4. Alternatives

4.1 Introduction to Alternatives

A detailed assessment of alternatives to the proposed incinerator at East Arm Wharf was conducted. The alternatives investigated were:

- Not proceeding with the proposal;
- Alternative technologies for treatment of quarantine waste; and
- Alternative locations for the placement of the incinerator.

4.2 Not Proceeding with the Proposal

In the event that a quarantine waste treatment facility is not provided in Darwin, it is likely that sea and air port operations will have to cease. The absence of a waste treatment facility in Darwin will mean that any quarantine waste brought into the ports will have to be disposed of at an alternate quarantine waste treatment facility, at an alternate port. This adds substantial costs to sea and air port operators and the capacity to transport significant amounts of waste may not be available and in some cases would be a breach of the *Marine Pollution Act 1999*. To comply with this Act a quarantine waste treatment facility must be provided.

4.3 Existing Operations

The current treatment of quarantine waste occurs at the existing incinerator at Fort Hill, in the former DPC area. The Northern Territory Government has made a commitment to decommission this existing incinerator and has proposed that a new incinerator facility be constructed at the East Arm Wharf. The existing incinerator has reached the end of its economic life and it no longer complies with relevant emission control guidelines (pers comm. DPC). The Fort Hill incinerator will be decommissioned as soon as an alternative facility is commissioned for use.

The current handling and disposal of untreated quarantine waste to landfill in Darwin is not considered to be satisfactory with the current infrastructure, and consequently the incineration of Darwin's total quarantine waste load by a new quarantine waste incinerator facility is considered to be the most appropriate method to treat the waste. The suitability of upgrading or refitting the existing incinerator at Fort Hill for continued use was not considered because the site is scheduled to be developed in the later stages of the Darwin waterfront project.

4.4 Alternative Treatment Systems

A detailed assessment of alternative waste treatment technologies was conducted to determine the recommended treatment method for quarantine waste entering Darwin ports. A summary of findings from the assessment is provided below. The detailed alternative treatment systems assessment is in Appendix E.

The objective of a quarantine waste treatment technology is to reduce the probability of the establishment of exotic pests and diseases to an acceptable level. As such, 'treatment' includes processes that remove the material from situations where pests and diseases can be transferred to suitable and/or susceptible hosts, as well as thermal, physical and/or chemical processes that kill such organisms if they are present in waste materials.

Treatment facilities must be constructed or managed to ensure quarantine security measures are maintained. This would include the control of vermin, and access by birds, the control of dust and retention of airborne pathogens within the confines of the facility, and the ability to maintain the facility in a clean and safe condition.

Different technologies eliminate or reduce the risks associated with quarantine wastes in different ways. Some technologies are suitable for the treatment of particular hazards while others are capable of effectively treating a broader range of potential hazards. The deployment of different treatment technologies for different hazards would result in requirements for strict waste classification and segregation procedures to ensure that wastes are treated by the appropriate technology.

When examining the range of technologies that can be used to treat some, most, or all of the quarantine waste currently generated it was crucial to consider the possible ramifications upstream that may impact on the waste segregation systems that waste generators currently have in place, and the possible ramifications and risks downstream if wastes are inappropriately segregated and therefore improperly treated.

In assessing types of quarantine waste treatment technology the most appropriate technology should ideally be:

- An established and proven technology;
- A relatively simple or well understood technology;
- Able to be largely produced locally;
- Able to be serviced and maintained locally;
- Considered environmentally sound;
- Produces a treated waste that can be disposed of to landfill as a non-hazardous general waste; and
- Cost-effective within the total waste management system.

The review of relevant quarantine treatment technologies is structured around the following basic categories:

- Incineration and other available thermal technologies;
- Available alternative technologies to incineration; and
- Emerging technologies that could be used to treat quarantine wastes.

An overview of each quarantine waste treatment option is below. The full analysis for each technology is provided in Appendix E.

