouth.

This makes a very impressive specification for a "waste segregation tool", and for the reasons stated above, is a most effective form of technology for a materials recovery system. With minimal capital investment, in a volatile commodity market place, the risk to any facility owner or operator is substantially reduced, when compared with an automated facility. Some rudimentary mechanical systems will, however, normally be required.

The simplest manual system involves hand selection of recyclable materials, usually from a conveyor belt. It is usually known as "hand picking". Hand picking is normally used on segregated mixed recyclables from household waste, or else on selected commercial or industrial waste, which contains a higher proportion of recyclables. Hand picking of unsorted MSW has been practised in the past, notably in the USA. Such systems are, however, no longer popular because of concerns about health and safety issues and working conditions. In addition, the conveyor capacity required would be too great to be economic for the amount of material that could be selected. It is, however, possible to hand select some of the bulkier and most easily identifiable materials, such as cardboard, from mixed MSW, even without a conveyor belt. In this case, however, the recovery rate is likely to be very low.

Mechanical systems

There are a number of options for mechanical sorting of wastes. Waste is a particularly difficult material to handle because of its heterogeneous nature and variability. Its generally low value can easily be outweighed by the cost of handling. The objective is therefore to handle it the minimum number of times and to use equipment which is robust and flexible. This approach has led to the development of standard components for waste or materials segregation, and these may be assembled in various combinations to give the required result for a particular waste stream.

At the reception end of the process, there will be some form of *storage bunker* or *apron* into or onto which waste will be discharged and from which the next part of the process will be fed by *loading shovel, conveyor or walking floor*. Where the waste is in plastic bags, a *bag splitter* may be used as the next stage, but depending upon the waste stream, other devices such as *crushers or pulverisers* may be used to reduce the waste to as uniform a feedstock as possible - a typical process engineering approach.

Trommels, "powerscreens" and sieves usually feature in the next stage to effect a first sort of waste by size or type, and may be combined with *air classification* to separate the lightweight fraction. Fine particles will drop out of the system at this stage and be further processed or taken for disposal. Lightweight materials may be blown onto their next stage for segregation, and by use of grids and sieves, the other materials may be grouped, conveyed to the next stage or even returned for further size reduction.

Once the waste is unbagged and in fairly open format on a conveyor belt, magnetic materials may be removed using an *overband magnet* or equivalent and non magnetic metals separated using *eddy current separators. Air classification, ballistic classification and flotation* may all be used for further automated separation, and *optical means* can be used for glass classification. Recent developments include means by which types of plastics may be differentiated.

This technology has been available for some time and has been proven to work effectively and reliably. In addition to being a valid process in its own right, mechanical sorting represents the first stage in some other processes for the treatment of MSW, for example, anaerobic digestion, composting and RDF production (see below).

In the late 70's, Warren Spring Laboratory of the UK performed a lot of this segregation work, principally on domestic waste, and some of the outcomes were embodied in two Waste Derived Fuel (WDF) plants in Doncaster and Byker. Several lessons were learnt from these two exercises. The most poignant was that there is little point in producing any waste derived product if there is no market for it (existing or created), and to reinforce that message, the Doncaster plant, after a few years operation was offered to interested contractors free of charge, was closed, the premises sold and the equipment scrapped.

Semi-Mechanical methods

The contracting side of waste management has generally been cautious about mechanising waste segregation because of the volatility of the markets and the high capital investment which increases the cost of the eventual reclaimed materials. Their approach has therefore been to automate certain functions within the overall process.

A typical initial phase for a contractor dealing in commercial wastes might include *a tipping apron, a wheeled loading shovel, an elevating conveyor, a picking belt* from which selected materials can be manually taken and dropped into *bunkers or containers* below, *a reject materials belt to a container or compactor, and a baler* or similar to bale up the card, paper or plastic for re-sale. There may be some form of *trommel or screen* where a front end segregation of fines is required. The equipment is simple, proven and not dedicated to any particular type of waste, so that as the market changes, the same equipment can respond and still be commercially viable.

2.2.2 Suitability for Different Waste Streams

Materials recovery in some form is appropriate for household, trade & commercial and industrial wastes, provided they are not hazardous. It is generally less suitable for the more specialised wastes. Table 2.2 shows suitability for the waste streams.

Table B2.2: Suitability for Materials Recovery Processes

Waste Type	Suitability
Household Wastes	✔
Trade and Commercial Wastes	✔
Construction and Demolition Wastes	✔
Manufacturing Wastes	✔
Hazardous Wastes	✘
Agricultural and Horticultural Wastes	✘
Healthcare Wastes	✘

2.2.3 Economics

The cost of operating MRFs varies between £20 and £50 per tonne of waste processed before sale of recovered materials, depending on the scale, sophistication and degree of separation achieved. These figures are for the range of throughputs common in, for example, the UK. In the Falkland Islands, the scale is so small that costs would be likely to be much higher still.

The simple picking belt MRF can operate economically at throughputs as low as 3,000 tonnes per annum and the economies of scale above this figure are not very great. A typical gross cost (before sale of recyclables) for such an operation would be around £20-25/tonne of waste processed. The net cost will depend on the value of the materials recovered. Figures as low as £2.50/tonne have been quoted[1] but these tend to have been calculated when the value of recovered materials were at a high point in the price cycle. In the Falkland Islands, the costs would be much higher, because of the very small volumes. We would expect a cost of around £50/tonne or more. Such plants are also labour intensive and would therefore not be appropriate.

For mechanical sorting, it is generally accepted that a minimum throughput of 100,000 tonnes per annum is required to achieve reasonable economies of scale. At this level, the cost is likely to be about £25-35 and the capital cost might be around £15-20 million, depending on the sophistication. Clearly this would not be appropriate for the Falkland Islands.

2.2.4 Suitability in the Falkland Islands

In view of the labour shortage and the very poor economies of scale, we cannot believe that any formal MRF would have application in the Falkland Islands. Source segregation appears to be the only viable solution.

2.2.5 Advantages and Disadvantages

Despite its non-applicability in the Falkland Islands, for the sake of completeness we outline the conventional advantages and disadvantages of MRFs below.

The advantages of MRFs are:

- They are flexible and, if correctly designed at the outset, can be gradually upgraded in technology as higher yield rates are required.
- They assist in achieving recycling targets.
- They reduce the amount of waste requiring landfilling, although only by the proportion of waste recovered, which is generally no more than 30% by weight.
- An automated MRF can be developed into a "front-end" for some other waste processing system, thereby further reducing the landfill requirement.

The disadvantages are:

- They are more expensive than the simple landfill alternative.
- Overall economics are difficult to forecast because of the dramatic fluctuations in the prices paid for recyclables according to market conditions.

2.3 Landfill Mining

Landfill mining - the extraction of potentially valuable materials from old landfills - has been practised in the United States. Wastes from a landfill in Lancaster County, Pennsylvania have been extracted for reuse to extend the life of the landfill[10]. They were segregated into three streams: a fuel for burning in a MSW Waste-to-energy plant (56%) a soil used as cover material on the landfill (41%) and rejects (3%) which were returned to the landfill. The "fuel" has a relatively low calorific value and it had to be mixed with fresh MSW, wood and tyres prior to combustion. It also contributes to higher wear and corrosion in the incinerator. Ferrous metals were also extracted and sold.

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1 *The West Sussex Recycling Initiative*. ERRA. 1994.

The value of the materials extracted is quoted at $13/tonne - before the costs of extraction. This includes paying a price for the soil cover material. It must be recognised that such a process present significant health and safety hazards and that, consequently, it is likely to be expensive to undertake.

We conclude that landfill mining will not be an economically viable process in the Falkland Islands.

2.4 Energy Recovery[2]

2.4.1 Rationale for Recovering Energy from Waste

Many wastes are composed of organic materials with a substantial energy content. Table 2.4 shows the energy content of wastes compared with coal. Generally speaking, the materials themselves have greater intrinsic value than their value as an energy source. The cost of segregation, collection, recovery and re-processing, however, is often substantial - in terms not only of human resources but also of energy and materials. Energy is a fundamental requirement of modern human activity and the use of waste materials to provide it saves on the consumption of natural resources. It is frequently the most economic and practical method of making use of waste.

Table 2.4: Calorific Values[3]

Material	Calorific Value (GJ/t)
MSW	9.5
Poultry litter	13
Typical Industrial waste	16
Dry sewage sludge	18
Tyres	32
Coal	29
Oil	40

The production of energy, whether in the form of electrical power or heat, normally involves combustion. Alternative energy sources do exist - such as nuclear power, solar power and wind energy but these have environmental and practical limitations, so that combustion of organic materials will continue to provide the major source of energy for the foreseeable future.

Combustion of organic materials produces carbon dioxide as a waste product. This gas is naturally present in the atmosphere and is the ultimate source of the carbon required to provide for the growth of all living matter. Combustion can also produce other harmful substances but, if carried out under controlled conditions with adequate equipment, such emissions may be kept to a minimum. The production of carbon dioxide, however, is completely unavoidable.

If all energy were to be produced from the combustion of recently grown living matter, such as wood, the effect would be neutral on the concentration of carbon dioxide in the atmosphere, since the growth of new fuel products would absorb the same amount of carbon dioxide as that produced during combustion. This would be an entirely sustainable position. Unfortunately, man's need for energy has created a demand for other fuel sources, namely the fossil fuels - coal, oil and natural gas. These have been formed from decaying organic matter over many millions of years and are being depleted at an alarming rate - over a timescale of decades, or centuries at most.

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2 Some of the material in this section has been derived from *Energy from Wastes*, a report by Brian Price published by Financial Times Energy Publishing, October 1996.

3 *Incineration of Waste*, Royal Commission on Environmental Pollution 17th Report

This is leading to an increase in the concentration of carbon dioxide in the atmosphere, which the consensus of scientific opinion believes is leading to a "greenhouse" effect and global warming.

Wastes contain a high proportion of biodegradable material. The process of biodegradation, whether naturally, in a landfill or in some controlled process will produce carbon dioxide and, in some cases methane. Methane is a more powerful greenhouse gas than carbon dioxide. When burnt or oxidised in the atmosphere it, too, converts to carbon dioxide. Thus, whether such waste is burnt or allowed to decompose, it will at best produce carbon dioxide and may also produce methane. Consequently, producing energy from waste by combustion (or any method, such as methanogenesis) is entirely neutral in its effect on carbon dioxide in the atmosphere - and consequently on the greenhouse effect and global warming where, by eliminating methane, it may actually have a positive effect.

It may therefore be deduced that the case for producing energy from waste, when the cost of recovering individual materials from it is high, is a strong one - provided that it is carried out in an environmentally acceptable manner and the economics are not prohibitive.

2.4.2 Energy Quality

Thermodynamics is a complex subject, but it involves the concept of energy quality. Electrical energy is a high grade. High temperature heat is a lower grade and low temperature heat is the lowest grade. High grade energy can be efficiently converted into lower grades but the converse is not true.

Consequently, using high grade energy for low grade applications, such as heating a room by electricity, is inherently inefficient. In conventional fossil fuel power stations, two thirds of the energy is discarded as waste heat in the form of warm water, through cooling towers or in the flue gases. If this waste heat can be used, for example in district heating schemes, it increases both the amount of useful energy produced per unit of fuel and per unit of carbon dioxide produced.

This has led to the concept of Combined Heat and Power (CHP), which is now gaining in popularity.

2.4.3 Technologies for Energy Recovery from Waste

The simplest means of obtaining energy from waste is to burn it in the condition in which it arises. This is done in an incinerator (see section B3.5), which may incorporate CHP, if a heat requirement exists at an economic distance.

The first alternative is to process the waste beforehand, to produce a fuel, usually known as WDF (see section B3.6). Another is pyrolysis and related techniques (section B3.7). The methane gas produced from Anaerobic Digestion (section B3.1) is also a source of energy as is, potentially, landfill gas, although in section B4.1.2 it will be seen that this would not be economic in the Falkland Islands.

2.4.4 Energy Markets

The market for electrical energy in the Falkland Islands is relatively simple. The PWD is the major supplier of electric power and the major potential purchaser. The marginal cost of production for the PWD is currently 5.4p per KWh, and this is the price they would be prepared to pay for electric energy. The price at which they supply it, however, is substantially higher than this, at 14.0p per KWh. An alternative user might be found but, insofar as this reduced demand for power from the PWD, the unit cost would increase. Thus the marginal cost is the appropriate one to use, unless power were sold to a user in Camp who generated his own power at higher cost. This can be as much as 25p/unit.

The supply of heat is another alternative, especially in a CHP scheme. Unfortunately, the cost of transmitting heat, in the form of hot water or steam, is very high. It is therefore unlikely that a waste-based CHP scheme would be viable in the Islands.

There are, however, some wastes which might prove to be a suitable energy source, if they were processed into fuel. These include waste oil and possibly paper and timber. This is discussed in section B3.6.

2.5 Reuse

2.5.1 Introduction

Reuse of waste materials is an appealing prospect but tends to have rather limited application. Most materials and products that can be reused are already reused as part of normal practice. This is certainly the case in the Falkland Islands.

There are three possibilities to increase reuse:

- A waste exchange
- A centre to accept and recondition "repairables"
- A resource centre for schools and playgroups which may enable reuse of selected waste materials

None of these is likely to have any significant effect on the quantity of waste requiring disposal. They are, however, all options which have benefit in raising public awareness. The cost of their operation and the demands on labour, however, will probably make them inappropriate for the Falkland Islands.

2.5.2 Waste Exchange

A Waste Exchange functions on the principle that one company's 'waste' can become another company's asset. In operation, it publicises surplus, redundant, waste or otherwise unwanted products and materials which companies wish to dispose of. Equally, companies in search of products and materials which might come into any of these categories can have their requirements publicised.

There need be no restriction on the range of items handled by a Waste Exchange - everything from nuts and bolts and office furniture to off-specification raw materials and potentially recyclable goods. Whether an item is supplied free, at a cost, or is bartered, is usually left to negotiation between the parties.

Waste exchanges of various kinds are in operation in the United States, United Kingdom, Canada, France, Germany, The Netherlands, Switzerland, Scandinavia and Japan, often on a regional basis under the aegis of Chambers of Commerce or similar bodies. They are viewed as a means of improving recycling performance, cutting the waste disposal costs of producers, conserving resources and reducing the environmental impact of hazardous waste disposal. In most cases, they operate outside the markets in which the developed reclamation and recycling industry is active.

However, the substantial failure rate of Waste Exchanges in the recent past points to a number of critical considerations that must be observed:

- Information must be disseminated with reasonable frequency (probably not longer than once a month) as the quantity, nature and availability of materials may change quite quickly. Users tend to be looking for a swift solution to what they regard as a problem.

- The time span between receipt of information and its subsequent publication must be minimised.

- A measure of confidentiality is frequently demanded and must be provided for. Thus reference to entries in the Exchange will be coded, responses being forwarded to the originator only by the secretariat of the Waste Exchange.

- Materials must be described fully and accurately, not all information being supplied necessarily being published.

- All forms of contamination must be stated clearly.

- Materials must be identified as one-off or occasional batches, or regular arisings (in which case rate of arising should be stated).

- Quantities must be assessed and quoted accurately.

- The location of materials must be made clear, because transport cost will be a critical consideration in deciding whether a transaction can take place.

- If a price is required, this should be stated in the bulletin.

- To avoid use of the Exchange as a free advertising service, the rules must include some form of price ceiling. Items that exceed this value can be advertised in the Exchange information bulletin for a fee, thus helping to offset operating costs.

Although waste producers may achieve an important reduction in their waste disposal costs by using a Waste Exchange, the effect on the total quantity of waste requiring disposal will almost certainly be negligible. Reductions of about 1% have been claimed, though not proved. The successful transactions of the UK Waste Materials Exchange between 1974 and 1979 are estimated to have amounted to only 0.03% of all UK industrial waste arisings, and less than 0.12% of all controlled industrial wastes generated in the same period.

In the Consultants' view, too much emphasis should not be placed on this aspect. A successful Waste Exchange will be responsible for placing many materials that ought never to be classified as 'wastes for final disposal', and will have an important function in changing companies' perception of materials that in the past they may have dismissed as 'wastes'.

In conclusion:

- A Waste Exchange can provide a cost-effective service to industry, where information provision and basic assistance in making transactions are offered in addition to services already being provided.

- Current Waste Exchange operations are financed principally by Chambers of Commerce and Trade, professional organisations, charitable foundations, and local, regional or national government bodies. Any type of self-financing can be discounted if success is a serious aim.

- Although the impact on total waste streams will be low, a Waste Exchange can keep significant quantities of potentially hazardous material out of the environment.

- A Waste Exchange can play an important role in raising consciousness in industry of the problems of waste disposal and the potential for re-use and recycling.

2.5.3 Repairables

An opportunity exists to re-cycle or re-use items (usually from, households) which are broken or in need of refurbishment. Many items in the household waste stream fall into this category as a result of built-in obsolescence or stylistic changes. To those who are more concerned with function than style, older, worn goods may be given an extended life provided that they can be refurbished at reasonable cost.

Following the 1939-45 World War, the culture whereby broken or worn items were repaired was replaced by a throw-away attitude brought about by the prowess of mass production and a new concept to fuel economic expansion, that of built-in obsolescence. Initially, the throw-away attitude was focussed on component parts of items which were cheaper to replace rather than repair because of the increasing cost of skilled labour. At the other extreme, it has encouraged the disposal of items purely on the basis of fashion.

The cycle has now turned back towards the "repairable" and the "recoverable", and manufacturers such as BMW are making a marketing virtue of the fact that their cars have a high proportion of re-usable materials.

A more humble and local example is to be seen in secondhand markets which have always been the source of goods for the poorer members of society. It is also noticeable that at some UK Transfer Stations and MRFs, which are already at the focus of waste collection, a thriving market to sell and recycle consumer durables is already naturally in existence where space permits.

In other countries, franchises or licenses are sometimes awarded to an individual or company who will have the rights to take goods brought to the transfer station or Civic Amenity site, and resell them to the general public. In some cases the goods may require a simple repair and this is often performed before re-sale.

Clearly the more complete and operational that goods are kept (rather than reduced to lower value component parts), then the higher the intrinsic value of the recycled goods. Where the goods cannot be kept operational, there is still scope to reclaim components for re-use, and if the components are no longer useful, then the materials from which they are composed gives a third tier of opportunity to re-use or recycle before the item is genuine waste.

We believe that, for the Falkland Islands, this option is probably already exploited a s far as it can be.

2.5.4 Schools Resource Centre

An innovative approach is being tried by Adur DC in the UK. Waste producers bring or arrange for collection of certain waste materials which may be of use to schools and playgroups. These can be small items of plastic, wood, glass, paper, card etc. which schools and playgroups can use for model making, writing, drawing and other educative purposes - along the style of the "Blue Peter" television programme. . In Adur, the centre is operated by an environmental charity. It employs one man with a collection van and the premises are provided free by the District Council. It is an enormous success with schools and serves as an important educational project.

Such a scheme, especially if it were operated on a voluntary basis by the school, may have some application in the Falkland Islands.

2.6 Recycling

2.6.1 Introduction

Recycling is a function of the economy. It is founded on the eternal laws of supply and demand, modified only where governments may prohibit the export of specific materials for strategic reasons.

Recycled materials are of great economic importance. They are cheaper than primary materials and play a competitive role in keeping the price of those primary materials within manageable limits. They conserve world resources of both finite and renewable materials. They reduce pollution and divert from the waste stream materials that would increase the burden of disposal.

It is estimated that the world recycling industry is responsible for the processing annually of more than 400m tonnes of materials worth in excess of US$ 40 billion.

There is, however, a widespread misunderstanding of what recycling actually means - leading to the misapprehension that collection is synonymous with consumption. This is not a matter of semantics but of understanding. There are essentially three functions in the recycling process: recovery, which consists of separating materials from waste for further processing, reclamation, which is the process of making potentially usable materials from those recovered, and recycling, which is the actual *use* of the reclaimed materials.

Recycling assumes the ability to *control* a whole series of events - from collection to accumulation, from processing to use as raw material - in making new products. In fact, there are very few examples of recycling in the true sense of the word anywhere in the world.

In reality, we are normally dealing with reclamation, which involves collection and processing, with consumption governed by supply and demand and the existence of appropriate capacity. Thus if consumption cannot cope with the volume of material being generated, that volume simply declines.

This fact is widely ignored, especially by environmentalists and policy makers who promote recycling as some magical means of ridding the community of waste disposal problems. The consequences of this attitude were especially evident in Germany some two or three years ago, where one of the richest nations in the world attempted to give itself the expensive satisfaction of recycling materials simply because it is believed they should be recycled. Germany's policy concentrated on collection, on the assumption that whatever surplus was generated could be exported. These exports, at prices subsidised by the German taxpayer, sometimes to the point where they slipped into negative value, damaged the economic recovery systems of many other countries. In this respect, Germany was not engaged in recycling; it merely exported its waste disposal problems. Fortunately, the problem has now been recognised and efforts are being made to ensure reclamation and true recycling in Germany.

Recycling - or more accurately reclamation - must be founded on firm economic principles. It operates in an international market where demand and prices are governed by international influences.

The considerable environmental value of recycling is a benefit derived from an economic activity. This benefit can be expanded only if there is capacity to consume the additional materials that will be collected. Thus, although it is important to establish the potential availability of a recyclable material, full-scale collection should not be started until consumption capacity is being established, and a clear market for the new products has been identified. In short, there is no point in collecting recyclable materials unless there is a market for them.

Government can assist the development of markets for recycled materials by ensuring that its procurement policies provide for their maximum economic use. "Pump priming" can be provided by state-backed research and development geared to specific, prioritised areas where clear advantages can be gained.

There is a wide range of economic instruments that can be applied to encourage recycling, such differential rates of tax, mandatory refundable deposits for containers etc. Legislation may be introduced to give preference to recycled materials over primary materials, or to prohibit the final disposal of certain materials. Such measures, however, have to be enforced and unless they can be enforced effectively, they will be ignored and come into disrepute.

Recycling can be expanded by effective marketing and publicity, by promoting clearly the opportunities that exist and the benefits that can be gained, and by providing whatever infrastructure may be necessary to realise that expansion. But at every stage, thorough cost analysis is essential to ensure that practical economic aims are in view.

Recycling cannot always be run as a discrete business at a net profit, but it can save money as well as reducing pollution and disposal problems when employed within manufacturing industries. As a tool, therefore, it can be applied in several ways. But none is more important to the Falkland Islands economy than import substitution. If this is coupled with the effect if high transport costs to ship materials off the Island, the emphasis in the Falkland Islands should be on recycling materials which can be used in local markets.

The markets for individual recovered materials and products are described in Annex A.

2.6.2 Role of the Private Sector

Recycling is an entirely market driven activity. Consequently, the private sector is best equipped to manage it - and does so in most countries.

We believe it is entirely appropriate for the private sector to undertake recycling activities. If recycling is to be maximised, they may require some support by the Government. There are a range of possibilities:

- Working closely with the private sector on matters of mutual interest
- Pricing strategies for disposal to encourage recycling
- Concessionary monopolies awarded by public tender
- Public education programmes
- Subsidies
- Making land available for recycling operations
- Granting the necessary planning permissions

2.6.3 Applicability in the Falkland Islands

Metals

In the Falkland Islands at present, there is no formal recycling of metals - either drinks cans or larger metal items. The exception is the activities of certain specialist metal workers, who rely strongly on recovered materials. This may help to reduce the quantity of waste produced, but it does not solve the problem of the relatively large quantities of metals which are not recovered.

Aluminium cans represent by far the most valuable packaging material entering the household waste stream. In the UK, British Alcan provides a consistent market at prices that are as stable as they could be (see A3.3). In the case of drinks cans, however, it is now often very difficult to distinguish between aluminium and tinplate. Mechanical segregation of mixed cans, however, raises few problems, and the equipment is relatively inexpensive. Tinplate cans, however, have little real value, but it might be possible to ship them to the UK at little or no net cost.

Redundant computer equipment may also have a value for shipping to the UK and this might be extended to other electronic and electrical products. Public awareness is an important aspect of success in such a venture.

Paper and Board

It is very unlikely that any positive economic benefit could be achieved by shipping paper to the UK for recycling, for the reasons explained in Appendix A. The potential for recycling paper must be found within the Falkland Islands.

The production of thermal insulation is likely to be the best possibility. Insulation is very important in the Falkland Islands, because of the climate. The business used to be very successful in the UK, but has dwindled because the scope declined - and grants for insulation of domestic properties were terminated.

Oil

There may well be scope for the installation of a simple plant for cleaning oily wastes to a standard where they could be used as a low grade fuel. This would help to reduce imports whilst offering value for money to potential users, such as Stanley growers. This is an area of particular interest to FIDC.

Tyres

There is a possibility that tyres from the Falkland Islands could be shipped to the UK for remoulding. This is successfully done from, for example, Guernsey, where shipping costs are higher than might be achieved from the Falkland Islands because of the special situation with the military.

There may conceivably be scope for the construction of artificial reefs to encourage fish to breed in the waters surrounding the Islands. This use for old tyres is not without problems in making constructions that will be a permanent feature of the seabed. The nature of the fishing industry in the region, however, makes this option unlikely.

Glass

This depends entirely on the possibility of exporting to the UK, but the outlet exists and, provided that shipping costs can be successfully negotiated, this is a possibility.

Wood

Wood is in extremely short supply in the Falkland Islands and, in the questionnaire distributed, a number of people requested more recycling of wood. This is an option which should be considered.

The provision of a CA site could enable easier recovery of discarded timber, but also some hand sorting at the landfill could be performed by the site operative to maximise recovery potential.

2.6.4 Advantages and Disadvantages

The advantages of recycling are:

- Finite natural resources are conserved
- Landfill space is conserved
- If recycled materials are used on the Island, imports can be reduced

The disadvantages are:

- Recycling can be uneconomic
- It may not be the best use of resources, especially if greater amounts of energy and other materials are required to achieve recycling
- Markets for recovered materials fluctuate widely

3. PRETREATMENT & REDUCTION METHODS

3.1 Anaerobic Digestion

3.1.1 Characteristics

The term anaerobic digestion (AD) - digestion in the absence of air or oxygen - is customarily used to describe the artificially accelerated decomposition of biodegradable matter in enclosed spaces or vessels. AD has been used for many years as a method of handling and processing certain types of organic wastes, for example sewage sludge and animal slurry. As a treatment for the organic fractions of Municipal Solid Wastes (MSW), however, it is relatively new. Anaerobic digestion results in two principal products: a methane-rich biogas, and a rich humus material ("digestate") which may be used as an organic soil conditioner or plant growing medium.

If MSW is used as the substrate, significant concerns exist about the content of heavy metals in the growing medium product. This can also be alleviated by separating vegetable, fruit and garden waste ("VFG waste" or "bio-waste") at source and applying the process to this waste stream only. Paper is also a suitable substrate, now that heavy metals from inks have been reduced and do not create such a problem. It can actually contribute to a higher grade of growing medium because of the fibres that it contains. Consequently, an alternative is to apply the process to mixed MSW by separating the non-biodegradable "contraries" (glass, plastic, metal etc.) mechanically at the front end of the process and then to digest the remainder of the material, including the paper. The AD process, because it operates on a liquid or semi-liquid substrate (water is added to the process), offers better separation of contaminants than aerobic composting. A number of claims have been made that the heavy metals problem experienced with aerobic composting of mixed MSW can be resolved in this way.

A significant proportion of the contraries are suitable for recycling (mainly metals and plastics), although the glass fraction is more suitable for use as recycled aggregate, because of contamination with ceramics and other heavy non-metallic materials. There will also be a reject stream which must be landfilled. This typically amounts to about 15-20%.

It should be emphasised that, whilst AD reduces the organic loading and pollution potential of the waste stream, it is only an economically viable process for MSW if a use can be found for the digestate. If the digestate has to be landfilled, the high capital costs of AD cannot be economically justified, even though the digestate does not produce so much leachate or landfill gas as raw MSW.

The constituents of the material fed into the AD process have a significant effect on gas production and the quality of the organic product at the end of the process. Some systems are designed to optimise gas yield for energy production, while others aim to optimise production of soil conditioner/growing medium, with energy as a less important by-product. Different systems can handle varying percentages of solid to liquid. While typical solid-to-liquid ratios are 10-25%, certain technologies can cope with solids as high as 30%.

Unit costs depend on the market for the products - gas and a growing medium. Gas can be used as an energy source and this normally has a readily available market - for heat or power generation. It can also be used to sterilise the growing medium product, although with a temperature of 70°C in the process, this may not be necessary. The market for the growing medium product is less easy to confirm. It will depend on the product quality, in terms of consistency of specification and heavy metal content. Extensive tests have been undertaken on the growing properties of the product from a pilot plant over an extended period of time with positive results. Progress has been made recently in the UK in convincing companies marketing garden compost to show an interest in using the product as a partial substitute for peat, on which there is environmental pressure to cease or reduce the rate of extraction. This has, however, yet to be tested in practice, since there is no production scale AD plant yet operating in the UK on MSW - although Kent County Council have recently awarded a contract to construct such a plant.

3.1.2 Suitability for Different Waste Streams

AD is essentially a process for biodegradable organic wastes. It can be applied to broader mixtures of wastes provided that they contain a high proportion of biodegradable materials and that non-biodegradable wastes can be removed at the initial sorting stage. Table B3.1.1 shows its general suitability for the Falkland Islands waste streams.

Table B3.1.1: Suitability for Anaerobic Digestion

Waste Type	Suitability
Household Wastes	✔
Trade and Commercial Wastes	✘✔
Construction and Demolition Wastes	✘
Manufacturing Wastes	✘
Hazardous Wastes	✘
Agricultural and Horticultural Wastes	✔✔
Healthcare Wastes	✘

3.1.3 Economics

Whilst AD is, like most other waste management technologies, subject to economies of scale, a typical plant throughput is about 30-50,000 tonnes per annum, which would be wholly inappropriate for the Falkland Islands. Capital costs for such a plant lie in the range of £8-10 million.

Much smaller plants do exist, such as the one installed in the Falkland Islands by UKFIT. This, however, is only suitable for small quantities of a single material, such as seaweed, for which it was purchased. It could not be used for the general waste streams which are being considered in this Study.

For the larger plants mentioned above, provided that reasonable markets for the products exist, costs are likely to range from £40 to £50 per tonne.

3.1.4 Applicability in the Falkland Islands

We do not consider that AD is an appropriate technology for the Falkland Islands.

3.1.5 Advantages and Disadvantages

The advantages of AD are:

- The generation and recovery of bio-gas from MSW is substantially more efficient compared with gas recovery from a landfill site, thus contributing to **reduction of the greenhouse effect** (methane in landfill gas is six times more powerful a greenhouse gas than carbon dioxide - the product of combustion of the gas). In an AD plant, degradation is accelerated and all of the bio-gas generated can be collected - as opposed to less than half.

- Since the gas can be collected, it can be used as fuel - providing **energy recovery**, unlike aerobic composting.

- Treatment of MSW in an AD plant **reduces substantially the volume of waste requiring landfilling** (by around 80-85%), and also makes landfill sites easier to manage by removing potentially problematic organic wastes.

- Sorting, leading to **recycling**, is a prerequisite for an AD plant for MSW. This may assist in the achievement of recycling targets.

- The digestate can, after screening and curing, be used as a **high-grade organic soil conditioner/plant growing medium** comparable in quality and appearance to natural peat.

- An AD plant is completely enclosed and does not produce a significant **odour** problem - unlike aerobic composting.

- An AD plant does not require such a large amount of **land** as an aerobic composting plant.

The disadvantages of AD are:

- The **technology is still under development**, certainly in the UK, and some would say it has yet to be fully proven and reliable. However, a great deal of research and development is under way at present, and several (reportedly 46) full-scale AD plants for treating MSW are already in operation or under construction worldwide.

- AD plants involve fairly sophisticated equipment and process controls, with a corresponding requirement for **skilled operation and maintenance.**

- AD plants are **expensive** to build and operate, although little different from an enclosed aerobic composting plant with odour removal.

- AD plants are relatively **sensitive** to significant variations in the **quality of the feedstock**.

3.2 Aerobic Composting

3.2.1 Characteristics

Aerobic composting describes a controlled process of aerobic decomposition of suitable organic waste matter. Composting is a natural process, the basic conditions for which are very simple and straightforward. It is necessary to create and maintain the optimum conditions for decomposition in respect of the mix and particle size of raw materials, temperature, moisture content and aeration.

Aerobic Composting results in two principal products: a moist, ammonia-rich gas containing odorous sulphur compounds, which is generally allowed to escape to atmosphere with or without treatment, and a rich humus material ("compost") which may be used as an organic soil conditioner or plant growing medium. This compost is generally free from pathogenic bacteria due to the elevated temperatures achieved by the organic material as a consequence of its biological degradation. The suitability of the compost for a given use may be affected by the quality of the feedstock and the significance of contaminants which may be derived from it.

The process can be conducted in varying degrees of sophistication ranging from open windrows turned by a simple loading shovel, through highly mechanised covered plant with forced draught and specialised turning equipment, to highly sophisticated process vessels and plant. The choice will depend upon the quantity, type and quality of the end product to be achieved and the process time required. It may also depend on the feedstock. Typically, a windrowing process, whilst not capital-intensive, can take 10-13 weeks in a British climate for conversion of the feedstock to product. In the Falkland Islands, it might take a longer period. Consequently, without accelerating techniques, a relatively large area of land is required to provide for storage of material in the process of decomposition. This is only a relative matter and, considering the availability of land in the Falkland Islands, should not present a problem.

Where there is a market for the end product then the high cost of separating contraries/non-compostable materials, and the investment in plant may be worthwhile. Where there is no market, then composting may be considered as a simple volume reduction route prior to landfilling - provided the costs are kept low.

A distinction can be made between composting systems which are designed to receive and process MSW or similar *mixed* wastes, and those which are designed to process "green" wastes (garden wastes) or "bio-wastes" (the source separated fraction of MSW, comprising vegetable, fruit and garden waste, sometimes with the addition of non-recyclable paper). In recent years, simple green waste composting has grown rapidly in the UK, whilst the composting of bio-waste is becoming increasingly popular in continental Europe and can be expected to be seen in the UK before long. Indeed, in countries such as Germany and France, all new composting schemes are based on bio-waste, because of the problems with compost quality and odour from mixed MSW.

Systems which operate on mixed MSW usually involve pre-sorting of the waste using MRF techniques. If MSW is used as the feedstock, significant concerns exist about the content of heavy metals in the growing medium product. The process, because it operates on a solid feedstock with a critical regime of aeration and water content, is less capable of offering separation of contaminants than anaerobic digestion and they may persist into the eventual product. A significant proportion of the contraries are suitable for recycling (mainly metals and plastics), although the glass fraction is more suitable for use as recycled aggregate, because of contamination with ceramics and other heavy non-metallic materials. There will also be a reject stream which must be landfilled. This typically amounts to about 15-20%.

It should be emphasised that, whilst aerobic composting reduces the organic loading and pollution potential of the waste stream, it is only an economically viable process for MSW if a use can be found for the compost. If the product has to be landfilled, the additional costs of composting must be less than the cost of the incremental void space consumed by waste which is not composted. Once in a landfill, however, provided that it is designed with suitable controls for leachate and landfill gas, a similar reduction in volume will take place by either aerobic or anaerobic decomposition (albeit over a longer period). This can be achieved with no extra (composting) effort so that there is no economic justification for composting in such a case.

In its simple (windrowing) form, following the removal of metals, plastics and other non-compostable materials from the feedstock as necessary, the waste will require handling into prismatic rows on a drained hard surface, aeration by turning and/or forced ventilation, frequent moisture content adjustment and handling into storage or despatch to the end user. The control of moisture is critical and in wet climates can oblige that the area is put under cover so that rainfall does not interfere with an otherwise regulated process. The emissions of ammonia, similarly can require some form of enclosure or collection ducting to collect and scrub the exhaust gas stream - which may be done with water and/or a “biofilter” made from compost mixed with woodchips.

A recent development is **tunnel composting**, in which the waste is placed in concrete chambers which enable better control of temperature and the aeration process.

Composting technology is well developed in Europe and North America, and can be applied to a wide range of waste feedstocks. In common with AD, sewage sludge may be included in the feedstock stream, provided particular attention is given to the turning and aeration regime to avoid an immobile core which can become anaerobic and odorous.

3.2.2 Suitability for Different Waste Streams

Aerobic composting is essentially a process for biodegradable organic wastes. It can be applied to broader mixtures of wastes provided that they contain a high proportion of biodegradable materials and that non-biodegradable wastes can be removed at the initial sorting stage. Although the process is claimed to work effectively for mixed MSW, we have some doubts that the end product will be usable. Such doubts have caused the virtual cessation of new projects for mixed waste composting in France and Germany.

Table B3.2.1 shows its general suitability for the Falkland Islands waste streams.

Table B3.2.1: Suitability for Aerobic Composting

Waste Type	Suitability
Household Wastes	✔
Trade and Commercial Wastes	✘✔
Construction and Demolition Wastes	✘
Manufacturing Wastes	✘
Hazardous Wastes	✘
Agricultural and Horticultural Wastes	✔✔
Healthcare Wastes	✘

3.2.3 Economics

Simple green waste windrow composting may be undertaken for about £15/tonne, at normal input rates, with relatively low capital expenditure. For the Falkland Islands the cost might be higher because of the low throughput. This will be examined in more detail in Stage 2.

A tunnel composting plant for 12,000 tonnes p.a. of green wastes[4] has recently been constructed in the UK for £1.7 million (including the cost of mobile plant). Total operating costs, including depreciation are estimated by the Consultants at about £18-20/tonne before product sales. This method could be used for green and horticultural wastes together with a proportion of separately collected bio-waste, provided that its quality is carefully controlled to minimise the content of contraries. It is doubtful whether sufficient material would be available in the Falkland Islands to enable such a plant to be economic.

Mixed MSW composting is likely to cost around £100/tonne at the scale appropriate for the Falkland Islands and there are doubts about its practicability, as mentioned above. It should be noted that at least one contract in the UK has been awarded at a price considerably lower than this, but we have severe doubts that this contract will be economically viable and there are even some doubts as to its technical feasibility.

3.2.4 Applicability in the Falkland Islands

Market for products

The market for a compost growing medium is reasonably well established in the UK, as a visit to any garden centre or nursery will show. The opportunity for using waste derived compost will depend on the quality of the product. If the product is produced from MSW, its quality is likely to be lower than that from an AD process.

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4 *European-style tunnel composting gains ground in the UK*, Barnes, L., "Wastes Management", March 1997

In the Falkland Islands, however, the soil quality is generally low and there could be a large demand for such a product, both in horticulture nd agriculture. It is doubtful, however, that economics would permit a significant price to be paid for such a compost product. It can simply be said that finding outlets at zero cost would not present a problem - which is not always in the case in countries such as the UK.

Inputs and Scale

The wastes suitable for aerobic composting would be similar to those for AD, as shown in Table 3.2.2.

Table B3.2.2: Waste Types for Aerobic Composting

Waste Type	Tonnes p.a.
Separately collected household wastes	150
Trade, Commercial and Industrial Wastes	50
Horticultural wastes	200
TOTAL	**400**

Location

The most suitable location for an aerobic composting plant for the Falkland Islands would be on land owned by PWD, in an area where the odour emissions could be tolerated. The Megabid site would be ideal.

The amount of land required would be no more than ½ acre for 400 t/year (8t/week) throughput. This equates to the compostable fraction of MSW and horticultural wastes.

3.2.5 Advantages and Disadvantages

The advantages of aerobic composting are:

- Provided that an outlet can be found for the compost product, composting reduces substantially the amount of waste requiring landfilling.
- The reject material that does require landfilling has a substantially lower biodegradable content.
- Sorting, leading to recycling, is a prerequisite for a compost plant for mixed waste, which assists in the achievement of recycling targets.

The disadvantages are:

- Composting, whether of mixed waste or biowaste, is a relatively expensive process.
- The product may not be sufficiently sterilised to kill all fungal spores and may carry plant diseases.
- The quality of the compost product from mixed waste composting is often poor and markets are difficult to find with any long term security.
- The process requires careful attention to turning and aeration regimes, which become more critical as food wastes and sewage sludge are added to eh the feedstock.

- The land take for a plant is comparatively great, compared with other processes.
- Mixed waste composting often leads to odour problems and thus limits the locations where such a plant may be established.

3.3 Home Composting and Wormeries

3.3.1 Characteristics

Many keen gardeners have always made compost from much of their garden waste - frequently by the "pile" method but also using more sophisticated equipment, often of home-made construction, to maximise access to air, thus improving compost quality. They then use the compost to improve soil quality and to return nutrients to it.

Equally, many gardeners do not bother with composting and place their garden waste in the refuse bin or make bonfires. Larger quantities of garden waste are, in the UK, taken to civic amenity sites.

An alternative, which is becoming popular in the UK, is to use a purpose designed home composting unit. There are a number of different types of unit, ranging in price from £9-£30. At the lower end of the price range, these units are generally suitable mainly for garden wastes. At the higher end, products such as the "Green Cone" can accept all kitchen wastes as well as a moderate quantity of garden waste thus, where used properly, almost eliminating the putrescible fraction of MSW from requiring collection.

The design of home composting units vary from a relatively simple container to the Green Cone, which has a double skin design which enables solar energy to force air through the waste to ensure an aerobic process. This could be particularly beneficial in the Falkland Islands, where temperatures are often too low for effective composting. It also has a lid to keep out flies and is dug into the ground to about ½ metre to ensure stability and access to bacteria and worms in the soil.

Wormeries operate on a similar principle, but use worms to assist in the digestion process. They, like the Green Cone, can process all food wastes, whereas most home composters cannot. One advantage of wormeries is that they can be used indoors, thus eliminating the need to take wastes outside for composting. They are not so suitable, however, for garden waste because of the quantity of this waste produced.

By providing home composting units or wormeries, a large proportion of the food and garden waste can be removed from MSW requiring collection.

The Green Cone is claimed to have reduced the weight of MSW collected by about 17% on collection rounds in the UK, whilst comparative studies in three Nottinghamshire districts indicate that other home composters and wormeries achieve about half of this reduction rate.

One of the problems with home composters and wormeries is that not every household has either the space and/or garden to install them nor, in some cases, the inclination to use them. Typical participation rates for Green Cones appear to be around 50%-80% but other types of home composter apparently require more skill and effort and take up rates tend to be lower. The waste reduction figures above take account of this effect.

One of their benefits is that, on selected routes with high participation rates, MSW collection can in theory) be carried out fortnightly, because the putrefaction and fly nuisance caused by food waste is all but eliminated. Beverley DC, for example, is now doing this, but is using the alternate week to collect source segregated dry recyclables - which it is enabled to do at little or no additional cost.

3.3.2 Suitability for Different Waste Types

Home composters and wormeries are only suitable for a portion of MSW and have no significant application for other waste streams.

3.3.3 Economics

Assuming that one of the more expensive and better composters is used, such as the Green Cone, the cost would be about £30 each, say £35 delivered and installed - which equates to about £6 each p.a. If about 80% of all householders were use them (see next section) the annual cost would be about £4,000, allowing for depreciation. If these achieve a diversion rate of 10%, the saving in tonnage delivered to the Stanley landfill would be about 80 tonnes p.a. This would have a negligible effect on costs, but would reduce the quantity of putrescible materials and hence the attraction to vermin.

The main value of home composting is when it is part of an overall plan which seeks to reduce the input of putrescible wastes to the landfill. In this case, leachate and gas production would be reduced.

3.3.4 Applicability in the Falkland Islands

It appears that the proportion of food and garden wastes in the Falkland Islands, at 40%, is somewhat higher than in the UK. We would therefore intuitively suggest that the response to the provision of home composting units would be quite strong. Consequently, it might be assumed that the take-up of Green Cones, if introduced throughout the Falkland Islands might lie near the top of the range - say 80%. If those who use them actually divert 90% of their food and garden waste, the overall diversion rate in Stanley would be about 30%.

One of the benefits of this method is that it is equally applicable in Camp as in Stanley and the cost figures in the section above have allowed for this. It is probable, however, that people in camp already use their food wastes for feeding chickens and other animals, so that they may have little interest in participating.

3.3.5 Advantages and Disadvantages

The advantages of home composting are:

- Reduction in amount of MSW to be collected can lead to savings in collection cost (though this would be small or negligible in the Falkland Islands).
- Reduction in amount of MSW for disposal can lead to savings in disposal cost (though this would be negligible in the Falkland Islands).
- Reduction in biodegradable content of waste requiring landfill can reduce methane and leachate production, reduce attraction to vermin and extend landfill life.
- Possible opportunity to move to fortnightly MSW collection or alternate collection of dry recyclables and residues.

The disadvantages are:

- Householder resistance to the use of home composters leads to less than full participation.
- Relatively high initial cash outflow.
- A wide range of products on the market, not all of which have comparable performance.
- Performance depends on householder education to ensure proper installation and use of home composters.

3.4 Aggregate Crushing

3.4.1 Characteristics

Coarse aggregate is used for two main purposes; fill and base material and concrete making. Finer aggregates are used for making mortars, render and screeds. In the UK, the main source of coarse aggregate is gravel extracted from quarries or dredged from the sea. In hard rock areas, it is frequently made by crushing hard rock.

Certain construction wastes, notably stone and concrete, can be crushed to form recycled aggregate. This requires substantial washing and grading before it can be used for concrete making and, indeed, may still not be suitable. It can, however, be used for backfill material and, if suitably graded, for sub-base in road construction.

In the UK, the use of secondary aggregates is well established and many companies produce quality materials which are sold. Different qualities of aggregate are sold for different purposes and there are few limitations. In Kent, for example, the proportion of bitumen coated materials for some road base construction is limited to 10% but this only applies to major roads where there is a frost risk.