4.4.1 Incineration

Incineration has traditionally been used to dispose of quarantine and other potentially bio-hazardous waste, for many decades.

Essentially all incineration based technologies rely on burning (oxidising and/or pyrolysing) the waste in a primary chamber, then further burning the emissions from the primary chamber in a secondary chamber to remove smoke and odour, then further treating the emissions to remove acid gases, organic compounds of incomplete combustion (e.g. PAHs) and/or reformation (e.g. dioxins and furans), particulates, and heavy metals.

Advanced quarantine waste incineration technologies typically utilise:

- Semi-continuous automated loading of waste into the primary chamber;
- Automated ash/debris removal from the primary chamber;
- Controlled air combustion within the primary chamber (using oxidising and reducing cycles);
- Temperature controlled firing to maintain optimal combustion conditions in both primary and secondary chambers;
- Maintenance of turbulence, oxidising conditions and a specified residence time in the secondary chamber (usually 1 second or greater);
- Heat recovery (via heat exchanger/boiler);
- Rapid quench system to reduce the opportunity of dioxin/furan formation; and
- Air pollution control equipment for acid gases, dioxins/furans, heavy metals and particulate reduction.

The air pollution control equipment now considered to be ‘best practice’ is a dry system that involves injecting lime and activated carbon into the gas stream, after the temperature of the gas stream has been reduced, and collecting this material in a baghouse. As gases mix with these materials and pass through filter bags caked with these materials the lime removes most of the hydrogen chloride, and some of the other acid gases, and the lime and carbon work to remove heavy metals, organic products of incomplete combustion (e.g. Polycyclic Aromatic Hydrocarbons (PAHs)), dioxins and furans.

It is possible to meet currently accepted emission standards with appropriate incineration technology fitted with the latest generation of air pollution control equipment.

Incineration technologies can accept almost all quarantine wastes, although large quantities of aerosol cans (containing butane) and other flammable materials that can potentially appear in quarantine wastes can explode and cause damage to the primary chamber, transiently reduce residence times, and in extreme cases activate by-pass conditions.

Proper incineration completely destroys the waste and achieves a significant reduction in both volume and mass (greater than 80%) which reduces landfill requirements, but as the ash can potentially contain leachable contaminates, such as heavy metals, it is normally regulated to be managed as a potentially hazardous waste, unless leachate testing demonstrates that it may be managed otherwise.

Non-combustible components of the quarantine waste stream, such as glass and metal, also remain in the ash. Primary chamber temperatures do need to be controlled between 650 - 900°C so that glass and metal do not slag and bind to the refractory lining of the primary chamber and cause maintenance issues in their removal.

Incineration ash and residues, and the lime/carbon waste need to meet leachate criteria for disposal to landfill. Some jurisdictions may classify incineration ash/residues and the lime/carbon mix as regulated industrial wastes that may require special landfilling requirements. Usually however these wastes present little environmental risk if disposed of into a properly designed secure landfill.

4.4.2 Chemical Disinfection

Chemical disinfection relies on a chemical agent killing potentially pathogenic organics. This occurs via different mechanisms depending on the agent, but can involve strong oxidising agents, altering pH, disruption to cell membranes via solvent action, or the denaturing of protein structures, and interfering with basic cellular function. Disinfection is the reduction of pathogenic organisms on objects or in materials so that they pose no threat of infection and disease.

A wide variety of chemical agents can be used as disinfectants, including: alcohol, phenol, formaldehyde, gluteraldehyde, boric acid, ethylene oxide, hydrogen peroxide, potassium permanganate, sodium hypochlorite, iodine, hexachlorophene, quaternary ammonium salts, heavy metals (such as mercury, copper and silver) and lime.

Fundamental to this technology is the need to macerate, shred and/or grind the waste to enhance surface area to volume ratio so as to allow better penetration of, or exposure to, the treatment media. This is a critical step and the degree of waste volume reduction and treatment efficiency is reliant on this step.