The most advanced application of recycling enforcement is said to operate in Denmark. There, landfill fees are extremely high, due to high landfill taxes, even for construction and demolition wastes. In addition however, Planning Controls are used to exert further influence by requiring, in the case of major projects, that construction wastes must be separated at source into containers for soils, stone, brick, wood and lastly, an unusable fraction. The last is said to be as little as 10% of the total. The incentive for waste producer is that, by following these rules, they will save the much higher costs of disposal to landfill.

3.4.2 Suitability for Different Waste Types

As its name implies, aggregate crushing is only suitable for construction and demolition wastes.

3.4.3 Economics

The process requires dedicated crushing equipment, which is expensive to purchase and operate. For the scale possible in the Falkland Islands, it is unlikely to be economic.

3.4.4 Applicability in the Falkland Islands

There is no shortage of stone for aggregate production in the Falkland Islands, unlike in some more densely populated countries, nor is there a critical shortage of space for inert waste landfilling. Consequently, we can see no application for this technique.

3.4.5 Advantages and Disadvantages

The main advantages of aggregate crushing are:

- It reduces the requirement for extraction of virgin material, thus saving natural resources.

The disadvantages are:

- The material is not suitable for all civil engineering applications
- Specification is important which means that the process should be managed by a professional and responsible operator

3.5 Waste-to-Energy

3.5.1 Characteristics

The technology of the recovery of energy from MSW by means of incineration needs little introduction. The high emission standards now imposed by European and UK legislation mean that the health risks are, quite frankly, negligible - although the general public does not necessarily perceive incineration in this light. It must be recognised, however, that a modern waste-to-energy plant is a complex piece of chemical engineering equipment and not a simple boiler. It therefore requires skilled and experienced people to operate it.

The technology is tried and tested and a number of waste-to-energy plants are currently being constructed in the UK. The most environmentally effective method of energy recovery is the so-called Combined Heat and Power (CHP) system, whereby the "low-grade" heat is recovered as hot water which is used for heating purposes. It is essential, however, to have a use for such heat conveniently close to the waste-to-energy plant for this to be economic, otherwise only electricity generation is practical. Incineration without energy recovery is not so environmentally or economically attractive.

The most commonly used method of incineration for MSW is the so-called "mass burn" system, which burns the waste without pre-processing - other than separating out bulky non- combustible items such as white goods. Typical plants burn from 150,000 to 1,000,000 tonnes p.a. Electricity is generated from steam produced in boilers within the plant.

An alternative, which is beginning to receive substantial attention in the UK, is the fluidised bed system, which offers better thermal efficiency and more effective burnout - leading to a more inert bottom ash. Some of these systems can generate power directly from gas turbines powered by the combustion gases. The fluidised bed consists of sand or limestone (which can remove acid gases) which is rendered into a fluid-like state by blowing air through it. This ensures very efficient combustion. The wastes are normally processed into c-WDF (see section B3.6) before introducing into fluidised bed plants.

The advantages of fluidised bed combustion are:

- Greater thermal efficiency (20% more net power output than mass burn)
- Less corrosion
- Lower maintenance costs
- Gas cleaning is easier, since many pollutants taken out at RDF stage
- Better combustion
- Carbon in ash up to 100 times lower than for mass burn.
- Ash may be used for lightweight building blocks.
- The front end of the plant is effectively an MRF and may readily be developed further to extract additional recyclables.
- Higher yields/quality of extracted metals because they are recovered before combustion

At the present time, EU directives specify emissions from incinerators as shown (in simplified form) in Table 3.5.1.

Table 3.5.1: EU Incinerator Emission Standards

Parameter (mg/m^3)	MSW <3t/hr	MSW>3t/hr	Hazardous waste
Dust	100	30	10
HCl	100	50	10
CO	100	100	50
HF	4	2	1
SO_2	300	300	50
Pb+Cr+Cu+Mn	5	5	0.5
Ni+As	1	1	
Could+Hg	0.2	0.2	0.1
VOCs	20	20	10
Dioxins (ng/m^3)			0.1

A new draft directive is being considered, though its status is not fully clear. This would raise the standards for MSW incinerators to those for hazardous waste incinerators and would introduce a statutory standard for NO_x emissions of 200 mg/m^3, compared with the current UK benchmark (non-statutory) figure of 300 mg/m^3.

The key components of a modern Waste-to-energy plant are:

- A facility and equipment for handling incoming waste.

For MSW, the waste is normally discharged into enclosed reception which are designed to minimise the spread of litter and the dispersion of dust and odours - with extracted air typically being fed into the incinerator. Waste is usually fed to the charging equipment using a gantry grabbing crane.

Additional dedicated equipment would be required for sewage sludge and also for healthcare waste, if either of these materials were to be handled.

- Waste charging equipment.

Waste is fed into the plant by means of ram, gravity or hopper feeds. Arrangements need to be made to prevent back flow of combustion products.

- The combustion furnace.

A number of different moving grate systems are used for transporting the waste through the combustion chamber. Primary combustion air is pumped through the grate. Secondary air is then introduced into the combustion gases above the waste to ensure complete combustion. A minimum combustion temperature of 850°C is normally required for MSW, whilst for healthcare waste 1000° or even 1100° is needed. The residence time for the combustion gas should be at least 2 seconds, with a minimum of 6% excess oxygen. Healthcare waste incinerators usually require a secondary combustion chamber to achieve the necessary temperature and residence time.

Modern MSW incinerators incorporate an additional "burn-out zone", in which the materials falling from the grate after combustion are maintained at an elevated temperature for a further period to maximise burn-out

The primary combustion chamber for most hazardous waste and some healthcare waste incinerators takes the form of a rotary kiln, similar in design to a cement kiln. These types of plant also require a secondary combustion chamber reaching temperatures of 1100°C and 1000°C respectively.

If healthcare waste is to be burnt in an MSW incinerator, it normally requires a separate primary combustion furnace. It would probably be most economic to undertake a "campaign" burn once a week, keeping the waste in refrigerated storage at other times, in order to minimise the need for additional fuel to achieve the necessary higher temperatures in the secondary combustion area.

- Ash handling equipment.

Two types of ash are produced. The major quantity (around 90%) of solid residues consist of "bottom ash", which falls off the grate after combustion. This tends to be a relatively inert, dense material and, in many countries, is used for such applications as sub-base in road building. Tests are also being undertaken in the UK for its use for the manufacture of bitumen coated black-top. It may therefore be possible to sell the material, although it would be more conservative to assume its disposal at zero cost. If these uses are not acceptable in the Falkland Islands, it will require landfill. It may contain significant quantities of ferrous metal, if this has not be pre-sorted. This can be removed by magnetic extraction. Non-ferrous metals can also be removed using eddy current separators.

The flue gas cleaning equipment will also produce fly ash. This material contains heavy metals and other contaminants and is usually regarded as a hazardous waste. In the UK, present standards permit it to be landfilled provided that the landfill is suitably lined to prevent leaching (i.e. a secure landfill). In the future, it is possible that it may be required to be subjected some form of treatment before landfilling, such as solidification or vitrification (B3.8).

- A waste heat boiler

Energy recovery is achieved by means of a waste heat boiler located in the hot combustion gases. Enclosed systems can be used whereby the water used for steam raising is recycled. In this case, the water used can be as little as 0.25 litres per tonne of waste incinerated. The water will require neutralisation and de-ionisation.

- Flue gas cleaning equipment

Flue gas cleaning is now a requirement for all MSW incinerators as well as for hazardous waste and healthcare waste incinerators. Particulate (dust) emission controls have been a feature of MSW incinerators for many years but the current EU directive requires additional scrubbing for acid gases, heavy metals and organic compounds.

Two systems of scrubbing are in general use - wet scrubbing with water or, better, lime or caustic, and dry scrubbing using lime, with the possible additional of activated carbon to remove dioxins and heavy metals. The latter system is gaining in popularity. With either system, a bag filter is frequently incorporated to remove the particulates, particularly form the dry system.

- A chimney stack to emit the cleaned flue gas.

The required chimney height will normally be determined by air dispersion modelling techniques and will depend on the volumes of waste handled and the combustion and gas cleaning technology employed. Wet scrubbing systems can give rise to a large visible steam plume. This should be avoided, by reheating the flue gases or by using a dry scrubbing system, since it frequently gives fire to objections from the public - whether or not it contains pollutants.

- Cooling towers.

Cooling towers or condensers are normally required in conjunction with the energy recovery process. A sealed system will avoid the production of a steam plume and problems with the need for biocides and their potential release to atmosphere.

- Process and flue gas monitoring equipment.

The EU directives require continuous monitoring for temperature (throughout the process), oxygen, dust and HCl, and periodic monitoring for SO_2, HF, heavy metals and VOCs. In addition, the ash should be sampled at regular intervals, together with any liquid effluent.

Incinerators for hazardous waste are considerably more specialised, but would not be appropriate for the Falkland Islands because of their high cost and the very low quantity of hazardous waste produced. Such hazardous wastes as are produced will be more cost-effectively incinerated in existing plants in the UK. It is known that the UK DoE will permit import of hazardous wastes for incineration.

Incinerators for healthcare wastes also tend to be specialised - particularly in the facilities for handling the incoming wastes. Combustion requirements also tend to be different from those for MSW, but it is possible to attach a small healthcare waste incinerator to the gas cleaning system of a MSW incinerator, thus reducing the cost compared with a stand-alone plant. Modern healthcare waste incinerators have similar gas cleaning facilities to hazardous waste incinerators, but they are much smaller and therefore less expensive. They could be used for burning relatively small quantities of hazardous wastes in addition to the healthcare wastes.

Specialised incinerators are also produced for the burning of animal carcases. The standard in the UK requires that these plants should be equipped with water scrubbing in the gas cleaning stage, which is less expensive than the type of equipment needed for a hazardous or healthcare waste incinerator. It is unlikely that such equipment would be necessary in the Falkland Islands, provided that the plant were located at a reasonable distance (say two miles) from housing.

An important feature of modern waste-to-energy plants is that they are designed for continuous operation, 24 hours a day and 7 days a week. Typical availability for a single line plant is around 7,800 hours a year. Operating plants on a single shift leads to greater stresses on a number of components, notably the refractory lining. Continuous operation of this kind is not possible, however, on plants with manual de-ashing systems. Nevertheless, better performance on these plants can be achieved by a period of continuous operation until de-ashing is required, rather than operating on a single shift system.

3.5.2 Suitability for Different Waste Types

The suitability of waste-to-energy for the various waste types is shown in Table B3.5.2

Table B3.5.2: Suitability for Waste-to-energy	
Waste Type	**Suitability**
Household Wastes	✔
Trade and Commercial Wastes	✔
Construction and Demolition Wastes	✘
Manufacturing Wastes	✔✘
Hazardous Wastes	✘✔*
Agricultural and Horticultural Wastes	✔
Healthcare Wastes	✔*

* in specialised plant

3.5.3 Economics

Economies of scale are substantial in waste-to-energy facilities. The generally accepted minimum annual throughput for an economic plant is around 200,000 tonnes. At this level, the cost is estimated to be £38/tonne[5], whilst at double the throughput, the cost falls by about £8/tonne.

Fluidised bed combustion plants have similar economics at throughputs of 200,000 t.p.a. and above but they are not so good below this level.

The Non-Fossil Fuel Obligation (NFFO) in the UK has subsidised the prices of electricity produced by waste-to-energy plants in recent years, reducing costs by about £5-£6/tonne over those quoted above. NFFO is no longer available for conventional MSW incinerators, unless they incorporate CHP or fluidised bed combustion.

Smaller, modular, waste-to-energy plants are now available with a capacity of as little 25,000 tonnes p.a. This is still far too large for the Falkland Islands and would not be economic. Such a plant, with full gas cleaning using lime and activated carbon is estimated to cost around £15 million. A modern plant has never been constructed to handle the volume of suitable wastes arising in the Falkland Islands.

The only economically feasible option in the Falkland Islands would be a combined plant to handle MSW, healthcare and hazardous wastes. It is difficult to estimate the capital cost, but it is unlikely to be less than £3 million. This would imply a cost per tonne of around £300 per tonne and would plainly be prohibitive.

The gross power output from such a plant would be 100-150 KW. The capital cost of installing power generation is likely to be at least £500,000 and probably nearer £750,000. The value of the power would be about £40-60,000. Thus the investment would show a rather marginal rate of return.

3.5.4 Applicability in the Falkland Islands

Inputs and Scale

The waste arising in the Falkland Islands at the present time which is suitable for waste-to-energy is estimated to be as shown in Table 3.5.3.

5 ETSU, 1995.

Table B3.5.3: Waste Types for Waste-to-energy	
Waste Type	**Tonnes p.a.**
Household wastes	800
Healthcare wastes	12
Hazardous wastes and oils	50
Trade, commercial and industrial wastes	400
TOTAL	**1,262**

These quantities would almost certainly render such a plant uneconomic, as explained in the section above.

3.5.5 Advantages and Disadvantages

The advantages of waste-to-energy are:

- A renewable source of energy.
- Five times greater useful energy per tonne of waste compared with landfill gas.
- Very high waste volume reduction - up to 90% by volume and 70% by weight of the original input crude waste.
- Converts organic wastes into biologically less active forms.
- Suitable for hazardous and healthcare wastes which should not be landfilled.
- Easily manageable, fairly compact plant with modest requirements in terms of site area.
- Very high plant availability and reliability is attainable.
- The potential exists to recover "low-grade" heat via CHP as well as to generate power.
- Incineration with energy recovery counts as "recovery" for the purposes of the impending producer responsibility regulations.

The disadvantages of waste-to-energy are:

- High initial capital cost of building a plant.
- Fairly sophisticated technology is employed requiring competent management and skilled technicians to operate and maintain effectively.
- May compete with recycling options.
- Possible objections to plant emissions, although modern process controls and gas-cleaning systems have reduced the levels of emissions dramatically over recent years;
- Possible objections associated with the stack;

- The fly-ash from gas cleaning is a "special" or potentially hazardous waste.

3.6 Waste Derived Fuel

3.6.1 Characteristics

Waste Derived Fuel (WDF, sometimes known as Refuse derived Fuel - RDF) is produced by processing waste in a series of mechanical sorting (as for an MRF) and shredding stages in order to separate the combustible fractions of the waste. WDF has sometimes been described as a product looking for a market. Notwithstanding the forward progress of technology since the 1970s, it is unlikely that waste derived fuel as originally contemplated will be produced in the near future - pother than as a precursor to fluidised bed combustion (see B3.5 above).

Either a loose fuel, known as fluff, floc or coarse WDF (c-WDF), or a densified pellet or briquette (d-WDF) is produced. The majority of WDF plants produce pellets approximately the size and shape of animal feed pellets. The characteristics of the fuel, especially calorific value, ash and moisture content, are obviously influenced by the composition of the waste.

In Europe d-WDF typically has a calorific value of around 16-19 MJ/kg, compared with 29 MJ/kg for industrial coal and about 10 MJ/kg for mixed MSW. Importantly, the ash content of d-WDF is around 15% by weight, whereas the ash content of industrial coal is about 6% by weight.

Numerous facilities to produce WDF from MSW were developed in the United States and Europe during the 70s and 80s, but many of these have since been closed or converted to other types of recovery process. There are currently four plants operating in the UK.

In the early WDF plants, MSW was seen as the main waste stream and various methods of sorting and segregation were applied to this feedstock to separate the combustible fraction. This approach was based on the rationale that MSW was available in large quantities and therefore such a waste stream offered potential economies of scale. Also MSW was a well characterised material with regular analyses by local authorities, so that the composition could be reasonably relied upon. By comparison, industrial waste was handled by the contracting community and very little or nothing was known about the waste streams available from that sector. This was a fundamental mistake. If the commercial, trade and industrial waste arisings, which generally contain a higher proportion of combustible materials and fewer contaminants, had received the same attention as MSW, then the plants at Doncaster (now closed) and Byker (still operating) in the UK might have been more successful.

The UK was not alone in this thinking, and at Dieppe a similar approach was also being taken with a plant which separated domestic waste into combustible and putrescible streams as the precursors of WDF and compost.

In the UK, the fuel produced comprises mainly paper, card, plastic, but inevitably it also contains fines and other less combustible items. This causes several problems:-

- The fuel produces a lot of ash, and the de-ashing process can also cause the "fire" to drop into the ash collection system.

- The combustion characteristics require a particular form of solid fuel grate or modifications to existing grates. A fluidised bed appears to be the best method of combustion.

- The emissions from the combustion of WDF made from MSW are outside acceptable limits, due to the presence of contaminants, notably chlorine (which produces dioxins) and heavy metals.

- The cost of drying the fuel pellets produced (in order to be able to store them without rotting) is more than the price for which the fuel can be sold.

Whilst there are still four plants still producing WDF from MSW in the UK, the fuel is only permitted to be burnt in plants specially adapted for the purpose with adequate emission control systems similar to those for MSW incinerators. New UK standards have recently been introduced.

Where there is an adjacent potential user for the fuel, who is prepared to set his combustion plant up to deal with the peculiarities of WDF, then consideration may still be given to WDF, although it is most likely to be more cost-effective to produce combined heat and power from a purpose designed MSW incinerator. Such an incinerator is probably the most serious competition for the combustible fraction of wastes because it requires less of the pre-conditioning and pre-treatment of the waste stream which WDF requires, yet still extracts almost the same gross amount of energy. As stated in section B3.5 above, however, the preparation of c-WDF is a normal precursor to fluidised bed incineration.

WDF in a different form, however, may have a role to play. Such WDF would consist of paper and wood separated from trade, commercial and industrial waste and also, possibly, MSW. This material can be shredded and compressed into briquettes or **"energy loaves"** which may be used as a fuel for providing heat and/or generating power. If the timber has been treated with pesticides, however, it can give rise to unacceptable and toxic emissions. It may therefore be better to rely solely on paper to form such briquettes, which could be burnt in place of peat. To obtain suitable paper for processing in this way would involve a separate collection system.

3.6.2 Suitability for Different Waste Streams

WDF is essentially a process which selects the combustible fraction from wastes and produces pellets or a bulk fuel which can be handled and stored easily. It can be applied to broader mixtures of wastes including trade & commercial and industrial provided that they contain a high proportion of combustible materials and that biodegradable wastes can be removed at the initial sorting stage. Table B3.6.1 shows its general suitability for the Falkland Islands waste streams.

Table B3.6.1: Suitability for Waste Derived Fuel

Waste Type	Suitability
Household Wastes	✔✘
Trade and Commercial Wastes	✔
Construction and Demolition Wastes	✘
Manufacturing Wastes	✔✘
Hazardous Wastes	✘
Agricultural and Horticultural Wastes	✘
Healthcare Wastes	✘

It is evident from the above that the process can deal with only those waste streams which have combustible fractions and therefore applicability is limited. Its greatest potential application is for segregated paper and wood from trade & commercial, industrial and possibly municipal wastes.

3.6.3 Economics

WDF plants for mixed MSW are, like incinerators, subject to economies of scale. A study by Aspinwall & Co for the UK DTI in 1992 indicated that the cost of processing and recovering the energy from WDF lay between £34 and £44 per tonne. Given the very small quantity of suitable wastes in the Falkland Islands, it can be expected that the cost of a WDF process for MSW would be enormously higher than this.

Waste oils, however, can offer an economic energy source. The cost of transporting oils to the UK for recovery is substantial, and offsets any price that may be paid for them. It is believed that a simple oil reprocessing plant might be economic in the Falkland Islands.

Similarly, **paper, polyethylene plastic and possibly shredded timber might be processed into a fuel** ("energy loaves") which could be used in peat stoves.

3.6.4 Applicability in the Falkland Islands

Inputs and Scale

It has been suggested above that oil and waste paper represent the main materials which could be used as fuel. The waste arising in the Falkland Islands at the present time which is suitable for fuel manufacture is estimated to be as shown in Table 3.6.2 and includes a nominal contribution from oil recovered from oily water and from Albermarle.

Table B3.6.2: Waste Types for Waste-to-energy

Waste Type	Oils - t.p.a.	Paper - t.p.a.
Household wastes		100
Hazardous wastes and oils	250	-
Trade, commercial and industrial wastes		250
TOTAL	**250**	**350**

Market for products

Potential users of "energy loaves" would be those who currently use peat as a fuel. It is understood that the use of peat in Stanley is declining quite rapidly, with only about 100 houses using this energy source. It is possible that they might be able to use the 350 tonnes of paper derived fuel produced - if they were prepared to convert to using this material. Another 120 houses in camp use peat, but the transport costs of the product would be high and involve additional scarce labour.

Stanley Growers have a capability to burn waste oil in their main boiler. They are also considering using waste oil heaters in some of the other greenhouses. In total, they use about 200 tonnes of oil p.a. and could therefore use all the available oil wastes produced by the civilian community. They also accept some waste oils from MPA, but the low flash point at present made this source unusable.

3.6.5 Advantages and Disadvantages

The advantages of WDF are:

- It provides a means of recovering the energy value of waste.
- It reduces the volume of waste requiring landfilling.
- The front-end portion of a large-scale WDF plant can recover materials for recycling.
- The fuel produced could be used as a low-grade energy source for use, for example, by the horticulture industry.
- The technology is developed and proven.

- WDF made from a limited range of source segregated paper and wood could be produced relatively cheaply and would produce a relatively clean fuel.

- The production of WDF is a normal precursor to fluidised bed combustion.

The disadvantages of WDF are:

- WDF made from MSW is a 'dirty' fuel to store, handle and burn, which has made it difficult to market to industrial solid fuel users.

- Considerable costs are involved in converting furnaces to use WDF, due to the variability in WDF quality, greater ash handling requirements and the effects on air emissions;

- The total costs of producing and using WDF have invariably been much higher than originally predicted and are certainly no less than conventional incineration.

It is unlikely that WDF from mixed MSW is a serious option for the future and we are not aware of any plans to establish new WDF facilities in the UK.

3.7 Pyrolysis

3.7.1 Characteristics

Pyrolysis is a term commonly given to a range of pyrolytic thermal treatment processes, which apply heat to waste (or other materials) in the absence of air to achieve a chemical transformation.

Pyrolysis, as applied to mixed wastes, is only just starting to be applied on a commercial scale. Its main potential advantages are that it offers greater thermal efficiency than straightforward incineration and also reduces the potential for harmful emissions. It must be stressed, however, that little experience has yet been obtained of running plants on a commercial scale and there have been some expensive failures in the relatively recent past. It cannot therefore yet be regarded as proven technology.

There are three basic types of pyrolytic thermal treatment processes which may be applied to waste, namely:-

- Pyrolysis
- Gasification
- Liquefaction

The term **pyrolysis** describes the thermal degradation of waste in the complete absence of air, oxygen or any other oxidising agent, or with such a limited supply that the gasification (see below) process does not take place to an appreciable extent. It may be described as partial gasification. Relatively low temperatures are employed (400-900°C, compared with 800-1200°C in gasification). Three products are always produced: gas, liquid and char, the relative proportions of which depend upon the pyrolysis method and reaction parameters.

Fast or Flash Pyrolysis is used to maximise either gas or liquified products according to the temperature employed. Moderate temperatures of 400-500°C and slow heating rates give charcoal as the main product, higher temperatures of 450-600°C and high heating rates give liquids as the main product and the highest temperatures of 700-900°C give gas as the main product.

The heat required for pyrolysis can be added indirectly in a variety of ways such as indirect heating through the reactor wall, direct contact with hot gas or hot liquid such as metal or molten salt, or directly by partial gasification with a limited addition of oxidising agent such as air to give a direct heat input from the waste itself.

Gasification is another major thermochemical conversion technology. In this process the primary products from pyrolysis react with oxygen in either air, steam and/or pure oxygen to convert all the solid and liquid products into gas through partial oxidation and thermal cracking reactions. Gas is the main product although a small amount of tar is also produced which can cause problems in some applications.

Liquefaction is the third main thermochemical conversion technology. This can be considered to be pyrolysis in a solvent at high pressure with reducing gases and a catalyst added to improve the liquid product quality. Little work is known to have been carried out on liquefaction of solid wastes and as this is already viewed as a long term option for biomass and wastes, it is unlikely to be a serious possibility for MSW. There are however some interesting possibilities with related technologies.

The oil produced from pyrolytic processes has quite unique characteristics in that:-

- Although it is an oil which will burn, it cannot be mixed with other oils
- It is very sensitive to temperature and irreversible physical and chemical changes take place above 100°C or 60°C for sustained periods.
- It cannot be distilled.

The development of processes to change substantially the proportions of the gas, liquid and solid products has only occurred over the last fifteen years. This is achieved by adjusting the rate of heating, the final pyrolysis reaction temperature and vapour residence time. From wood, for example, total yields are maximised at around 75% w/w at a temperature of 510±10°C and vapour residence times up to 1 second. Other work has attempted to exploit the complex degradation mechanisms by carrying out pyrolysis in unusual environments such as vacuum and hydrogen.

There is currently a project in Puerto Rico by a Canadian company DynaMotive, supported by Chase Manhattan Bank for 100t/day (30,000t/yr input) demonstration plant as a precursor for a plant for the main city of San Juan. Completion is scheduled for November 1998. The oil which will be the main product will be used to replace 3000 second Bunker C oil and the char will be used to generate heat for the process.

This plant takes pre-sorted MSW and treats it with steam to give some form of homogenisation when macerated. The product is then pyrolysed with a 70% yield of oil.

A small batch process plant has been developed in the UK for tyres. The plant has a capacity of about 250 t.p.a. and costs about £1 million. Unless the cost of tyre disposal is very high, it is not an economically viable process and we are not aware that any plant has yet been installed.

The pyrolysis process cannot really yet be described as proven technology.

3.7.2 Suitability for Different Waste Streams

The spectrum and characteristics of products depend greatly on the feed material and mode of processing and process parameters. There is extensive data on the characteristics of pyrolysis products from biomass (e.g. straw, lees from brewing etc.) and woody waste materials, but data from MSW and plastics processing is a little more sparse and generalised conclusions are not possible.

Table 3.7.1 shows its general suitability for the Falkland Islands waste streams.

Table 3.7.1: Suitability for Pyrolysis	
Waste Type	**Suitability**
Household Wastes	✔
Trade and Commercial Wastes	✔
Construction and Demolition Wastes	✘
Manufacturing Wastes	✔✘
Hazardous Wastes	✔✘
Agricultural and Horticultural Wastes	✘
Healthcare Wastes	✘

3.7.3 Economics

A figure of £5.5 million has been quoted for a plant to take 30,000 t.p.a. of wood chips at 10% moisture, shred them and pyrolyse them to give an oil. This capital sum increases to £10 million when power generation plant is included. The plant will generate 6.5MW of electric power. It is likely that the breakeven price for the sale of the power will be around 6p/KW - similar to the marginal cost of power in the Falkland Islands. The scale is, of course, substantially too high.

The figures and economics for MSW are not known but are likely to be less favourable than for incineration.

3.7.4 Applicability in the Falkland Islands

The scale of a pyrolysis plant would inevitably preclude its adoption in the Falkland Islands

3.7.5 Advantages and Disadvantages

The advantages of pyrolysis are:

- A better thermal output per tonne input that straight mass burn incineration.
- Low temperature technology
- The cost of a suitable plant would be comparable with a mass-burn incinerator
- Air emissions are better than those for an incinerator.

The disadvantages of pyrolysis are:

- The technology for MSW is relatively unproven
- The cost of pre-sorting might tip the balance more in favour of mass-burn with its proven technology and ability to take a wider range of wastes.

3.8 Solidification and Vitrification

3.8.1 Characteristics

Solidification (or stabilisation) is a process for fixing hazardous components of solid wastes (usually heavy metals in hydroxide and sulphide sludges) so that they are chemically trapped and less easy to leach out. In the Falkland Islands context, there are no significant quantities of this type of waste and it is therefore not a relevant process. The commonest method is based on cement and/or other pozzolanic materials such as aluminum silicate and fly ash from power stations.

Vitrification, where the material is melted into a glass-like matrix usually derived from sand, is another process which is even more effective than the cement-type processes. Again it has little relevance for the Falkland Islands.

4. FINAL DISPOSAL

4.1 Landfill

4.1.1 Characteristics

Landfill is essentially the disposal method of last resort. It lies at the bottom of the waste hierarchy. For some wastes there is no practical treatment or recovery method. In addition, all the known waste treatment and recovery processes produce reject material (usually at least 30% by weight). For these materials there is no complete alternative disposal method. Consequently, **any waste management strategy must make provision for landfill.**

Landfill is also the least expensive option - provided that suitable land is available within an economic distance of waste arisings. The extent to which landfill will be relied upon within a waste management strategy will depend on the availability of financial resources to move to waste management methods which are higher up the hierarchy. In developing countries, landfill is frequently the only method that is used or foreseen to be used and resources are devoted as much as possible to ensuring that it is practised in an environmentally sound manner. In most developed countries, however, **landfill will tend to play an important but probably diminishing part in future strategies**

Landfill as a disposal technique has received enormous attention during the last 20 years and has been subject to extensive investigation and analysis. Consequently there has been a steady stream of modifications to what is considered good practice. The UK has been in the forefront of developing and applying new techniques and, in the DoE's Waste Management Paper 26, has produced guidance notes which are probably the best in the world. Even so landfill continues to receive criticism. Its future in Europe is likely to change again during the next ten years. The influence that will drive the changes is the **EU Landfill Directive,** the main content of which seeks to **reduce the organic content of wastes deposited at landfills.** Reasons which support this change are:

- The theory of sustainability requires that practice being carried on now should not result in an unacceptable problem for future generations. Reducing the proportion of organic waste should reduce the commitment for aftercare which, for a landfill accepting organic wastes, can be expected to last forty years or more.

- A higher proportion of organic waste increases the rate of production of landfill gas, which contains methane. Methane contributes to a substantially greater "greenhouse effect" than carbon dioxide, which is the product from waste-to-energy schemes. The amount of landfill gas is, of course, proportionate to the organic content. The amount escaping from landfills can be reduced by about 30%, either by exploiting the gas as a fuel or flaring it.

4.1.2 Energy Recovery from Landfill Gas

The methane gas generated as the organic wastes decompose in a landfill requires careful control, in order to prevent the risk of fire or explosion, if it arises in significant quantities. Its emission to the atmosphere also needs to be minimised, as methane is a powerful greenhouse gas.

In the UK in 1994 there were 94 schemes whereby landfill gas is used to generate power which are subsidised by the Government's NFFO[6] scheme. There are also other schemes which do not take advantage of the NFFO subsidy. The installation of power generation equipment, however, is expensive and it is doubtful whether many of these projects would have taken place without the NFFO subsidy.

Even with the subsidy, it is reckoned that a landfill requires ½ to 1 million tonnes of MSW to be in place over a ten year period before a power generation scheme becomes economic. Consequently, power generation from landfill gas will therefore never be economic in the Falkland Islands.

Indeed, the quantity of landfill gas generated from the small Falkland Islands waste stream is unlikely even to require any significant degree of control.

4.1.3 Suitability for Different Waste Streams

Most wastes and residues of treatments may be deposited directly into landfills, subject to appropriate measures to protect the environment and local amenities. Table B4.1.1 shows this.

Table B4.1.1: Suitability for Landfill

Waste Type	Suitability
Household Wastes	✔
Trade and Commercial Wastes	✔
Construction and Demolition Wastes	✔
Manufacturing Wastes	✔
Hazardous Wastes	✘
Agricultural and Horticultural Wastes	✔
Healthcare Wastes	✘

Note: ✘ In these cases, landfill of part of the waste stream may be possible following treatment or in a special secure area..

4.1.4 Economics

Landfill is currently the least expensive waste management option. It is subject to economies of scale and also to opportunistic pricing based on the availability of conveniently located alternatives. Current costs in the UK can typically be expected to lie around £10-20/tonne, although prices for large contracts at around £5/tonne are still not unknown. The issue of scale in the Falkland Islands will mean that unit costs will be substantially higher than this.

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6 Non-Fossil Fuel Obligation

The cost of landfill includes the preparation of the initial infrastructure, the intermittent cost of preparing space for waste, the annual operational cost, the restoration and the aftercare programme. For the UK and for many other countries there is the additional burden of the landfill tax. Without the tax element, the long run marginal cost of landfill at new sites is likely to lie between £15 and £25 per tonne at typical UK input levels.

4.1.5 Applicability in the Falkland Islands

Landfill in the Falkland Islands will undoubtedly form a major part of the waste management strategy. The costs and options are evaluated in the main body of this report.

4.1.6 Advantages and Disadvantages

The advantages of landfilling are:

- Landfilling is well tested and researched. It is reliable and will always be required as one of a range of disposal options.
- Landfill is suitable for the widest range of wastes.
- Landfill is currently the least expensive option.
- About 30%-40% of the methane produced as the MSW biodegrades in a landfill site can be recovered and used as an energy source or flared. Exploitation of gas is, normally, only economic in landfill sites containing more than about ½ million tonnes of MSW and it is necessary to establish a market for the energy recovered.
- It is a means of reclamation of derelict land and can be used to reclaim new land from the sea.
- Well-designed landfills can be unobtrusive.

The disadvantages are:

- Whilst environmentally acceptable, it is still the least attractive environmental option and lies at the bottom of the waste management hierarchy.
- A finite risk of pollution from operational landfills will always exist.
- Its versatility and low cost dissuades innovative approaches to waste management.
- As time progresses, the margin of cost advantage that it presently has may become eroded due to the application of landfill taxes or other sanctions.
- The remainder of the methane generated as the waste biodegrades is emitted to the atmosphere. Methane is many times more potent than carbon dioxide (the product if MSW is incinerated) as a greenhouse gas.
- Methane also presents the risk of fire or explosion, although proper management can reduce this to negligible proportions.
- Energy recovery from landfills is less efficient than some other options, such as waste-to-energy.
- After landfilling, land may retain some contamination and be unsuitable for many uses.

- It is generally perceived by the public to be the least attractive option.
- landfills, in common with most waste management activities, are always likely to cause some noise, odour and unsightliness.
- Successor sites are becoming increasingly difficult to obtain and may not be sustainable in the long run.

4.2 Transfer of Wastes

4.2.1 Introduction

It can be envisaged that the provision of suitable treatment or disposal options for all wastes on the Falkland Islands might either be difficult to achieve or prohibitively expensive. It is therefore worth considering the option of delivering wastes to a facility located elsewhere. In addition, it may be appropriate to transfer wastes from Stanley to, for example a landfill at MPA. In order to do either of these things, a **transfer station** would be necessary.

4.2.2 Overseas Destination for Wastes

The practical overseas destination options for wastes from the Falkland Islands are limited by a combination of factors. The only potential candidates are:

- UK
- A South American State

Whilst the UK may well be the most appropriate destination for hazardous wastes, for non-hazardous solid wastes, **landfill in the UK would not be permitted according to Government policy**. We believe that South American States would also be unwilling to accept wastes for landfill, which would be contrary to the spirit, if not the letter, of the Basel Convention.

Consequently, we rule out any chance of export of non-hazardous wastes.

4.2.3 Transfer within the Falkland Islands

Because of the economies of scale of landfill, particularly landfill of biodegradable wastes, one serious option which needs to be considered is that only one landfill is constructed to serve both MPA and Stanley. The military at MPA appear fairly determined to develop a new landfill. There is also considerable more land available in the vicinity which is suitable.

One option is therefore to consider transferring wastes from Stanley to the MPA landfill. For this reason it is necessary to consider the transfer process.

4.2.4 The Elements of Transfer

Transfer systems comprise three basic elements:-

- A transfer facility (or several facilities) at which waste collection vehicles can discharge their loads in a regulated and controlled manner, and which can re-load the waste into larger or easier handled unit loads, thus providing economic and environmental benefits.
- A transport system capable of reliably, efficiently and regularly transporting a bulk cargo over large distances.
- A reception facility at the ultimate destination of the wastes capable of receiving the bulk waste in its transported form and getting it to the point of disposal or discharge.

4.2.5 The Transfer Facility

The object of a transfer station is to:

- Receive the vehicles, which have collected the waste, in an orderly fashion
- Determine their payload
- Direct them to a point of discharge
- Despatch them in an orderly manner
- To handle the waste into the chosen unit load format
- To load the unit loads onto the transport system (and unload any empty containers if used)
- To act as an interface between the transport system and the collection vehicles.

Good transfer station design attempts to:

- provide an orderly and efficient traffic management system for the incoming collection vehicles (minimal queuing, no queuing on the public highway, quick turn-around);

- minimise the amount of handling of the waste;

- conduct most handling operations under cover (or in a building) to limit odour, dust, noise etc.

There are many examples worldwide of transfer stations which have been engineered to fit into the very heart of cities without becoming "bad-neighbours".

Irrespective of the transfer transportation system chosen and its form of unit load, there are some common features to any transfer station.

- Vehicle reception, weighbridge (optional - but strongly recommended), check-in and queuing space off the public highway.

- A discharge apron or "tipping hall" where the collection vehicles discharge.

- A re-loading or waste processing activity.

- Despatch and reception facilities for the bulk-haul medium selected (vehicle or container bays or docks) although these may be on another nearby site if a shuttle service is provided.

4.2.6 The Transfer Process

Ideally the transfer activity should be conducted inside a simple building with the following features:

- Adequate headroom
- Natural or artificial lighting
- Adequate ventilation
- Dust suppression or air extraction/filtration equipment
- Adequate vehicle manoeuvring space
- An adequate number of discharge points or bays in which collection vehicles can discharge their waste.

In many crude transfer stations the transfer operation is conducted in the open air with no enclosure such as a building, but this can give rise to unacceptable levels of dust, noise, odour and visual impact, which may offend neighbours and make such an operation unacceptable.

4.2.7 Transport Systems

The transport system influences the form of both the transfer and reception facilities. Waste is conventionally carried over longer distances in three basic forms:

- In bulk (loose or semi-loose)
- Containerised
- Baled

These may, variously, suit the three principal forms of transport which are:

- Road
- Rail
- River, Canal or Sea

In the Falkland Islands, road transport is likely to be the most economic option, because of the small quantities of waste.

4.2.8 Unit Loads

At the core of the transfer process is the formation of a uniform or Unit Load which forms the basis of further handling. For the Falkland Islands, the following are considered relevant:

- Bulk road vehicles - 18-23 tonne payload
- Demountable compaction containers - 12-14 tonne payload

Bulk Road Vehicles

The "bulker" vehicle is a full size articulated vehicle up to 16.5m long x 4.2m high and 2.5 m wide and weighing up to 38 tonnes gross. It is not really suitable for the road system in the Falkland Islands. Also the quantity of waste required to be moved does not justify such large vehicles.

Demountable Compaction Containers

The demountable compaction container, is a well proven unit load for road and marine transport, and is an ideal unit load for the intermodal transfer to any of the identified destinations. Containers tend to be in the size range 25-35m^3 capacity and in order to have a cost effective payload, have the waste compacted into them using a static transfer compactor. They have the advantage that once in an enclosed container the waste is well contained, hidden from view and not readily identifiable as waste.

Static compactors range in size from 0.5-8.5 m^3 swept volume per stroke They are hydraulic machines which force waste into a vehicle body or container. The maximum effective throughput of larger units is about 30-40 tonnes per hour.

Typical compaction containers suitable for transfer include:

- A 30 cubic metre closed container suitable for hook lift systems (of the "Multilift" type). These can also have a trailer for a second container.

- A derivative of the 6 metre (20 feet) long ISO freight container (27 cubic metres) which is specially designed to receive compacted waste.

Whilst ISO containers are frequently used for marine hauled waste or where there is a need for intermodal transportation, because there is so much standard handling equipment available, it is unlikely to be appropriate for the Falkland Islands. The hook lift container is definitely the better option. In the UK, three or four axle vehicles are usually used, permitting larger containers. For the Falkland Islands, we would recommend a three axle vehicle.

4.2.9 Economics

The economics of transfer are evaluated in the main body of this report.

4.2.10 Suitability for the Falkland Islands

Transfer is a very real option for the Falkland Islands and has been evaluated in the main body of the report.

4.3. Healthcare Waste Processes

4.3.1 Introduction

Healthcare wastes are, effectively a special subset of hazardous wastes. They arise in the Falkland Islands in small quantities but, because of the very substantial health risks that they present, they require effective destruction by incineration or one of the other methods described below.

4.3.2 Treatment Options

There are essentially four major options for treatment of healthcare wastes. These are described below.

Dedicated Incineration Plant

The most generally favoured method for the disposal of healthcare wastes is incineration. Healthcare wastes contain substantial quantities of PVC plastic, which contribute to the production of substantial amounts of acid gases and, potentially, dioxins in the combustion gases. For this reason, in the EU, healthcare wastes are required to be incinerated in plants with appropriate gas cleaning facilities.

It can be argued that, in the Falkland Islands, the quantities are so small that the harmful gases emitted from the existing incinerator - which has no gas cleaning - do not present a major health risk. There are, however, ways in which the plant could be better managed, and possibly modified, to improve its current environmental performance.

At the present time, the required emission standards in the UK for plants operating at a throughput of less than 1 tonne/hour[7] are shown in Table B4.3.1.

7 *Process Guidance Note PG 5/1 (95)*, UK DoE

Table B4.3.1: Healthcare Waste Incineration Emission Standards (<1t/hr)	
Parameter	**Concentration (mg/Nm^3)**
Dust	30
HCl	30
CO	50
SO_2	300
VOCs	20
Dioxins	1 ng
Cadmium	0.1
Mercury	0.1
Other heavy metals	1

A plant of the necessary capacity for Falkland Islands healthcare wastes with suitable emission controls is likely to cost about £½-1 million, which is **likely to be prohibitively expensive** - giving costs of several thousand pounds sterling per tonne.

The ash from incineration requires landfilling under supervision, with the ash being buried immediately. Because of possible heavy metal contamination, a secure landfill is preferable.

Co-incineration with MSW

It is possible to incinerate healthcare waste in an MSW incinerator but, in the UK at least, a specialised combustion furnace would be required, which could then be attached to the MSW incinerator's gas cleaning system. In any event, a specialised handling system would be required.

Autoclaving

Small quantities of infectious waste, particularly from pathology laboratories are frequently sterilised in an autoclave. A common practice is to use special colour-coded bags for autoclaving, the favoured colour being light blue. The bags may be equipped with autoclave tape, which signifies when the waste has been subjected to sufficient time and temperature to ensure sterilisation. This tape is then used to seal the bags, which are usually incinerated.

Large quantities of waste (generally excluding human tissue and sharps) are treated in large steam sterilisation plants. These are relatively expensive and the cost is similar to incineration. The waste is first macerated (in order to make it less objectionable in appearance at a landfill) then sterilised by passing steam through the waste. It is then dried and compacted before disposal with MSW. Provided the autoclaving process is operated for a sufficiently long time to ensure sterilisation, this method does not present a health hazard, but the procedure is not suitable for sharps and the resulting waste may not be considered acceptable at a landfill from an aesthetic point of view.

The system is suitable if the waste is then incinerated in a MSW incinerator but this. of course, adds to the cost.

A recent development is the continuous feed auger system, which is capable of handling several tonnes per hour and operates at temperatures substantially above that achieved by conventional autoclaving (130°C). Such a system, however, is almost as expensive as incineration, although emissions to atmosphere are reduced. It also requires a landfill suitable for receiving the sterilised waste. It is not appropriate for the small tonnage arising in the Falkland Islands.

Microwave Irradiation

Microwave technology is a relatively new heat treatment technology which is in use in France, Germany, The USA, the UK and Ireland. It is not suitable for human tissue, pathology waste or sharps and other metal objects.

Waste is first macerated and then water is added by spray or steam. The waste is then passed by a feed screw across a series of microwave power packs which raise the temperature to at least 100°C for a specified retention time. The residue is then suitable for disposal with MSW, but the same comments as for autoclaving apply.

The cost is similar to that for incineration at reasonable scale but would be more expensive at the low volumes arising in the Falkland Islands.

Other techniques

Other techniques which are used are pyrolysis, gas sterilisation and chemical disinfection. These techniques are only appropriate on a large scale and may not be suitable for entire spectrum of healthcare wastes. They are no less expensive than incineration.

Recommendation

In our opinion, the environmental impact of incinerating the small amount of healthcare waste arising in the Falkland Islands in the existing plant would be small in absolute terms. It should, however, be improved and operated in a better manner. This is discussed in the main body of the report.

4.4 Hazardous Waste Processes

Hazardous waste treatment processes are complex and tend to be specific for different waste streams. They are also capital intensive and demonstrate substantial economies of scale. There is no possibility that, for the small quantities of hazardous waste arising in the Falkland Islands, it could be economic to install hazardous waste treatment plant of any kind. The only practical economic option is to export these wastes to the UK for treatment.

The main processes in use in the UK at present for different waste types are shown in table B4.5.