The potency or power of a disinfectant is usually affected by time, temperature, pH and concentration. The death rate of organisms is affected by the length of time the organisms are exposed to the agent. Acid and alkaline conditions can also increase potency of some agents (e.g. hypochlorites), and are fundamental to the actions of others (e.g. lime).

The technology as commercially developed involves:

» Automated loading of waste into a feed hopper;

» Shredding and/or grinding of waste;

» Introduction of disinfectant either before, during or after shredding;

» Mixing of the waste in some instances;

» Holding the waste for a time determined to result in at least a 99.99% reduction in viable pathogens; and

» Compaction of the waste for disposal to landfill.

The two most common disinfectants used in this manner are:

» Hypochlorite solution; or

» Lime.

The hypochlorite solution produces a wet waste so though there has been volume reduction via shredding, the waste will increase in weight dependent of the absorbed and residual content of the disinfectant solution.

The lime based technique produces an essentially dry waste, as the lime absorbs moisture. However, a small amount of moisture either in the waste, or added during the process, is desirable in ensuring that the fine lime powder dispersed throughout the waste hydrates to produce an elevated pH (greater than 12) throughout the waste. This will continue to occur for some time after the waste has been exposed to the lime, and continue even while the waste is being transported. The addition of lime will also increase the mass of the waste depending on the amount used.

Some of the other chemical agents listed above (i.e. ethylene oxide, formaldehyde, alcohol, etc) are themselves potentially hazardous, and thus can generate hazardous wastes with their own occupational and environmental management issues.

There is a risk associated with waste materials that cannot be processed by this technology being introduced in the waste stream designated for this type of treatment, such as chemicals, drugs, animal carcasses, and some wooden articles. This is a waste segregation issue.

If shredding does not occur to a sufficiently small particle size exposure of the waste to the treatment media may not occur to the extent required.

Where hypochlorite solution is used to treat the waste this will result in a liquid waste stream that consists of those materials able to be leached or dissolved from the waste and residual hypochlorite solution. This liquid waste can be relatively high in total dissolved solids (TDS) and biological oxygen demand (BOD) and usually requires a permit from the local sewerage authority for authorised discharge to sewer.

4.4.3 Steam Sterilisation

To sterilise a material means, in literal terms, to eliminate all living organisms in, or on, the material. However, most laboratories say a sample is sterile if the probability of finding live organisms in a material is no greater than one chance in a million.

When properly carried out, sterilisation procedures ensure that even highly resistant bacterial endospores and fungal spores are killed.

Heat is the preferred agent of sterilisation. Moist heat destroys micro-organisms mainly by denaturing proteins. Moist heat can also interfere with lipids (fatty substances) in the cell membrane. Heat also inactivates many viruses, but those that can infect even after their protein coats are denatured require more extreme heat treatment, such as steam under pressure that will also disrupt a virus' nucleic acids.

Moist heat penetrates better than dry heat and is the most widely used physical agent for sterilisation. To be effective the total material has to reach a given temperature for a specific time known to kill the target pests and pathogens.

Most plants autoclaving waste for quarantine purposes in Australia are now required to treat to a core temperature of 1400°C for 30 minutes, and some operate at higher temperatures and longer times, to ensure complete penetration and treatment efficacy. At these temperatures almost all bacteria, spores and viruses can be destroyed.

Autoclaves, rotoclaves, and to a lesser extent, hydoclaves are pressurised vessels holding steam at scalding temperatures. They are obviously designed to safely contain the design pressures and the steam, but dependent on how they are operated and maintained there could be a potential risk of failure of components, or procedures that might result in a release of steam.

The only risk to treatment efficacy is if the required parameters of pressure, temperature and time are not met, or where penetration and even distribution of heat throughout the waste does not occur due to compaction, encapsulation, the size and volume of the article etc.

To ensure the proper ongoing performance of the autoclaving process the operator must be aware of the type and quantities of material being treated so that appropriate time/temperature parameters are applied to each load. Loose, dry loads will require different time/temperature treatments compared to wet/moist, dense loads. This variation can apply between different loads of quarantine waste.