Table B4.4.1: Hazardous Waste Treatment Processes	
Process	**Waste Types**
Incineration in dedicated hazardous waste incinerator	Organic wastes
Use as fuel in cement kilns	Organic wastes with low halogen content
Physico-chemical treatment	Inorganic wastes
Oil/water separation	Oil/water mixtures
Solidification	Inorganic wastes with significant concentrations of very toxic heavy metals
Secure landfill	Many solid, non-flammable wastes

APPENDIX C

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Appendix C REFERENCES

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APPENDIX D

VISITS

DESIRE THE RIGHT

HALCROW

1996
The Queen's Award For Export Achievement

Appendix D PEOPLE MET DURING VISIT TO THE FALKLAND ISLANDS 1997

John Barton	Fisheries
Stephen Bell	Aspinwalls
Kathy Biles	Chamber of Commerce
Keith Biles	Chamber of Commerce
Paul Bonner	Waste Contractor
Juanita Brock	Chamber of Commerce
Tony Burnett	Penguin News
Mike Burret	Stanley Services
Mike Butcher	Metalworker
Nikki Buxton	Chamber of Commerce
Gerald Cheek	FIGAS
Jon Clark	Harbour Master
Tim Cotter	FIDC
Roger Diggle	Chief Medical Officer
Sinead Doherty	Environmental Planning
Tom Eggeling	Environmental Planning
Mike Forrest	PWD
Andrew Gurr	Chief Executive
Les Halliday et al	Government Representative and residents of Fox Bay East and West
Les Harris	Power Station
Derek Howatt	Treasury
Russ Jarvis	First Secretary
Robert King	Customs
Manfred Keenleyside	PWD
David Lang	Attorney General
David Langridge	Education Department
Tony McMullen et al	Goose Green farm manager and residents of Goose Green
Bob Meyer	Defence Works Advisor, MPA
Tim Miller	Stanley Growers
Conner Nolan	Fisheries
Hugh Normand	FIDC
Andy Peverill	Deputy Defence Works Advisor, MPA
Bob Reid	Department of Agriculture
Phyl Rendell	Director of Oil
Jeremy Smith	Falklands Conservation
Roger Spink	FIC
Carol Stewart	FIBS
Richard Wagner	Treasury
Hamish Wylie	Chamber of Commerce

APPENDIX E

QUESTIONNAIRE DISTRIBUTED TO HOUSEHOLDS AND COMMERCE

HALCROW

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ENVIRONMENTAL PROTECTION IN THE FALKLAND ISLANDS

YOU CAN HELP!!!
(BY FILLING IN THIS QUESTIONNAIRE)

The Falkland Islands Government has recently asked for advice about what we can do to improve the effect on our environment of the way in which our waste materials - waste from households like yours as well as wastes from commerce and industry - are handled. Because you, the householders, produce wastes and need to have them dealt with, **we need your views about this.**

Waste is the stuff we no longer need and want to get rid of. **It cannot be made to disappear**. This is a fundamental law of science. If we don't manage it properly, it can **harm our environment** in many ways, including:

- It may not look nice, such as litter or piles of rotting rubbish.
- It can pollute the water that we drink or swim in.
- It can harm or kill domestic and wild animals.
- If it is allowed to rot, it can produce gases which increase the "greenhouse effect".
- If it is burnt, it can produce poisonous gases.

There are five things that we can do about waste:

- **Don't produce it** in the first place. This may help to reduce the quantity of waste a little but, as everybody knows, there will always be waste to get rid of.

- **Reuse it** - which involves using it for something else, such as using jam jars as containers for keeping things in. This is something we are good at doing in the Falkland Islands. We may be able to do better.

- **Recycle it** - this requires certain things, such as cans and bottles, to be collected separately so that they can be reprocessed and made into new materials. Sometimes this can be very expensive and may possibly use more of the earth's resources (such as oil and energy) than it saves.

- **Treat it**, using some process - such as composting or incinerating - that will reduce its volume and/or make it less polluting.

- **Dispose of it**, usually by putting it on a piece of land, perhaps in an old quarry. This used to be called a dump, but there are now ways of doing this so that it causes little or no pollution, smell, flies, rats, litter or other unpleasant effects.

Some of these processes can **cost a lot of money**. Others may need **your help** to be effective. You should know, however, that whatever is done with our wastes, we will always need somewhere to dispose of some, if not all, of it. We need your views about three things:

- How much do you care about the effect of your waste on your environment?

- Do you think that more of your Government's money should be spent on improving the way in which waste is dealt with?

- Would you be prepared to help by sorting out materials which could be easily recycled or processed?

If you care about your environment, please fill in the questionnaire on the next page and put it in the post box. We would like views not only from Stanley but also from Camp, where the issues are likely to be different.

FALKLAND ISLANDS GOVERNMENT

QUESTIONNAIRE: WASTE MANAGEMENT AND THE ENVIRONMENT

Is protection of your environment important to you?	Very important	☐
	Quite important	☐
	Not very important	☐
	Not at all important	☐
Do you think that your waste can affect the environment?	Yes	☐
	No	☐
Do you believe that the way in which your waste is dealt with should be improved?	Yes	☐
	No	☐
If new ways of improving waste management were more expensive, do you think that this would be a good way for the Falkland Islands Government to spend its money?	Yes	☐
	To some extent	☐
	No	☐
Would you take your cans and bottles to a separate container located near, say, your shops for recycling?	Yes	☐
	No	☐
If you were given two "wheelie" bins, would you separate food and garden wastes into one and other wastes into the other?	Yes	☐
	No	☐

Please give any views you may have about how you think your wastes should be dealt with or any other opinions you may have about how waste management could be improved:

Please fold and return to address shown overleaf by 4 September 1997

WASTE PRODUCTION QUESTIONNAIRE

Name of business/company:

Address: Telephone No.

Contact name:

How do you deal with the wastes you produce? PWD arranges collection
FIC collects in skips
Discharged to sewer
Other Please specify:

Number of waste containers .... Size ....
Frequency of collection ....
Principal constituents of waste:

Do you have any particular waste management problems? If so, please explain.

Do you have any views as to the type of facilities that you would like to see provided? If so, please explain.

WE/aph/FALK/M196/10.97

APPENDIX F

QUESTIONNAIRE DISTRIBUTED TO SHIPPING

HALCROW

The Queen's Award For Export Achievement

A SURVEY OF SHIP WASTE DISPOSAL FOR THE PUBLIC WORKS DEPARTMENT OF THE FALKLAND ISLANDS GOVERNMENT.

1. GENERAL

(i) Name	
(ii) Company / Organisation	
(iii) Address	

2. TYPES OF VESSELS

Please indicate the type and number of vessels that use Falkland Islands ports

Vessel Type	Number of Vessels
Cruise Liner	
Refrigerated Cargo	
Bulk Carrier	
Container ship	
Product Tankers	
Fishing Trawler	
Research Vessel	
Tug	
Supply Vessel	
Jigging Vessel	
Longline Fishing Vessel	
Pleasure craft	
Other (please specify)	

3. WHICH FALKLAND Islands HARBOURS DO YOU USE ?

Harbour	Total number of vessel visits per year	Size of vessels (GRT)

4. TYPE OF WASTE

What types of waste are produced by your ships ?

Type of waste	How frequently is this waste produced (often, sometimes, never)	Description of waste or waste sources	Typical quantities produced annually (weight or volume)
Garbage (domestic type)			
Oily waste			
Liquid effluent			
Chemical waste			
Waste food products from third Countries			
Other (specify)			

5. WASTE DISPOSAL

How do you dispose of ship generated waste ?

Type of waste	**Dump at sea**	**Dispose of at Falkland Islands port**	**Dispose of at another port**	**Treat on ship**
Garbage				
Oily waste				
Liquid effluent				
Chemical waste				
Waste food third Countries				
Other (specify)				

6. WASTE TREATMENT EQUIPMENT

Do your vessels have any on-board waste treatment equipment ?

Treatment Equipment		**Tick (if appropriate)**
Incinerator	Oil	
	Garbage	
Sewage plant	Macerator	
	Full treatment	
Compactor	Garbage	
Other (specify)		

7. DISPOSING OF WASTE IN PORT

(i) What facilities have you used to dispose of waste in Falkland Islands ports (eg skip, incinerator, compressor, bins, sacks, drains) ?	
(ii) What new facilities would you like to see in Falkland Islands ports ?	

8. FUTURE WASTE DISPOSAL NEEDS

	YES / NO	TYPE	ANNUAL AMOUNT (mass or volume)
Are your companies vessels likely to produce increased amounts of waste in the future ?			

9. WASTE MANAGEMENT POLICY

	YES / NO
Is your company aware of MARPOL regulations ?	
Does your company have a waste management policy (if yes give details) ?	

APPENDIX G

IMPLICATIONS OF DEVELOPMENT OF PETROLEUM EXPLORATION AND EXPLOITATION FOR WASTE MANAGEMENT

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Appendix G

IMPLICATIONS OF DEVELOPMENT OF PETROLEUM EXPLORATION AND EXPLOITATION FOR WASTE MANAGEMENT

1. INTRODUCTION

In addition to the indigenous waste production from terrestrial sources, waste will be created offshore by the activities of the oil and gas industry. The offshore oil and gas industry has the potential to contribute both ordinary (i.e. controlled waste in a UK context) domestic refuse and special wastes. This section will address:

The types of waste material which are likely to be created;

A projection of the amount of wastes likely to be generated, and

The options for handling and disposal.

1.1 Definitions

For the purpose of this document, general waste will be used to describe non-hazardous wastes such as paper, putrescible wastes and inert materials such as rubble and scrap metal. Special wastes are considered as those which are hazardous to the environment and potentially dangerous, for example oil, solvents and chemicals. Waste oil and oil contaminated water are given special consideration. The remainder of this report has the following structure:

Section 2:	Lists the data sources and evaluation methods;
Section 3:	Discusses the generic types of waste arising from the oil and gas industry, and
Section 4:	Estimates the amount of waste likely to be generated by the anticipated oil and gas industry in the Falklands and discusses disposal options.

2. DATA SOURCES AND METHODS

The following is based on information obtained from:

United Kingdom Offshore Oil Operators Association, Waste Management Study
Lasmo Oil;
Orcal Fuels Ltd; and
UK Waste.

Information was obtained by telephone consultations and site visits undertaken during September and October 1997. The purpose of the consultations was to identify the waste streams from hydrocarbons exploration and production. By relating the types and volumes of waste to the amount and type of activity, the characteristics of the waste produced in the Falklands can be estimated

The UKOOA waste study provided detail of the waste derived form the UK oil and gas installations, broken down by the type of waste and by the harbour where it is received. These data include the waste derived from both exploration and production and represents the situation from a mature state of development. It does not take into account waste from supply and standby vessels, consequently waste oils and oil contaminated bilge water are treated separately.

The information obtained from Lasmo Oil related to the current exploration program in the Falkland Island territorial waters. Orcal Fuels Ltd collect waste oil from Harbour and have recently completed a study on the volumes of oil and oily waste generated from the harbour collections . These data have been produced on a sectorial basis separating inputs from the hydrocarbons industry vessels. UK Waste handle general and special waste from offshore installations.

Assumptions have been made in the interpretation of the data. These will be discussed in more detail in the relevant sections of the report.

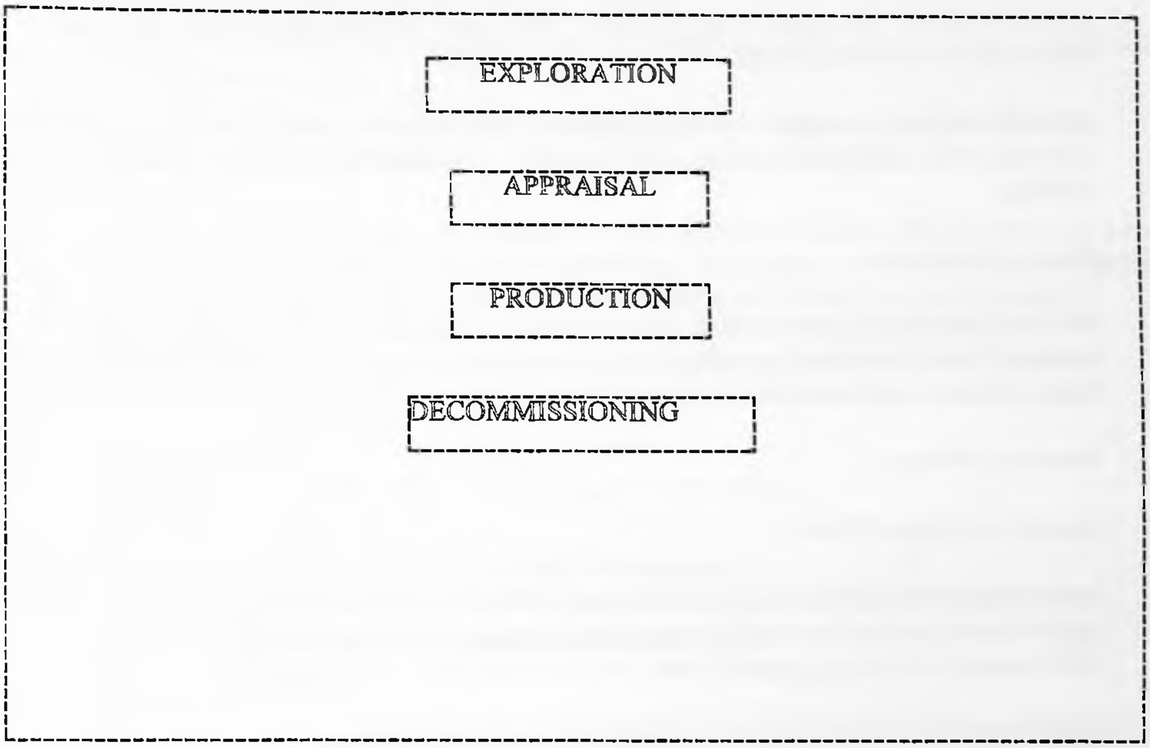
3. WASTE PRODUCTION IN THE HYDROCARBONS INDUSTRY

3.1 Overview

In order to understand the implications of the hydrocarbons industry for the Falklands it is necessary to briefly describe the types of activities involved in the exploration and production process.

Offshore exploration and production of hydrocarbons have a number of distinct phases as described below, all of which are responsible for generating waste.

Figure 1: Phases in oil and gas exploration and production



The different phases are considered in more detail as follows.

3.1.1 Exploration and Appraisal

Geological information is used to identify the depth and location of potential oil and gas reservoirs. Exploration and appraisal will usually involve a program of drilling designed to identify the nature location extent and economic viability of a hydrocarbons reservoir. The program will involve the drilling of one or more wells from a mobile drilling rig, which is temporarily moved into location. The nature of this drilling vessel will depend on the water depth and operating conditions.

Once the drilling rig is in position and preparations have been completed, the well will be drilled. Down-hole conditions are analysed and the presence and extent of hydrocarbons assessed. If the indications are favourable that an economically viable reservoir is present then further appraisal drilling will be undertaken.

If viable the field is likely to be progressed to the next stage of development, production. In common with all offshore operations, exploration and appraisal drilling are mainly supported and re-supplied by sea. The highly specialist nature of the industry requires support from industry specific supply bases which will have access to specialist technical and logistical facilities.

3.1.2 Production

Production involves the placement of a more permanent installation in a suitable position within the field. In many cases, these are fixed installations of steel or concrete, which stand on the seabed. Modern trends in production platform design include Floating Production and Storage Vessels (FPSV) which resemble tankers which have been tethered to the seabed with anchors. These are coupled to subsea wellheads via flexible pipes through which the hydrocarbons are conveyed to storage tanks. These newer designs require fewer personnel and may be used in deep water.

Some drilling may be required during production for a variety of technical reasons. For the purposes of this study this drilling activity would be considered similar to the exploration drilling.

3.1.3 Decommissioning

When the field has reached the end of its economic life the installations may have to be removed from the seabed, depending on the local environmental requirements. In the case of fixed platforms, this produces a very large volume of waste material.

3.2 Sources of Waste

3.2.1 General and Special Waste

During exploration and production solid waste will be derived from the domestic and operational sources on the installation and will comprise of a mixture of different types of refuse material including organic mater, contaminated containers, plastics, metals and paper.

Solid waste is usually segregated into special, metaliferous and other i.e. general. Galley waste is often macerated and disposed of to the sea. Other controlled waste may be compacted and stored in covered skips, back-loaded for transport onshore. Black water from the sewage system usually to a sewage treatment unit. The waste is macerated, treated and then discharged to the sea.

Inorganic salts will, under some conditions, build up on pieces of equipment exposed to reservoir water. This process concentrates naturally occurring radioactive salts, which are co-precipitated. The resulting scale is low level radioactive waste and has to be removed periodically at specialist treatment centres.

The amounts of waste material created during decommissioning are significant and will consist of a variety of substances, mainly metal or concrete.

3.2.2 Waste Oil and Oil Contaminated Materials

Supply and standby vessels will also produce a volume of waste oil and oil contaminated water.

Surface drainage on installations, which may contain oil and chemical residues, is collected and settled into water, oil and solids by gravity. Oil is stored and transported to shore for disposal. The water phase is pumped to the waste-water tank, treated and discharged overboard. In most modern systems, the water is automatically tested and in the event that the oil content exceeds 15mg/l (ppm), it is automatically fed back to the waste-water tank for re-treatment. Separated oil is discharged automatically to the waste.

The nature of oil spillages, which may occur during exploration, can be regarded as falling into two types. A very unlikely but potentially significant spillage occurring due to a loss of well control and less rare, but very much smaller accidental spillages occurring for example during loading of fuels and lubes.

Oil spillages are often combated with absorbent materials which would be regarded as special waste. If oil reaches the shore, sand and strand-line debris may be contaminated and require disposal.

3.2.3 Drill Cuttings and Drilling Fluids

Except during the drilling of the top section of the well (the tophole), the drill stem (the metal tubes carrying the drill bit) is enclosed in a casing. The casing rises to the base of the drilling vessel to form a closed system allowing the circulation of drilling fluid (see Figure 2). Drilling fluid has four main purposes:

Lubrication of the drill bit;

Removal of the broken rock (cuttings) to the surface;

Prevention of the sudden escape of oil and gas,

Maintenance of the physical integrity of the well

Drilling fluids are composite liquids consisting mainly of a base liquid and a bulking agent. The base liquid is usually water or low toxicity oil. A variety of other substances can be added to the fluid and the precise formulation depends on a number of factors such as the geological conditions, well conditions, and environmental constraints.

Typical drilling fluid additives for a single well site drilled with water based mud are listed in Table 1. All the constituents listed in this case are approved by MAFF. They are also designated as having very low environmental toxicity graded 0 or 1 under the Offshore Chemical Notification Scheme (OSCNS) administered by MAFF and most are on the Paris Commission (PAR COM) Green List which identifies the least environmentally damaging products available.

Table 1. **Typical water based drilling mud constituents.**

Product	Chemical name	Function	OCNS/PARCOM rating
Bentonite	Sodium montrofilonite	Viscosifier	0/Green List
Caustic Soda	Sodium hydroxide	pH control	1/Green List
Soda ash	Sodium carbonate	Calcium ion removal	1/Green List
CMC (hv)	Sodium carboxymethyl cellulose	Fluid loss control	0/Green List
KCL Brine	Potassium chloride	Scale inhibitor	0/Green List
Dextrid	Modified potato starch	Filtration control	1
PAC-l/r	Polyanionic cellulose	Filtration control	0/Green List
XC Polymer	Xanthan gum	Viscosifier	0/Green List
DCP 202 (Glycol)	Polyethylene glycol	Scale stabiliser	0
Baracarb	Calcium carbonate	Weighting agent	0/Green List
Barite	Barium sulphate	Weighting agent	0/Green List
Barascav D	Sodium sulphide	Oxygen scavenger	0
Barofibre	Pulverised cellulose	Lost circulation material	0
Baradefoam	Alcohol/fatty acid	Defoaming agent	0
Con Det	Anionic surfactant	Detergent	0
Guar Gum	Guar Gum	Viscosifier	0

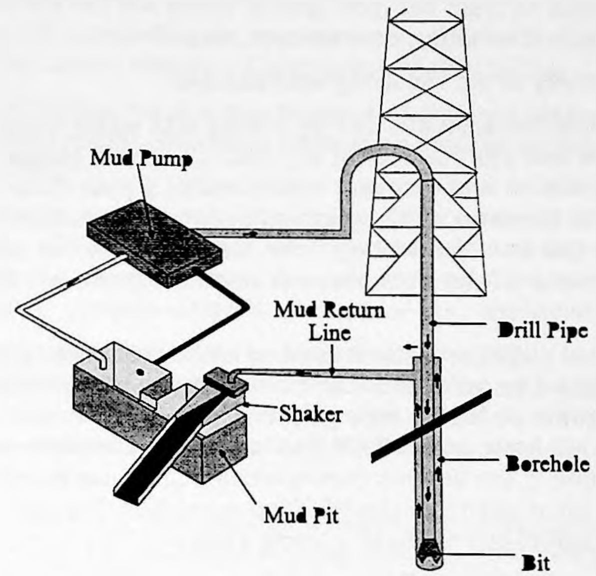


Figure 2. Schematic of drilling mud system

Drilling fluid is pumped down the centre of the drill pipe and picks up cuttings from the bottom of the well which are carried to the surface with the returning flow between the drill pipe and the casing (see Figure 3). During the initial stage (spudding), the drilling fluid and cuttings are discharged onto the seabed. Once the top hole has been completed, a length of casing is added from the drill floor to the bottom of the first section providing a closed system for the circulation of drilling fluid.

Excess drilling fluid, are often formulated. This, in combination to the washings from storage tanks requires specialist disposal onshore.

In addition to oil produced on the installation, supply, and standby vessels will also produce waste drilling mud residues from tank washings.

3.3 Impacts of Waste

3.3.1 Impacts of Drill Cuttings Disposal

The cuttings and drilling fluid are separated in the solids control unit although a small amount of drilling fluid will remain on the cuttings after treatment. The cuttings are usually then discharged through a pipe extending 15m below the sea surface. The recovered drilling fluid may be re-conditioned and re-used if possible. Volumes of drill cuttings discharged during the drilling of a single well will be approximately 400 – 1000 tonnes which assuming a specific gravity of 2 will equate to 200 –500 m^3.

The operational discharge of cuttings and drill fluid constituents can occur throughout the exploration and production process although most drilling takes place prior to the production phase.

In general, drilling fluids and cuttings have two main impacts on the receiving aquatic environment. Firstly, toxic effects may occur due to constituents of the drilling fluid particularly if oil based muds are used, and secondly there is potential for a smothering effect on benthic fauna by fine particulate material in areas adjacent to the well. The magnitude of the impact will depend on several factors:

The nature of the amounts of toxic material on the cuttings;

The amount of material deposited which is related to the amount of drilling activity;

Dispersion in the marine environment; and

The sensitivity of the receiving environment.

Studies suggest that the area effected by drilling with water based muds is confined to within 100m of the well site (Gillmor *et al*, 1985; Daan and Mulder, 1993a) and complete re-colonisation and recovery occurs within a year (Daan and Mulder, 1993b). Currents determine the area within which cuttings initially accumulate and subsequently the rate at which cuttings may disperse from this zone. The main impact on the benthic infauna will be from physical smothering and will be restricted to the areas where this is severe.

With the disposal of cuttings contaminated by oil based muds, gross changes to benthic communities can occur at 500m from the point of discharge and subtle changes further away, at 1000m for production platforms. In addition to smothering, base oil residues will have toxic effect, and will cause enrichment of the sediment and subsequent changes in the benthic communities. Chemical monitoring has revealed base oil residues have been identified 2000m away from the point of discharge on the direction of the residual current flow (Cairns 1992).

As with water based muds the impacts will depend on the amount of drilling activity, and therefore the amount of material deposited.

The significance of the impacts will depend on the sensitivity of the seabed habitat and marine resources in the area of the discharge. In highly sensitive areas where, for example, valuable fisheries resources are vulnerable, the use of 'Zero Discharge' techniques may be considered. In these circumstances, the drill cuttings may be re-injected into the well or returned to the shore for recovery of mud constituents and disposal on land under controlled conditions. This approach is justified where there are no alternative, less sensitive locations for the drilling operations.

4. ANALYSIS OF WASTE ARISINGS

4.1 General and Special Waste

UKOOA have analysed the waste arising from the main oil and gas industry ports and harbours in the UK accounting for approximately 70% of the total number of installation in the United Kingdom Continental Shelf (UKCS).

Table A1.1 summarises the average tonnage of different kinds of waste, which are produced for every million tons of oil production (figures include the gas production as crude oil equivalent).

These data indicate that the generation of 'general waste' at 309.16 tns/10^6tnsoil is the largest category. This is expected, as 'general waste' will include the broadest range of waste. Scrap metal accounts for the second largest amount generated at 138.2tns/10^6tnsoil. Special waste is an order of magnitude less at 12.28 tns/10^6tnsoil.

In total there were 26 installations contributing to the 25263 tonnes of waste landed in Aberdeen in 1994 accounting for 38% of the UKCS waste production (Table A1.2). The 26 installations consisting of 9 drilling rigs, 15 production platforms, and 2 accommodation platforms and equalled 21% percent of the UKCS installations in the study (UKOOA 1995).

Table A1.3 illustrates that the average tonnage of waste produced per installation varies widely. It can be suggested that the different harbours predominately serve different areas of the UKCS as summarised in Table 2. It can be concluded therefore, that the amount of waste produced per installation by the Northern North Sea oil fields served by Aberdeen, Lerwick and Peterhead is higher than the Southern North Sea and Irish Sea gas fields.

Table 2: Oil and gas production areas served by UK ports

Port	Area
Aberdeen	Central/Northern North Sea oil and gas fields
Great Yarmouth	Southern North Sea gas fields
Heysham	Irish Sea gas fields
Lerwick	East Shetlands Basin Oil Fields
Lowestoft	Southern North Sea gas fields
Peterhead	Central and Northern North Sea oil fields

This suggests a relationship between the type of offshore operation and the amount of waste generated.

The analysis of these figures does provide a model for estimating the waste arisings for the Falklands based on the number of installations and the amount of oil/gas produced. However, there are a number of potential causes of error.

The UKOOA data and the results of the consultations for this study are based in part on estimations and inevitably inaccuracies will result in derived figures. Initially the oil and gas industry will be in an exploration phase in which the characteristics of the waste produced will be different from more mature operating areas. Secondly, the nature of the developments in the Falklands are likely to be different in comparison with the North Sea fields due to advances in production technology which have realised improvements in efficiency of both manpower and materials.

FIG awarded licenses for oil and gas exploration in 1996. The concessions available were to the north west of the islands and over 150km offshore. The first exploration drilling by a consortium of oil companies is due to take place in 1998. A further round of licensing will include concessions to the south west of the islands.

The wastes, generated during a typical exploration program in the Falkland Islands are estimated below in Table 3.

Table 3: Summary of anticipated wastes from Lasmo exploration rig Borny Dolphin[1]

	Galley waste	Cuttings	Deck waste	Metal	Special waste
Rig	Disposed to sea	Disposed to sea	123	18	6
Standby vessels	Disposed to sea	Disposed to sea	0	1	0
Supply vessels	Disposed to sea	Disposed to sea	0	1	1
Total tonnes		3044	123	20	7

[1] Data ERT 1997

The potential size and nature of the oil and gas resources around the Falklands is largely unknown at present and is unlikely to be remain so, until exploration activity has been completed in a number of locations.

The socio-economic Study undertaken by Coopers & Lybrand in Augst 1997 suggests two possible oil scenarios - a modest oil find and a large oil find. The modest oil find assumes a 200 million barrel field with one production rig. The large oil find assumes a 1 billion barrel field with four production rigs.

The amount of waste generated according to this scenario is estimated in Table 4.

The figures are estimated, from the estimations of waste arising per installation from: the UKCS, Aberdeen (highest) and Lowestoft (lowest).

These figures are estimates only and will be heavily depended on the nature of the operations, which are eventually developed. General waste production will be between 300 and 2500 tonnes and special waste from installations alone will be approximately 50 tonnes. Typical constituents of special waste passing through Aberdeen are listed in Table 5.

Table 4: **Projections for annual waste produced by Falklands oil and gas industry based on average of UKCS, Aberdeen and Lowestoft.**

Waste	Falklands projection	UKCS average	Aberdeen	Lowestoft
General, tonnes	350	1400	2300	350
Metal, tonnes	160	640	1400	180
Drums, tonnes	7	28	65	0
Special, tonnes	14	56	45	60
Wood, tonnes	2	8	9	0
Paper, tonnes	3	12	30	12
Total	546	2184	3850	600
Oily water, litre	160,000			
Oily waste,litre	320,000			

Figures exclude Waste oil based mud, brine and tank washings

Table 5: Oil and gas industry special waste passing through Aberdeen Harbour per month

Waste type	Quantity	Comments
Special waste[1]	100 tonnes	Flammable liquids, stabilisation chemicals, contaminated pigs, corrosive chemicals, oil rags and filters, anti freeze
Oily water	100,000 litre	50 supply boats
Oil waste[2]	250,000 litre	50 supply boats plus arisings from installations

[1]UK Waste Aberdeen

[2]Orcal Fuels Ltd

4.1.1 Waste Oil and Oil Contaminated Materials

Using the data from Orcal Fuels for Aberdeen Harbour in Table 5 it can be calculated that each the activities required to run each installation, supplied from Aberdeen, will contribute an estimated 82,000 litres per year[1] of waste oil and 40,500 litres of oil contaminated water per year.

The annual waste oil and oil contaminated bilge water production anticipated for the Falklands oil and gas industry is predicted from the data for Aberdeen (Table 5) at approximately 500 tonnes. It should be noted that these data include waste from the supply and standby fleet which were not included in the UKOOA figures for special waste.

Although a serious oil spillage is unlikely, the amount of contaminated material generated if the spill impacted land, could be considerable. In the context of the Falklands, a loss of well control or 'blow out' in the south west of the Islands would be most likely to result in an impact to the coast. The potential availability of rig to drill a relief well is limited so such an incident could result in a very large spill, which could impact a large area of coast.

It is difficult to predict the amount of contaminated material that would result from such a spill however it is speculated it could be in the order of 10,000 to 100,000 tonnes created as oil mixes with strand-line detritus and sediment.

4.1.2 Drill Cuttings and Drilling Fluids

Referring to Table A1.3 it is estimated that each installation supplied from Aberdeen produces an average of 444.3 tonnes of waste bulk drilling fluid and tank washings per year. According to the projected offshore oil and gas production activity for the Falklands an estimation of 1777.2 Tonnes/yr can be made. However these data are subject to inherent imprecision and should be interpreted with care, (see page 7 of the UKOOA study).

The amounts of contaminated drill cuttings generated depend on the number and depth of wells drilled. This could be as many as 40 per installation[2]. If each well generates an average of 750 tonnes of cuttings this equals 120,000 tonnes for the four installations

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[1] Based on 26 installations from the UKOOA study equalling 70% therefore (26÷70) x 100 =37 installations

[2] Confidential source based on Northern North Sea FPSV

anticipated. Again, these figures will be subject to significant variation.

4.1.3 Decommissioning

The amount of waste generated during decommissioning is likely to be reduced significantly with modern designs of installation. Floating installations would be moved at the end of the viability of the well and located elsewhere. There may be some subsea installations which cannot be moved.

4.2 Disposal Options

4.2.1 General and Special Waste

Initial exploration activity will be supplied and supported from outside the Falklands. Small amounts of general waste could be received on the Falklands if suitable handling facilities were available. All special waste including oil would be returned to the UK or South America for specialist disposal.The source and treatment options of the various streams generated offshore are listed in Table 6.

In the longer term, the potential for the Falklands to develop significant waste handling infrastructure for the oil and gas industry will depend on the extent to which the islands have a supply function. If vessels were returning to the Falklands for other supplies then it could be expedient to back-load some of the waste at the same time.

Special waste requiring specialist handling and equipment is unlikely to be disposed of in the Falklands except for some oily waste. A key to the development of waste handling facilities would be segregation of waste offshore. Facilities would be more viable if they were concentrated on the types of waste, which could be of economic value to the islands i.e. wood.

Shetland Isles have invested in waste management facilities, including an incinerator, drilling mud recycling facilities, partly in response to the demands of the oil and gas industry. However, the scale of the industry in the Shetlands is greater than that predicted for Falklands

There are therefore three scenarios for the development of waste disposal facilities.

Low level occasional use of existing facilities for general waste. Some treatment of oily waste, under the MARPOL convention.

Intermediate waste handling and transfer as part of supply function. Disposal facilities for certain kinds of waste.

Specific waste treatment and disposal facilities to support oil and gas industry.

4.2.2 Waste Oil and Oil Contaminated Material

Port reception facilities for waste oil and oil contaminated bilge water are a requirement of MARPOL. This should be constructed with sufficient capacity to handle the anticipated loading from the offshore oil and gas related traffic and other marine traffic. Whether this waste oil would be suitable as a fuel would depend on its quality and the nature of the treatment. Refining to constant standard is not considered viable on the Falklands. A schematic design for a waste oil treatment system is provided in Appendix Two.

Table 6: Summary of waste streams, sources, treatment and disposal routes from offshore operations.

Waste	Source	Treatment
Used mud and tank washings	Storage tanks	Return to shore, re-use or landfill
Contaminated cuttings	Exploration and drilling	Separation of mud and disposal of cuttings to seabed
Contaminated cuttings in environmentally sensitive areas	Exploration and drilling	Return to shore for separation of mud and landfill of residues
Oily water	Bilges and drainage	Return to shore, separation, re-use,landfill, incineration
Special wastes	Oils, chemicals and contaminated materials	Return to shore, incineration, landfill
Low level radioactive scale	Pipe cleaning	Specialist treatment and disposal
Oil contaminated soil/detritus	Spills	Landfill, bioremediation, chemical treatment
Organic waste	Galley waste, packaging, waste paper	Landfill, incineration
Scrap metal	Operational	Re-use
Scrap metal	Decommissioning	Re-use or sea disposal

In case of a serious oil spill a proportion of the contamination would weather naturally, however if it was necessary to remove and dispose of oiled material, this could cause significant logistical difficulties.

Options for disposal would include:

Local burying;

Transport to lined landfill, and

Offsite treatment.

4.2.3 Drill cuttings

Currently the drilling operations planned are anticipated to use water based mud, which will be discharged, to sea. The offshore disposal of drill cuttings contaminated with water based mud is not considered to pose a threat to the marine environment unless the environment is exceptionally sensitive. In this case a zero discharge approach may be considered if the location of the drilling operation cannot be moved to alternate, less sensitive position. The contaminated cuttings would require landfill.

In some circumstances, it may be necessary to use oil-based muds. The impacts will depend on the sensitivity of the receiving environment, the degree and extent of contamination. Zero discharge wells drilled with oil based mud.

Waste drilling fluids and contaminated cuttings would require special treatment and handling, although it is envisaged that tank-cleaningresidues could be collected in the Falklands and shipped in bulk to a treatment centre elsewhere.

4.2.4 Decommissioning

The role of waste disposal infrastructure in the Falkland in decommissioning will depend on its prior development to support operations. It is unlikely that there would be significant requirement for specialist facilities for decommissioning alone.

4.2.5 Oil treatment

The above is a suggested schematic diagram for an oil contaminated water treatment system which should be capable of producing water quality of 2ppm oil.

Oil and oil contaminated water are held separately. The oil-contaminated water is initially subject to gravity separation. Recovered oil is returned to the oil storage tank, the water fraction is passed to an ultra-filtration or de-emulsification step. Oil recovered from this step is pumped to the oil tank. The waste-water is passed through a carbon filter and then discharged to the environment.

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APPENDIX 1 : ANALYSIS OF WASTE ARISING FROM UKCS OIL AND GAS EXPLORATION

Table A1.1 **Waste produced by category and port for UKCS oil and Gas Exploration[1,2] and equivalent tonnage waste produced per tonne oil and gas production**

Waste	Aberdeen	Great Yarmouth	Heysham	Lerwick	Lowestoft	Peterhead	Total tonnes	Total per million tonnes oil
General	14990	3580	2300	8406	1513	11875	42664	309
Metal	9306	406	160	664	784	7757	19077	138
Drums	421	56	8	0	0	388	873	6
Special	294	77	83	79	257	904	1694	12
Wood	58	51	60	0	0	20	189	1
Paper	194	20	0	0	50	79	343	2
Drilling fluids	11550	12106	98	391	493	209214	233762	1690

[1]UKOOA 1995

[2]Figures exclude Waste oil based mud, brine and tank washings

[3]Figures based on 1991 production figures for oil and gas, gas as crude oil equivalents 138.6 x10^6 tonnes, Source DTI 1992

Table A1.2 **Percentage waste produced by category and port for UKCS oil and Gas Exploration[1,2]**

Waste	Aberdeen	Great Yarmouth	Heysham	Lerwick	Lowestoft	Peterhead
	%	%	%	%	%	%
UK Installations	22	19	8	17	14	21
General	35	8	5	20	4	28
Metal	49	2	1	3	4	41
Drums	49	6	1	0	0	44
Special	17	4	5	5	15	53
Wood	31	27	32	0	0	11
Paper	57	6	0	0	15	23

[1]UKOOA 1995

[2]Figures exclude Waste oil based mud, brine and tank washings

Table A1.3 Average tonnage waste produced by per installation and port for UKCS oil and Gas Exploration per year[1,2]

Waste	Aberdeen	Great Yarmouth	Heysham	Lerwick	Lowestoft	Peterhead	Total
Number of Installations	26	23	10	20	17	25	121
General	576	156	230	420	89	475	
Metal	357	18	16	33	46	310	
Drums	16	2	1	0	0	16	
Special	11	3	8	4	15	36	
Wood	2	2	6	0	0	1	
Paper	7	1	0	0	3	3	
Drilling fluids	444	526	10	20	29	8364	

[1]UKOOA 1995

[2]Figures exclude Waste oil based mud, brine and tank washings

APPENDIX H

PART 1 : TERMS OF REFERENCE OF MAIN STUDY

PART 2 : TERMS OF REFERENCE OF ADDITIONAL TASKS

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THE FALKLAND ISLANDS: WASTE MANAGEMENT AND DISPOSAL

1. THE APPOINTMENT OF CONSULTANTS AND TERMS OF REFERENCE ("TORs")

A. The Falkland Islands Government wishes to appoint a consultant or firm of consultants ("the Consultants") to advise it as to the policies and strategies it should adopt and the steps it should take (including the provision of facilities, the acquisition of equipment and the contents of any local legislation it may be necessary to enact) to introduce and maintain Waste Management and Disposal systems resulting in environmentally acceptable practices, consistent with relevant international obligations and suitable to the circumstances of the Falkland Islands. While the "BATNIEC" (Best Available Technology Not Involving Excessive Cost) principle may be expected to apply, solutions involving a "trade off" of higher capital investment for a lower ongoing labour requirement may need to be considered where appropriate in the light of the shortage of labour in the Falkland Islands.

B. Persons or firms interested in appointment as the Consultants are invited to write to the Chief Executive, Falkland Islands Government, The Secretariat, Stanley, Falkland Islands so as to reach him before 28th February 1997. Interested persons or firms should demonstrate knowledge and experience in relation to the identification of waste streams and the management and disposal of hazardous waste, industrial waste, trade and office waste and domestic waste. Experience in relation to the disposal ashore of ship-derived waste and the disposal of wastes derived from offshore petroleum exploration and production operations would be particularly useful as would experience of problems related to waste disposal in a remote community. Applications should include relevant particulars of the personnel who would be assigned to the consultancy, the remuneration or basis of remuneration expected, the period of time expected to be occupied by the consultancy, any stages into which the applicant would propose to divide it, and the anticipated overall cost of the consultancy to the Falkland Islands Government. A fixed fee basis would be preferred but other bases of remuneration (e.g. day rates) will be considered. The Falkland Islands Government does not bind itself to appoint any applicant, but expects to appoint the Consultants by about the end of March 1997.

C. **The Terms of Reference** for the Consultancy ("TORs") are so far as is consistent with the BATNIEC principle (as qualified in paragraph 1.A above)—

> 1. To devise a National Waste Strategy for the Falkland Islands covering all existing and presently identifiable future waste streams (with the exception, subject to possible co-operation in relation to reuse or recycling of any wastes either in the Falkland Islands or overseas, of

any waste streams in relation to which the military are responsible for management and disposal of waste) such Strategy—

(a) to propose appropriate arrangements in relation to the management and disposal of hazardous waste of all kind, industrial waste, domestic waste, office waste and trade waste;

(b) be designed in such a way that (if the Strategy is implemented) waste of all kinds occurring in the Falkland Islands will be recovered or disposed of in such a way as not to endanger human health without the use of processes or methods which could harm the environment and, in particular, without—

(i) risk to water, air, soil, plants or animals;

(ii) causing nuisance through noise or odours;

(iii) adversely affecting the landscape or places of special interest;

(c) to encourage the development of appropriate techniques for the final disposal of dangerous substances contained in waste designed for recovery,

and without prejudice to the generality of the foregoing—

2. To include in the Strategy measures or proposals to encourage the recovery of waste by means of recycling, reuse or reclamation or any other process and the use of waste as a source of energy so far as the Consultants consider that they may be practicable in the circumstances of the remoteness of the Falkland Islands, the size and distribution of their population, the lack of local industry and the volume of wastes of various categories produced.

3. To address in particular the institution of proper measures for dealing with hazardous waste occurring in the Falkland Islands, its handling, treatment and disposal whether in the Falkland Islands or overseas and for that purpose to identify the waste streams and categories of hazardous waste it is necessary to take into account.

4. In so far as the Consultants may come to the conclusion that any hazardous waste cannot economically be disposed of in the Falkland Islands without danger to human health or unacceptable harm to the environment, to examine the possibility and practicability of making arrangements for that waste to be dealt with overseas and, in that connection to advise—

(a) whether the Falkland Islands should request the United Kingdom Government to apply the Convention on the Transboundary Movement of Hazardous Waste (the Basel Convention) to the Falkland Islands; and

(b) as to the administrative procedures and legislation (in outline, by reference if appropriate to a model or models elsewhere) which would be required and other implications for the Falkland Islands of adherence to the Convention.

5. To consider the existing situation at the Eliza Cove tip/landfill site and Mary Hill Quarry tip and to advise what steps should be taken in relation to their future operation and management, including the acquisition of any appropriate equipment and staffing.

6. To advise whether new legislation as to waste management and disposal is necessary (beyond that which may be advised by virtue of TOR 4(b)) and, if so, to indicate its contents (in outline) and identify any appropriate model or models for it.

7. To advise—

(a) whether the incinerator described in Annex 1 has any utility for the disposal of waste (e.g. as a relatively portable incinerator which could acceptably be used for the disposal of hazardous waste *in situ*);

(b) as to the need (or otherwise) to acquire a further incinerator, its siting, specifications, operating criteria and likely cost and whether any such incinerator (if sited elsewhere (e.g. at the Eliza Cove site), could acceptably be used for incineration of waste from the proposed new Abattoir.

8. To advise what facilities (if any) need to be provided by the Falkland Islands Government—

(a) having regard to its obligations under MARPOL, for the reception of oily waste from ships;

(b) for the reception of oily waste from the civilian community

and any possibilities for the reuse or recycling of such waste.

9. To advise what facilities (if any), having regard to its obligations under MARPOL, need to be provided by the Falkland Islands Government for the reception of garbage from ships.

10. To advise what steps (if any) the Falkland Islands Government needs to take in relation to its obligations under the Vienna Convention (and Montreal Protocol) as to the Ozone Layer (e.g. as to disposal of wastes which may contain CFC's or halons).

11. To advise on the possibility, on an organised basis, of economic reuse or recycling of scrap metal (for example beverage cans) and other materials either locally or by export overseas for the purpose.

12. To advise as to possible methods of disposal of supplies of sheep-dip containing organo-phosphates, scattered at various locations in the Falkland Islands, which are known to be in deteriorating containers.

13. To advise on any viable alternatives to disposal by landfill which may be available and as to practicable methods of reducing the volume of material, not recovered, reused or incinerated, disposed of to landfill.

14. To advise as to any opportunities of co-operation between the Falkland Islands Government and the military, as to the management and disposal of waste in the Falkland Islands.

15. To advise as to the measures (including provision of facilities and imposition of requirements) which ought to be taken by the Falkland Islands Government in relation to the disposal of wastes arising from the exploration for and exploitation of petroleum in the waters surrounding the Falkland Islands and from British Antarctic Survey Bases in Antarctica, at present transported for disposal at the military landfill/tip at Mount Pleasant.

16. To advise on the number, experience and training of staff which would be required to implement the Waste Management and Disposal Strategy advised by the Consultants

D. Information on the Falkland Islands and the present situation in relation to Waste Disposal and Management in the Falkland Islands is contained in the following paragraphs and where appropriate is cross-referenced to the relevant TOR. Further information is available on request through the Chief Executive, Falkland Islands Government, at the address given above (Fax: 27109).

2. THE FALKLAND ISLANDS

A. The Falkland Islands are a group of about 320 islands of various sizes, 12 of which are inhabited, lying between 51° and 53° 30' South and 57° 40' and 61° 20' West. The islands have a total land area of approximately 4,750 square miles (approximately equal to that of Northern Ireland) and cover an area of land and ocean about equal to that of Wales. The ordinary population of the islands is 2,221 of whom 1,636 live in the town of Stanley. In addition there are approximately 2,000 persons constituting the military garrison and the personnel of their civilian contractors. Most of these live at Mount Pleasant, 35 miles to the west of Stanley on the island of East Falkland, but there are three mountain-top radar sites. There are small civilian settlements at Fitzroy, Goose Green, North Arm and Walker Creek (in East Falkland) and at Port Howard, Fox Bay East, Fox Bay West, Port Stephens and Hill Cove in West Falkland.

B. The Falkland Islands are a colony (dependent territory) of the United Kingdom which is responsible for the islands' defence and external affairs. The Falkland Islands for all practical purposes have full internal self-government. There are no local authorities, so that in relation to internal matters (including waste management and disposal) the Falkland Islands Government is the unitary authority. While the military and their civilian contractors are de facto responsible for their own waste disposal arrangements, a national waste disposal strategy needs to take them into account.

C. One or more visits to the Falkland Islands by the Consultants are likely to be necessary. It is unlikely that the consultancy could satisfactorily be performed purely as a "desk study". An air service by RAF Tristar provides an airlink between the United Kingdom and the Falkland Islands from RAF Brize Norton and the Falkland Islands via Ascension Island. A limited number of civilian passengers are carried on these flights (frequency approximately six flights per four week period) and bookings can be made via the Travel Co-ordinator, Falkland Islands Government Office, 14 Broadway, London SW1H 0BH (Tel: 0171 222 2542, Fax: 0171 222 2375). At certain times of year (particularly in December and January) seats are in short supply.

D. In addition, the British Airways flight on Tuesday nights from London Heathrow on Tuesday nights to Santiago in Chile connects and interlines there with Aerovias DAP's flight via Punta Arenas to the Falkland Islands, arriving in the Falkland Islands on Wednesday evenings (the return Aerovias Dap flight to Santiago departs on Thursday mornings).

E. Stanley Harbour constitutes the major civilian port in the Falkland Islands and there is a military port at Mare Harbour 8 miles from Mount Pleasant. Vessels carrying civilian cargo come to the Falkland Islands about every month or six weeks. Shipping services are operated under charter by Darwin Shipping, a subsidiary of the Falkland Islands Company Limited and by Hogg Robinson Transport. Wool constitutes the only major return cargo and vessels leave partially empty and endeavour to pick up cargo in South America. In addition Berkeley Sound on East Falkland is a major fishing port where fishing vessels fishing in the Falkland Islands fishing waters transfer their catch to reefers, pick up some local supplies taken from Stanley by launch or tender and bunker with fuel.

3. SOURCES OF WASTE IN THE FALKLAND ISLANDS

A. There are at present four sources of waste in the Falkland Islands:

(i) the civilian population;

(ii) the military garrison and their associated contractors;

(iii) the fishing fleet operating in Falkland Islands' waters;

(iv) merchant shipping visiting the Falkland Islands.

There may well, within the next few years, be a fifth: the offshore petroleum exploration and production industry.

B. The waste produced by the civilian community may be divided into hazardous waste, industrial waste and domestic waste. For present purposes "hazardous waste" is defined as:

> any gaseous, liquid or solid waste, which because of its quantity, physical, chemical or infectious characteristics can result in hazards to human health or the environment when improperly handled, stored, transported, treated or disposed of.
>
> *(it is believed that that the above definition will include all substances which are "hazardous wastes" for the purposes of the 1989 Basel Convention, mentioned below)*

C. No special facilities for the disposal of hazardous waste (except for medical waste at the King Edward VII Memorial Hospital Stanley where there is a small incinerator) have yet been provided by the Falkland Islands Government. The Consultants advice is requested as to suitable arrangements for the management and disposal of hazardous waste (*see* TOR 3) It is understood that the United Kingdom has not yet applied the Convention on the Control of Transboundary Movement of Hazardous Waste (1989) to the Falkland Islands, but that if it is necessary, in the circumstances of the Falkland Islands, to export such wastes falling within the category of hazardous wastes for treatment or disposal, rather than treating and disposing of them locally, adherence to the Convention and compliance with its terms may be appropriate. (*see* TOR 4(a)). Suitable local legislation might then be required (*see* TOR 4(b)). It is thought that the same categories of hazardous waste may be found in the civilian community in the Falkland Islands as might be expected to be found in any village or small town in the western world. Examples of such hazardous waste are organic acids and alkalis (bases), chlorofluorocarbons (CFC's), nickel cadmium (Ni-Cd) and lithium batteries, empty containers ("container" for this purpose meaning a portable device in which a hazardous material is stored), paints and paint thinners and oily wastes. It is believed that Waste Streams 1, 3, 4, 5, 6, 8, 9, 12,13 and 16 in Table II.1 to the Convention exist in the civilian community in the Falkland Islands. The Consultants are asked (*see* TOR 3) after consideration of the circumstances of the Falkland Islands, following a visit or visits, to identify any other hazardous waste and Waste Streams which it is necessary to take into account in formulating a Waste Management and Disposal Strategy.

E. While the Falkland Islands possesses little that can be categorised as industry, there is of course a substantial amount of industrial waste in the civilian community (i.e. non-hazardous operational waste) such as scrap metal, wooden pallets, plastic and cardboard packaging. Some scrap metal is exported from time to time to Chile and some wooden pallets are re-used (e.g. for fencing purposes) or burnt as fuel, but there are no formal arrangements for re-use or recycling and the lack of facilities for local recycling means that a greater volume of waste has to be disposed of in other ways. The possibility of re-use or recycling a greater volume and variety of wastes needs to be investigated (*see* TOR 2).

F. Much the same applies in respect of office waste (e.g. used stationery, plastics, packaging materials, printer cartridges and toner for copying machines).

G. The Falkland Islands Government operates, through a contractor, a fortnightly domestic waste collection service in Stanley. At present each dwelling stores its domestic refuse for collection in old fuel barrels which are for the most part placed at or near the boundary of the property with the road or footpath. The barrels are collected on a flatbed trailer and taken to the tip at Eliza Cove, two miles south east of Stanley. This obviously environmentally unsatisfactory system is about to be replaced by a system using wheeled bins and a refuse lorry of a type familiar in the United Kingdom and elsewhere. At present, persons burn much of the refuse in the old fuel barrels, so as to make room for more refuse. As may be imagined, the fumes are extremely unpleasant and (in the case of burning of polystyrene and plastics) may be toxic. There is no garden refuse collection service, and no service for collection of old refrigerators, cookers, bedsteads and the like. Persons usually dispose of them by taking them themselves to the tip. Public access to the tip is unrestricted, and it may be if proper management of the tip is to be introduced (*see* TOR 5) public access to the tip may be prevented or at least restricted and consequentially consideration may have to be given to the provision of facilities convenient to the public for disposal of garden refuse and old refrigerators, cookers, deep-freezers and the like. There is no scrap-yard in operation.

H. Outside Stanley, there is no refuse collection service provided by the Falkland Islands Government. Each settlement and farm is responsible for making its own arrangements.

4. LEGISLATION APPLICABLE TO WASTE IN THE CIVILIAN COMMUNITY

A. In relation to waste produced in the civilian community, there is little applicable legislation. A building bylaw requires each dwellinghouse to be equipped with an ashpit for the reception of ash, but this is not now enforced. Twenty years ago, peat was the principal fuel used for cooking and heating, but its use is declining in favour of oil-fired or gas-fired appliances.

B. Under the Planning Ordinance 1991, (similar in general terms to corresponding English legislation) the establishment of a facilities for the disposal of refuse would constitute "development" requiring the grant of planning permission. An Environmental Impact Statement would almost certainly be required for anything but a very small waste disposal site. The Eliza Cove Tip was established shortly before the Ordinance came into force, did not require planning permission and consequently no conditions on its use and operation exist. No Environmental Impact Statement was obtained. The Consultants are asked (*see* TOR 6) to consider whether specific legislation in relation to waste management and disposal is necessary, or whether alternatively it may be dealt with administratively. (N.b. EC Directives 75/442/EEC ("the Waste Framework Directive") and amending Directive 91/156/EEC do not apply to the Falkland Islands. The United Kingdom legislation giving effect to the Directives (Part I of the Control of Pollution Act 1974 (the original Directive) and Part II of the Environmental Protection Act 1990) and which provides for a waste disposal licensing system may be too complex for Falkland Islands circumstances. It is thought that it might however be necessary to consider some legislation of that nature if it is necessary to apply the Basel Convention 1989 (see paragraph 3D above. Equally Directive 91/157/EEC (Batteries and Accumulators containing Dangerous Substances) and 91/689/EEC (Hazardous Waste) do not apply to the Falkland Islands, although the measures they enjoin may be ones which ought to be considered. (*see* TOR 6).).

5. THE ELIZA COVE TIP

Waste received at the Eliza Cove tip is not segregated into categories in any organised manner. Hazardous waste and non-hazardous waste are jumbled together and no efforts are made on any official basis for the reuse or recycling of waste dumped at the tip. Comparatively large amounts of uncovered refuse accumulate, including parts of animal carcasses slaughtered at the local slaughterhouse. These are eaten by scavenging seabirds which congregate at the tip in large numbers. Members of the public visit the tip to dump bulky items of various kinds. Others scavenge the tip for anything which may come in useful which has been dumped by somebody else. A bulldozer and operative (for landfill of the refuse) are in attendance during the working week, but no staff are in attendance at holidays and weekends. There is no incinerator, although quantities of refuse are burnt in the open air. The tip is said to be infested by rats, but perhaps due to its distance from the town no nuisance from them, or from smoke or smell generated by the tip has been experienced in Stanley. It is possible that the meat and other refuse dumped on the tip may be a breeding ground for the bluebottles (locally known as "blue buzzers") fairly plentiful in parts of Stanley during the summer months. The tip adjoins a beach and from time to time paper and plastic bags from the tip are blown on the beach. The beach is not accessible to the public because it is mined (and access to the tip is by road leading through a number of minefields). The soil of the tip is undoubtedly highly contaminated by hazardous waste. Some of this may leach into the sea, but no harmful effects to wildlife have been identified. Improvement in conditions at the tip is seen as urgent (*see* TOR 5). At present, heavier items are tipped at a disused quarry, Mary Hill Quarry, just over four miles east of Stanley, to the north of Stanley Airport. This tip is not thought to be satisfactorily managed, and may need to be closed.

6. WASTE OIL DISPOSAL

A. The Falkland Islands Government has recently acquired a waste oil burner to enable it to dispose of a quantity of old bunker fuel for sealers stored in a leaking tank at a long-disused sealing station, and it is possible that this may be useful for other waste disposal purposes (*see* TOR 7) Particulars of the waste oil burner are attached as Annex 1 . It is perhaps not suitable for general incineration purposes and perhaps consideration ought to be given to the installation of a rotary kiln incinerator at the Eliza Cove site or elsewhere. It will be necessary to consider whether legislation should be enacted as to the operation of such plants (vide Directive 94/67/EC and Part 1 Environmental Protection Act 1990, neither of which apply in the Falkland Islands), particularly as they may operated in the private sector (e.g. the oil exploration and production industry). It may be that the standards set out in Directive 94/67/EC would provide acceptable criteria in relation to the design/operation of any incinerator incinerating hazardous wastes in the Falkland Islands.

B. There may be a need to provide facilities for disposal of waste oil from ships (*see* TOR 8). At present no special facilities are provided for disposal of waste oil in the civilian community and, in Stanley, much of it is likely to find its way into the surface water system (which flows into the harbour) or onto the ground. Some people are known to dispose of waste motor oil and used cooking oil by pouring onto the ground at the Eliza Cove tip.

7. THE NEW ABATTOIR

A new abattoir is to be constructed to the west of Stanley to EC standards, funded by the EEC. It had been proposed that waste from the abattoir should be processed to provide mammalian fertiliser which might be spread so as to improve grasslands and pasturage. For reasons associated with BSE and scrapie, the UK has recently prohibited mammalian fertiliser being used on pasturage (even though the fertiliser will be absorbed into the soil, grazing animals ingest an amount of soil, so that they could become infected with BSE or scrapie in this way). It may be, and particularly if the ban of the use of mammalian fertiliser on pasturage is adopted throughout the European Community, that it will be necessary to impose a similar ban in the Falkland Islands. While it will still be possible to use a proportion of the fertiliser produced on horticultural, agricultural and garden land, there will be a need to be able satisfactorily to dispose of the remainder. It will be less in bulk than if it had not been processed. Additionally it may be necessary to incinerate or bury the heads and spinal columns of sheep, if it cannot be immediately established to the satisfaction of the EC that the Falkland Islands are scrapie free (there has been no reported case). The provision or joint use of a suitable incinerator needs to be considered (*see* TOR 7)

8. CFC's AND HALONS

The Vienna Convention 1985 on the Protection of the Ozone Layer, the Montreal Protocol to that Convention and the 1990 Amendment to the Montreal Protocol have been applied to the Falkland Islands. Local legislation has not yet been enacted, although a Bill reached an advanced draft. It is necessary to give consideration to the enactment of implementing legislation and the practical steps to be taken for the implementation of the Convention and Protocol. These would appear to need to include, in particular, the removal of CFC's from scrapped refrigerators and deep-freezers and therefore special arrangements in relation to the disposal of refrigerators (*see* TOR 10).

9. DUMPING AT SEA

The London Convention 1972 on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter has been applied to the Falkland Islands by the United Kingdom. In respect of other of its dependent territories, the United Kingdom has made an Order in Council under the Food and Environment Protection Act 1985 applying, with modifications, the legislation enabling the Convention to be given effect in the United Kingdom. For some reason, not now known, this Order does not include the Falkland Islands among the territories to which it applies. The Order is expected to be amended or replaced so as to give effect to new legislation, now required by virtue of an amendment of the Convention, prohibiting incineration of refuse at sea. The amending or replacing Order is to include the Falkland Islands among the territories to which it applies. In the meantime, the London Convention is given partial effect in terms of Falkland Islands law by the Marine Environment Protection Ordinance 1994 and the Dumping at Sea Order 1994 made under it. Dumping at sea is within the terms of reference) only in so far as it may have implications for the offshore oil exploration and production industry in its operations in Falkland Islands waters (see below).

10. URBAN WASTE WATER TREATMENT

Directive 91/271/EEC concerning Urban Waste Water Treatment does not apply to the Falkland Islands. Untreated discharge through a large number of combined sewage/surface water outfalls into Stanley Harbour takes place. An *e coli* count of the water at various points of the harbour is taken on an annual basis. These have so far disclosed no health risk, and levels below those frequent in the United Kingdom (the low count may in part be due to the low water temperature). The disposal of Urban Waste Water is outside the TOR's.

11. WASTE COLLECTION SERVICE OUTSIDE STANLEY

A. As mentioned above, the Falkland Islands Government does not provide any waste collection or treatment service outside Stanley. It is clearly not feasible, or at least sensible, having regard to the distances and costs involved, for it to do so in relation to ordinary household refuse. However in relation to material which can be recycled (e.g. scrap metal) it may be that provision of a service of collection ought to be considered, in the interests of amenity and the environment, even if the recovered value of the waste material concerned falls far short of the cost of collection and transport (*see* TOR 11). The same might apply in relation to hazardous waste of some kinds.

B. There is a particular difficulty in relation to one category of hazardous waste which may be found at various locations on sheep farms in the Falkland Islands. This is in relation to rusting cans of sheep dip which were by law required to held on sheep farms to be available to dip sheep against scab and other afflictions. The afflictions have not existed in Falkland Islands sheep for many years, and sheep stations are no longer required to hold the sheep dip. The dip is understood to contain or consist of organo-phosphates which may be hazardous to human health. The Falkland Islands Government has been unable to devise a method of safe collection and disposal (and believes that the latter, for disposal within the Islands, might require incineration facilities). There may be a danger, if the cans leak or burst, of the contents of the cans leaching into the water supply. The Consultants will need to consider and advise upon the problem (*see* TOR 12)

12. ALTERNATIVE METHODS OF WASTE DISPOSAL

The method chosen by the Falkland Islands Government for waste disposal has been landfill (without, so far, any organised consideration of reuse or recycling/recovery so as to reduce the quantity of waste disposed of by landfill). No consideration has so far been given, for example, to biodegradation of oily wastes in a pit by tillage and addition of nutrients. The Consultants should advise on any alternatives to landfill (including partial alternatives such as reuse, recycling/recovery, always subject to the BATNIEC principle) (*see* TOR's 11 and 13). The amount of landfill required is increased by bottles and beer and soft drink cans. There are no facilities in the Falkland Islands for recycling these. The Consultants should advise on any practical options for reducing the volume of these wastes (e.g. possibly segregation and crushing at source or at the tip) (*see* TOR 13), particularly since there are few available landfill sites in the vicinity of Stanley and the capacity of the existing tip at Eliza Cove is finite.

13. WASTE DISPOSAL BY THE MILITARY

The military operate, through a contractor, a landfill site at Mount Pleasant in a disused quarry. It is understood that from time to time they receive waste from the British Antarctic Survey Bases in Antarctica. So far as is known to the Falkland Islands Government the tip is satisfactorily operated. No information is available to it generally in relation to the disposal of hazardous waste generated by the military and its contractors, or by the British Antarctic Survey. It is believed that out of date ammunition is returned to the United Kingdom by ship (in one recent instance, with the approval of the Falkland Islands Government, some ammunition which had deteriorated so that it was unsafe to transport was detonated locally). It is necessary to consider the military disposal of waste in connection with possible co-operation as to recycling or recovery, and as to the satisfactory disposal of hazardous waste (*see* TOR 14).

14. THE FISHING FLEET

A. At times over 100 fishing vessels are fishing in the fishing waters surrounding the Falkland Islands and for the most part outside the territorial waters of the Falkland Islands. The great majority of these fishing vessels are flagged in foreign countries, but some are registered in the Falkland Islands or in the United Kingdom or other Red Ensign Registries. In respect of those which are registered in the Falkland Islands or the United Kingdom, the Merchant Shipping (Prevention of Pollution by Garbage) Regulations 1988 (as amended) apply. The regulations do not apply to foreign-flagged vessels, but under the law of the flag, if the flag state applies Annex V to MARPOL (the International Convention for the Prevention of Pollution by Ships 1973), such vessels may have corresponding obligations. These however will only be enforceable by the flag state. "Garbage" is defined in the regulations as meaning—

> all kinds of victual, domestic and operational waste, excluding fresh fish and parts thereof, generated during the normal operation of the ship and liable to be disposed of continuously or periodically except sewage originating from ships

and "operational waste" is defined as meaning—

> all maintenance wastes, cargo associated wastes and cargo wastes except residues or wastes from oil or oily mixtures, noxious liquid substances, non-polluting liquid substances or harmful substances in packaged form

Dunnage, lining and packing materials which will float cannot lawfully be discharged by a ship to which the regulations apply within 25 miles from land and other garbage cannot be discharged within 12 miles from the nearest point of land unless it has been comminuted so as to be capable of passing through a 25mm mesh screen when it cannot be discharged within 3 miles of the nearest point of land.

B. Annex V to MARPOL has been applied to the Falkland Islands. Consequently there is an obligation for the Falkland Islands to provide at ports and harbours in the Falkland Islands adequate facilities for the reception of garbage from ships (but the Merchant Shipping (Reception Facilities for Garbage) Regulations 1988 of the United Kingdom have not been applied in the Falkland Islands). The ports in the Falkland Islands used by fishing vessels are Berkeley Sound and Stanley Harbour. There is no pier or dock in Berkeley Sound, but garbage is received (at a price) by ships' agents aboard their launches (there is no garbage scow) and the facilities at the two quays in Stanley Harbour are nothing more sophisticated than skips available to receive the garbage. The Consultants are asked to advise on the adequacy of arrangements having regard to the Falkland Islands obligations under MARPOL (*see* TOR 9).

C. Similarly, under Regulation 12 in Annex V to MARPOL, there are obligations as to the provision of reception facilities of oily residues retained on ships and not discharged into the sea in accordance with Regulation 9 in Annex V. These obligations may apply in relation to Stanley and Berkeley Sound. Berkeley Sound is a bunkering port for the fishing fleets but it is thought that the volume loaded does not exceed on average 1,000 metric tons per day so (see Regulation 12.2(b) Annex V)). On that basis, the special facilities for oil tankers carrying other than crude oil may not be required and the standard of reception facilities required (in relation to both ports) would be those required to fulfil the Regulation 12.2(e) and 12.3(e) obligations. The Consultants are asked to advise in relation to this topic (*see* TOR 9).

D. Annex IV to MARPOL (which would require the provision of facilities for the acceptance of sewage from ships: see Regulation 10) has not been applied to the Falkland Islands.

15. MERCHANT SHIPPING VISITING THE FALKLAND ISLANDS

What is said in paragraph 14 (except in relation to Berkeley Sound) is also valid in respect of merchant shipping. In addition to the local coastal vessel (Tamar F.I., which is locally registered), there are visits every four to six weeks by freighters from the United Kingdom and, during the summer months, by two research vessels belonging to the British Antarctic Survey, and by a number of cruise vessels. Stanley is also a port of call for a few yachtsmen engaged in long-distance voyaging. It should be noted that there is a complete prohibition on discharge of garbage from any vessel in waters south of 60 degrees South (which constitute a MARPOL Special Area), and that Stanley may be the first port of call for some vessels who have visited that area.

16. OIL EXPLORATION AND PRODUCTION

A. Following seismic surveys of the Falkland Islands designated waters during 1992 and 1993, a Production Licence licensing round was opened in October 1995 in relation to 12 tranches of blocks to the north of the Falkland Islands and 7 tranches of blocks to the south of the Falkland Islands. This resulted in licences being granted in respect of 7 northern tranches (none to the south of the Falkland Islands). Seismic surveys by the successful consortia will begin in December 1996 and it is expected that the first exploratory well may be drilled before the end of 1997.

B. Little by way of waste (additional to ordinary ship-generated waste) is likely to be generated by offshore seismic activities. The picture changes when drilling commences. The wastes which may be generated are shown in Annex 2 (Table IV.1 of *The Exploration and Production Waste Management Guidelines* published in September 1993 as Report 2.58 by the Oil Industry International Exploration and Production Forum (the "E & P Forum") of 25-28 Old Burlington Street London W1X 1LB). The waste disposal options in relation to the various wastes are said to be those summarised in Table VI.1 to that Report (copied as Annex 3).

C. It may be possible simply administratively to require oil companies to follow "best oil industry practice" (and to define that as being the *Guidelines* mentioned in the preceding paragraph). That would leave the Falkland Islands Government without legal powers and remedies and sanctions against transgressors in the event of default, and appropriate legislation might therefore be necessary. The Consultants are asked to advise (*see* TOR 15).

17. PERSONNEL AND TRAINING

As far as is known, there is nobody at present in the service of the Falkland Islands Government who has had any training in waste management and disposal. The Consultants are asked to consider and advise whether specialist personnel and training are necessary (*see* TOR 16).

Part 2: TERMS OF REFERENCE OF ADDITIONAL TASKS

1. Establish the quality of the water of Stanley Harbour relative to the standards normally set by the EC for bathing

In discussions with the PWD this has been agreed to entail:

Provision of a statement setting out for Stanley Harbour the precise requirements of EC for bathing water and how these may be assessed in practice, ie a schedule of tests, details of the methods and a programme for the tests over a prescribed period.

2. Determine if the treatment of raw sewage which enters Stanley Harbour should be undertaken to enable the above standards to be met

In discussions with the PWD this has been agreed to entail:

Assessment of the results of the programme of tests with recommendations.

It may be noted that the proposed test programme presented in the Consultation Paper was considered by the Fisheries Department and others to be somewhat onerous. An amended request for proposals was suggested in comments from the Fisheries Department presented in Appendix K. The revised proposals are presented in Section 13 of the Final Report.

APPENDIX I

ECOLOGICAL MONITORING OF ELIZA COVE AND MARY HILL LANDFILLS

HALCROW

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FALKLANDS WASTE DISPOSAL

Ecological Survey Methodology

Introduction

A recent development or change of land-use may have a number of impacts on the surrounding flora and fauna, arising after alterations are complete. Therefore, it is essential to obtain baseline data on the local ecology prior to these land-use changes. This, in conjunction with a five year monitoring programme using identical survey methodologies to the those used for gathering baseline data, will act as a basis for determining whether any detrimental impacts are occurring to the flora and fauna. If the surveys are carried out frequently, any slight changes in the local ecology will be detected early enough to allow remedial action to be developed and brought into action to arrest any detrimental changes.

Potential problems arising from the capping, compression of waste, abandonment of a household refuse dump and the opening of a new area for waste disposal, arise mainly from the possibility of waste products breaking down and leaching into surrounding habitats causing localised damage to the flora and fauna.

Baseline Survey Methods for the Coastal and Marine Environment

The best results for such a study would be obtained if a series of line transects are established in the littoral, intertidal and sublittoral environment, directly below the area where leaching occurs. These transects should be established directly below the site where potential leaching may occur and stretch out to sea for 1km. They should be spaced at 50m intervals commencing 100m either side of the area under study. These peripheral transects will act as controls to assess whether any changes are due to natural processes or through problems associated with leachate. This would give a total of nine linear transects.

0.1m^2 quatrads should then be established within the littoral habitats at the mean high, mid and low tide levels. If the substrate is sediment, then this should be dug out to 30cm in depth and the sediment sample should be passed though 4mm, 2mm and 1mm seives. Samples collected by this method should then be identified and the data should be analysed. If the quadrat is located in a rocky environment, flora and fauna samples should be collected by hand searching methods.

Subtidal methods of sampling, providing the seabed consists of sediment, should be carried out along these transect lines at fixed 250m intervals using a Van Veen Grab (0.1m^3). The sediment samples should then be seived using 4mm, 2mm and 1mm meshes. The fauna should be identified to whatever taxonomic level is possible and those not easily identified should be preserved in 4% formaldehyde as reference specimens for further identification. If the seabed is primarily rock, scuba diving will need to take place to where visual observations will be made and samples will be collected for further identification.

These procedures will need to be carried out at the same time each year for the ongoing monitoring, preferably in early summer, when many marine organisms are sexually mature and more readily identifiable. The study would be enhanced further if surveys took place in each season, amounting to four times per year.

To minimise costs it would be preferable for local ecologists to carry out the work or to utilise ecologists visiting for other projects. However if this is not possible and ecologists from UK are required indicative costs are given below.

Baseline Survey Methods for the Terrestrial Environment Adjacent to Eliza Cove and Maryhill Quarry Dumps

Surveys on the terrestrial environment should be carried out on the landward side of Eliza Cove Dump and southward of Maryhill Quarry Dump. This will enable baseline data to be obtained in order to monitor the habitats over a five year period after the land-use changes have taken place. This will then allow an assessment to be made in order to determine whether leachate from the breakdown of dumped materials is having an impact on any adjacent terrestrial habitats.

This will involve the undertaking of an initial survey during the spring and summer of both areas to identify the habitat types, and the fauna and flora present. This will also assist in determining the total number of quadrats necessary and most appropriate time of year to carry out the line transect surveys. Prior to the undertaking of each follow up survey, the area adjacent to the dump should be inspected for visible signs of leachate.

Survey methods applied to these areas will involve the use of fixed straight line transects commencing at the dumping site and proceeding inland at right angles to the coastline. These transects should run parallel and be spaced at 20m intervals stretching from the dumping site to 100m inland. A $1m^2$ quadrat will then be placed at 5m intervals along each linear transect. The flora within this quadrat should then be identified and the percentage cover of each species should be estimated. The results should then be plotted on a graph representing each transect. This will then act as a baseline for the monitoring programme, which should take place over a five year period after which it should be reviewed. An evaluation and an assessment of the results should be made each year to determine whether any changes are taking place. Controls either side of the study area, away from possible effects of the leachate, should be carried out using an identical methodology to the above. This would enable any changes to be detected, which are taking place through either natural widespread occurrences or solely due to the localised effects of dumping.

Each consecutive survey should take place along the same transect route and at the same time each season to keep parameters constant. This will facilitate analysis of the data, particularly as some species may not be easily identified at other times of year.

A total of approximately 10-15 line quadrats per site will be necessary to give the appropriate coverage of the areas concerned. This will enable significant changes in vegetation cover to be determined should they occur. Each quadrat will have 21 sample points giving a total of 630 sample points over 30 quadrats.

Alternatively, random sampling methods could be used depending upon the findings of an initial walkover survey carried out to assess the extent and contiguous nature of the habitats. The sampling method would entail the use of one hundred $0.1m^2$ (the size of quadrat would be dependent upon the size of the species being surveyed) mini-quadrats randomly placed in fixed $5m^2$ blocks, along each linear transect. The presence of each species in each quadrat would then be noted. This method would then allow statistical analysis to be applied in order to determine the significance of any changes.

INDICATIVE COSTS OF PROGRAMME BASED ON PROVISION OF EXPERTISE FROM UK

Marine Environment

2 Marine Biologists

Survey work	10
Analysis and reporting	10

Terrestrial Environment

Terrestrial ecologist

Walkover survey of both sites	1day
Setting up of line transects for collecting baseline data:	1day
Survey of line transects	4 days
Collation of data, analysis and reporting	7 days

Assistant

Walkover survey of both sites	1day
Setting up of line transects for collecting baseline data:	1day
Survey of line transects	4 days
Collation of data, analysis and reporting	7 days

Cost of Equipment

Survey poles, measures, etc.	£150
Additional equipment hire	£800
Cost of Manpower	£10800
Total	£11750

Plus flights and subsistence at cost

APPENDIX J

LANDFILLING PROCEDURES FOR USE IN CAMP

Appendix J LANDFILLING PROCEDURES FOR USE IN CAMP

This appendix contains recommendations for the landfilling procedures to be used in camp.

Access Control

Access to the site should be controlled by means of a stockproof post and wire fence.

Equipment

Occasional visits to the site, at least every three months, should be made by earth moving plant - perhaps a tractor with a front loader bucket - in order to construct trenches, tidy up the site and apply cover where necessary and available.

Controlled Burning of Wastes

At present, the burning of waste takes place before or after reclamation. This is to reduce the volume of waste to be disposed of and its attraction to vermin, wildlife and livestock, which are then at risk. Efficient burning also reduces the leachate generation potential. The burning of waste, however, is unacceptable in urban areas, because of health dangers caused by air pollution, and because of odours and aesthetics. Burning should also be discouraged at householders own premises.

Burning is, nonetheless, considered acceptable for small landfills in Camp, provided that they are at least 1,000m downwind of housing and not located at an elevation above that of the housing.

As indicated, burning of waste at landfills can endanger public health and safety, and degrade the environment, especially if not conducted in a proper manner. It is therefore necessary to provide guidelines for controlled burning. Wherever the burning of waste is practised, all relevant occupational safety requirements must be met and efficient burning to avoid adverse environmental impacts is recommended.

Efficient burning depends on the combustibility of the material and the amount of oxygen available. In order to promote efficient burning the following steps are recommended:

Removal of less combustible wastes

It is recommended that less combustible wastes be separated from those wastes to be burned. Hazardous materials should also be removed (see below).

Non-combustible wastes

Non combustible wastes such as soil and building wastes or ashes should be set aside for using as cover or placing in the landfill when a machine is brought to the site.

Ensuring adequate oxygen

In addition to minimising the non-combustible wastes, adequate oxygen in the burning process must be ensured. The more oxygen available, the less smoke generated and the more complete the process. Where an oxygen deficiency exists, smouldering, smoke, unpleasant odours and potentially harmful emissions may result.

In order to ensure adequate oxygen in the burning process, it is recommended that:

- Waste for burning should be deposited some 2m from the main waste body and be burned in small controlled fires, rather than allowing the whole waste body to burn in an uncontrolled manner.
- Waste for burning should be placed on top of metals and other object remaining after previous fires, to assist acces of oxygen to the underneath of the waste.
- The small controlled fires should be tended and turned with long metal rakes when necessary to facilitate better aeration.

Handling after burning

Before burned waste can be moved, separated for reclamation or covered, it must be completely burned and hence extinguished. Failure to adhere to this could result in uncontrolled burning over large areas and ongoing smouldering which is difficult to extinguish. In addition to the environmental impacts of the above, the handling of burning waste by landfill plant could also be extremely dangerous.

Regular visits by an operator with a loader are important to tidy up the fringes of the deposits, move any non combustible waste into the landfill and to cover with soil. Completely burned waste should, as far as possible, be handled the same way as unburned wastes using the sanitary landfill principles of compaction and cover.

Health and Safety Aspects

Loads of waste should be inspected before ignition to identify any materials which present obvious safety hazards. There are essentially two types of hazard which can readily be avoided:

- Risk of explosion - from aerosol cans, gas cylinders and closed containers of any kind.
- Risk of toxic fumes - from certain plastics such as PVC and polyurethane (PU) and also from pesticides and pharmaceuticals. The plastics may not be easy to identify but certain objects will be, namely plastic channelling, pipes, flower pots and flexible foam. These materials may all contain PVC or PU. The precautionary principle should be adopted and any suspect materials removed.

Site operatives should always remain upwind from any burning waste. A simple windsock made from waste textile will indicate wind direction if necessary. They should also stand clear of the burning waste to avoid risk of injury from minor explosions which may occur.

Site operatives should wear suitable protective clothing, including gloves, boots and overalls, together with smoke masks and goggles if necessary.

Method of Landfilling

Where relatively small volumes of waste are disposed of, trenches are often used in preference to cells - which are used on larger sites. This may not be possible in certain areas of rocky outcrops but is generally desirable and efforts should be made to select an area in which trenches may be dug. Such trenches may be excavated on an ongoing basis during the operation at frequent intervals. There should be sufficient trench capacity on site to accommodate at least one week's waste but it will be satisfactory to provide trench capacity for up to 18 months at one time.

Trenches should be suitably fenced or protected, and off-loading must be such that persons or vehicles cannot accidentally fall into the excavation.

Waste should be deposited into the trench, spread and compacted as much as possible, until it reaches a depth of between 0.5m and 1.0m. With the trench method, covering is desirable and the spoil from the excavation makes this possible.

Health and Safety

Any landfill is, by its very nature, a potentially dangerous place. For example, injuries may occur from glass and metal in the waste, from falling on uneven or unsound ground, from flying debris, from fires and from moving vehicles and plant, especially when reversing.

Control of Nuisances

Nuisances resulting from the landfill operation should be controlled as follows:

Fires

Where burning is permitted, nuisances such as air pollution and odour must be avoided by ensuring efficient combustion as recommended above.

Litter

It is a requirement that all litter be contained within the site. This may be achieved by controlled burning of waste that could be windblown. Windblown litter should be picked up and removed from fences and vegetation. On sites characterised by high winds, movable litter fences may also be required.

Odours

Good practice limits odour by controlled burning and, where necessary, immediate cover. Compliance with the guidelines on protection distances, however, should avoid this problem.

In the case of controlled burning sites, some smell is inevitable so that tolerance of it is dependent on the direction of prevailing winds and the distance to homes.

Vermin and disease vectors

Landfill sites should be kept free of vermin. Appropriate measures, such as immediate cover of putrescible material, must be taken to eliminate or minimise disease vectors such as rats or flies. Ageing household waste, especially if left uncovered or unburnt can encourage insect populations to grow rapidly.

Difficult Wastes

Difficult wastes are those wastes which, whilst acceptable for disposal at a landfill on the basis of their overall properties, have some characteristics which require a particular method of handling which is not part of the general site operating procedure. Individual procedures are appropriate for these types of materials. Some examples are given below:

Tyres

Tyres, if deposited whole in a landfill can rise and cause void spaces which break the surface and encourage vermin. They also contribute to surface instability and represent a fire risk. It is not advisable to store tyres in large quantities, as this can present a fire risk with the potential for excessive black smoke. Ideally they should be quartered before landfilling. If they are to be landfilled in their whole state, this should be done in a controlled fashion, with individual tyres being placed flat and separate from one another on the base of the landfill before being covered with waste or, preferably, cover material. Each single layer should be covered before further tyres are added.

Bulky waste and empty containers

Bulky waste and empty containers should be crushed where possible before being covered with further material, in order to avoid the creation of void spaces. In many cases, however, items of bulky waste may have some reclamation value - for example as scrap metal - and may be shipped back to Stanley for recycling.

Finely divided material (e.g. powders and dusts)

Materials which may give rise to excessive dust when tipped should ideally be wetted before discharge and covered with other waste as soon as possible.

Very light materials which may be easily windblown (e.g. expanded polystyrene)

Light materials should ideally not be deposited during periods of high winds. They should be burnt or covered rapidly to prevent wind scatter.

Animal carcases and other putrescible and potentially malodorous materials

Such materials should ideally be placed in excavations and should in any event be covered or burnt rapidly to minimise odour impacts.

Drainage and leachate management

For very small sites of the kind occurring in Camp, water pollution and drainage is not a major issue. Nevertheless, it is desirable to construct a trench to divert upslope runoff so that the amount of water permeating the site is kept to a minimum.

Such leachate as may be generated from the site should be drained to a central point, where it may be stored to allowed natural oxygenation before discharge. Discharge should be to a watercourse of reasonable size or, ideally, direct to the sea. Sites should not be constructed close, or discharge, to small streams or bodies of water.

Progressive Restoration of Completed Areas

The progressive restoration of landfills by means of the placing of final cover and the establishment of vegetation is highly desirable, in order to prevent soil erosion and to improve visual appearance. Where feasible, revegetation should commence on all areas where no further waste deposition will take place.

On completion of an area, a minimum of 300mm of final cover should be applied. Final cover should comprise soil that can support vegetation. In order to prevent erosion and improve aesthetics, re-vegetation should commence as soon as possible.

Inspecting and Monitoring the Site Operation

Operating landfill sites should be inspected and monitored on an annual basis to verify that the landfill is operated to the standards required.

Inspection and monitoring may also quantify any effect of the operation on the environment, particularly on the water regime, and serve as an early warning system, so that any problems that arise can be identified and rectified. These would include problems such as malfunctioning drainage systems and ground or surface water pollution.

Appendix K

COMMENTS ON THE CONSULTATION REPORT

M E M O R A N D U M

To: Deputy Director of Public Works

From: Director of Fisheries

Date: 17 November 1997 (Ref: 1100.97) No of pages Including this one

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Falkland Islands Waste Disposal

I have the following comments on the consultation paper:

1. Numerous suggestions are made as to incorporating a charge for waste disposal into Fishing Licence fees and/or harbour dues. It is suggested that such charges may be increased to reflect the costs of waste disposal. We are content with the concept that waste disposal costs be incorporated into some other charge, such as harbour dues, and that waste disposal is not, therefore, seen as another cost. As all vessels visiting the port on commercial visits are liable for harbour dues, it seems that it would be better to deem waste disposal costs to be part of harbour dues rather than introduce an additional component into fishing licence fees. Vessels visiting for medical reasons do not pay harbour dues.

2. There is a potential problem in that waste disposal from ships may only be practical for vessels alongside FIPASS in Stanley Harbour, or in Port William. Whilst it is a matter for discussion with the launch operators, it might be unlikely (and undesirable in some conditions), that existing launches would venture far with a skip onboard and probably not as far as Berkeley Sound. They might have problems in rough conditions. There are suggestions at times that the vessels in Berkeley Sound could be better serviced from launches operating from Green Patch. Again, it can be rough in Berkeley Sound, and it is questionable whether existing launches are best designed for transporting skips.

3. We were left a bit uncertain as to whether there was a fully costed plan for treating waste oils from ships, including collection, storage, treatment, disposal. Would this rely on drums, or would a small road tanker be provided for use at FIPASS?

4. The Marine Officer suggests it might be useful to have a recommendation that those regulations/clauses which apply the Law on Pollution by Garbage and Oil, to foreign flag vessels in the UK, be similarly applied in Falklands' waters.

5. Stanley Harbour Water Quantity:

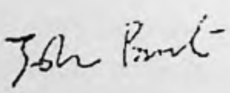
The proposal seems to be quite expensive for a study which is only going to provide a snapshot in time, albeit providing some useful hard data. Our 'gut feeling' is that up to this point, the quality of water in the harbour has been acceptable. This might change over the next year as Stanley will expand with the East Stanley development together with other house building, as well as an increase in the visiting population in connection with oil. Consequently, the state of the harbour may well change and it would be useful to have a longer term monitoring programme at an acceptable cost. Repeat surveys at c. 28K are unlikely to be attractive. It may be impossible to provide a longer term programme at reasonable cost unless some way of doing the work 'in house' can be found.

6. I did not immediately see any reference to the potential hazard of introducing unwanted diseases or whatever from foreign waste foodstuffs being discharged from ships. I may have missed this. There are customs/veterinary restrictions on the importation of a number of foodstuffs, including some from South America. It is not inconceivable that bags of such foodstuffs could be landed as waste. It may be that the disposal system is considered adequate to avoid any problems.

7. Appendix I - Ecological Monitoring:

Our Senior Fisheries Scientist queries whether marine monitoring sites have been identified for Eliza Cove and Maryhill landfills. Eliza Cove suffers from being surrounded by minefields. The ideal marine site for Maryhill may be less obvious.

8. As a general (non-fish) observation, I would favour the simplest low-tech options, i.e. landfilling as much as possible. I doubt whether the resources (manpower in particular) exist for higher tech solutions which may require sorting etc.



John Barton
Director of Fisheries

c.c. to FPO
AG

Appendix L

STANLEY MUNICIPAL WASTE ANALYSIS
NOVEMBER 1997

DESIRE THE RIGHT

HALCROW

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APPENDIX L

STANLEY MUNICIPAL WASTE ANALYSIS NOVEMBER 1997

1. INTRODUCTION

Baseline quantitative and qualitative data on the arisings of Stanley municipal solid waste are important to an understanding of social changes impacting on waste management. They are also crucial for deriving options for recycling and disposal methods within a waste management strategy.

An analysis of one week's municipal solid waste arisings was therefore undertaken to:

Determine the quantity of arisings

Determine the percentage composition of waste on a mass basis

The trials were preceded by a publicity campaign to encourage waste separation with the objective of minimising the contact between putrescible and potentially recyclable materials.

The trial examined all waste delivered to the landfill site by the town collection service for a one week test period. The data produced is therefore only indicative as:

No data was available on seasonal variations

A larger than normal percentage of waste is delivered directly to the landfill by residents.

Residents make frequent visits to the landfill to recover materials and may have disturbed the waste awaiting analysis whilst the team was not present

The waste was subdivided for analysis. The divisions were made on a volume basis, hence not all waste was weighed.

The sub-sample examined in detail to determine the concentration of residual components not suitable for hand picking was limited in size.

Some soil was inevitably included in the sample weighings.

2. METHOD

Black plastic refuse sacks marked with a white cross were distributed by the Public Works Department to each household in Stanley two weeks prior to the trials. The PWD produced a note for distribution with these sacks requesting householders to place all putrescible material and paper in these sacks during the week of the trials. The marked sacks were to be sealed when filled and placed together with mixed refuse in the bins provided for collection by the waste contractor.

During Friday 21 November and Saturday 22 November the contractor collected 8 loads which were deposited in separate piles at the front of the Eliza Cove landfill on a flat dry surface. One load originated only from the public houses in Stanley (Pile 1). The remaining piles were all of household origin. The weather during the two days of analysis was blustery although there was no significant precipitation.

The trials were undertaken by the Consultants with assistance from two PWD employees, one of whom operated the site bulldozer. Each of the personnel was provided with protective clothing and gloves.

Separated hand picked waste was placed in sacks and weighed on a 2m x 1m blockboard platform supported on two levelled load cells. The load cells were connected to the Landrover battery with a digital output display in the Landrover cab. The output was recorded to the nearest 0.5kg. For hand picked low density waste the mass of the sack was sometimes a significant proportion of the total and a tare allowance was therefore made for sack weights by weighing a sample of twenty empty sacks and deducting an appropriate amount from the total mass of each waste component.

Unsorted waste was weighed using the same platform. The unsorted waste was loaded into large cardboard containers prior to weighing. The tare weight of cardboard was not recorded as the mass of container compared to contents was insignificant.

Pile 1 was analysed to gain information on the potential for source separation within the public houses to aid recycling.

Piles 2, 3, 4 and 5 were amalgamated and mixed using the bulldozer. The combined waste was split into two equal piles by volume (Piles A and B). Large objects were removed from Pile A which was then formed into a cone. Large objects included plastic bags containing only kitchen or garden waste. The cone was divided into quarters and opposite quarters removed and weighed. The remaining quarters were again formed into a cone and the process repeated until the remaining waste amounted to a manageable size of about 400kg. Pile B was discarded.

Pile 1 was coned and quartered twice using shovels and rakes. The three-quarters removed were weighed and the remaining quarter separated into its components without further subdivision.

The reduced Pile A was hand picked to remove larger objects which could easily be identified and were not significantly contaminated by other materials. Cans were separated into steel and aluminium using a magnet.

Weighings of all the separated materials were made in the following categories:

Putrescibles
Glass
 - green
 - brown
 - clear
Cans
 - aluminium
 - steel
Paper and cardboard
Plastics
Textiles
Miscellaneous mostly peat ash
Copper, lead and other metals

During picking the reduced Pile A became smaller in size and was spread out to the thickness of approximately 0.15m to aid extraction. The remaining waste after picking down to finger sized objects was shovelled into a single pile weighing 160kg. This pile was coned and quartered using shovels down to a sub sample size of 40kg. This remaining sub sample was carefully separated down to pea sized particles.

The percentage composition of the classified material from both households and public houses was determined and used to estimate the composition of the unclassified proportion of each sample.

The estimated mass of each component of the unclassified material was added to the measured mass of each component of the classified material. This process was carried out for waste from both households and public houses.

The public house waste consisted only of the two fractions, classified and unclassified material.

The household waste consisted of several fractions from piles 2,3,4 and 5 including:

Large items
Classified material
Unclassified material

together with the unweighed piles 6,7 and 8.

The total mass of household waste was therefore estimated by multiplying the total mass of materials in piles 2 - 5 by a factor of 7/4.

The total arisings for the week consisted of the estimated mass of piles 2 - 8 together with the measured mass of public house waste.

A summary of all the weighings and estimates of composition is given in Table 1 and 2.

3. COMMENTS

3.1 Marked bag experiment

The possibilities for recycling MSW are greatly increased by the segregation of materials at source to prevent contamination and dilution of the target material.

The marked plastic bags distributed to each household were separated and opened on site and it is estimated that only about 20% of those distributed were used. Of the bags used some 50% contained clean material which could be considered for recycling. The remainder contained contaminated material or mixed recyclable material requiring further manual inputs before being able to be considered for recycling.

On the basis of this test it was thought likely that the poor response from householders would preclude the possibility of a recycling option based on source segregation forming a part of the future waste management strategy for Stanley.

3.2 Recycling of public house waste

On a volume basis, the public house waste consisted mostly of cans and bottles. However, the waste contained more putrescible material than the average for the town and this severely contaminated the potentially recyclable fraction.

It is worthwhile noting that 90% of the cans collected were low value steel and on a mass basis the public house waste contained double the amount of cans compared with the average for the town.

4. SUMMARY OF RESULTS

Table 1. Mass and percentage composition of Public House waste

One-quarter classified waste	kg	%
Putrescibles	108	46.9
Paper	4.5	2.0
Green glass	58.5	25.4
Brown glass	19	8.2
Clear glass	15	6.5
Plastic	1	0.4
Aluminium cans	2.5	0.9
Steel cans	22	9.8
Sub-total	230.5	
Three-quarters unclassified waste	617.5	
Total public house waste	848	

Table 2. **Mass and composition of combined household and public house waste**

	kg	%
Putrescibles	5174.4	39.8
Paper	1545.1	11.9
Green glass	1964.9	15.1
Brown glass	853.9	6.6
Clear glass	715.9	5.5
Plastic	922.1	7.1
Aluminium cans	55.0	0.4
Steel cans	635.2	4.9
Textiles	246.4	1.9
Miscellaneous and peat ash	836.6	6.4
Wood	23.8	0.2
Copper and lead	39.7	0.3
Total weekly arisings	13013.1	