There is a risk associated with waste materials that cannot be processed by this technology. These include chemicals (particularly flammable liquids), drugs, some specific biomedical wastes (such as cytotoxics, and anatomical wastes), and animal carcasses etc. This is a waste segregation issue for the generator. If this cannot occur at the level required to ensure the efficacy or safety of this process, then it undermines this technique's suitability.

Steam does not mix with oily or fatty materials and, therefore, permeable materials such as these may not be heated to the required temperature.

Waste material is normally delivered in sealed, plastic bags and may have large pieces of waste that are unlikely to be effectively treated during the normal autoclaving process unless shredded. Unless special autoclave bags are used normal plastic bags must be opened to allow for penetration of the steam. However, the normal practice is not to open bags of quarantine wastes once they are sealed as it creates the opportunity for organisms to escape.

If shredding does not occur, penetration of steam into the waste may not occur due to the insulating characteristics of wastes surrounding an article requiring treatment. This has been demonstrated with sealed bags of waste being autoclaved where the wastes in the middle of the bag were not exposed to an adequate temperature for a sufficient time. In addition the heat will melt the plastic, which may then envelope the material and further prevent penetration of heat.

Shredding or grinding activities can result in the dispersal of airborne material that may contain pathogenic organisms unless air movement is properly controlled and treated.

Autoclaves, rotoclaves and hydroclaves all involve some minor discharges to air, some liquid wastes (condensate) and the resultant treated solid waste that may be wet or dry.

4.4.4 Gamma Irradiation

Gamma irradiation is a physical means of sterilisation or decontamination.

Gamma irradiation kills parasites, bacteria, viruses and fungal spores by breaking down nucleic proteins and therefore inhibiting cellular division. Essentially, energy passes through the treated product disrupting any of the organic processes that cause contamination.

Gamma irradiation exposes products or substances to gamma rays. Gamma rays are electromagnetic radiation of very short wave lengths (similar to UV). Gamma rays are used for many purposes from communications (radio waves) to cancer treatment applications.

The most common source of gamma rays for irradiation processing comes from the radioactive isotope Cobalt 60. It is manufactured specifically for the gamma irradiation process.

The treatment consists of exposing the material to be treated for a set time thus accumulating the required dose of gamma radiation. As the source essentially emits radiation at a set rate, dosage is determined by the period of exposure.

Currently this process is not used for quarantine waste. Materials to be irradiated are loaded onto a conveyor for transport to the irradiation chamber where they are exposed to gamma rays. This chamber is constructed of two metres of reinforced concrete. Cobalt 60 pellets are sealed inside stainless steel cylinders known as source pencils. These pencils are arranged in a moveable rack and stored in a pool of pure water. The source rack can only be in one of two positions: the storage position (submerged in a deep pool of water) or the raised operating position. The products are then circulated to ensure an even exposure to the ionising energy.

The volume, mass and density of the goods need to be known for the correct dose and exposure time to be calculated. A test strip that is yellow in colour is attached to boxes of articles to be processed and after being exposed to sufficient gamma radiation this test strip turns red, indicating that the goods have been treated.

Gamma irradiation is the most hazardous form of penetrating ionising radiation. It can kill living things, which is why it can be used to sterilise medical paraphernalia and treat potentially bio-hazardous materials such as quarantine and related wastes. It is an extremely hazardous treatment media.

Like most of the other alternative technologies considered, gamma irradiation has some inherent limitations in that it cannot process any chemical wastes and drugs, as these wastes would remain essentially unchanged. Similarly, anatomical wastes or animal carcasses would pass through unchanged and would not appear to be treated. High-risk quarantine and microbiological/pathological wastes can however be effectively treated by gamma irradiation.

There is the risk that inappropriate wastes could find their way into the waste stream designated for treatment by gamma irradiation, and the resultant waste would still possess potential hazards to waste handlers and the environment, when the waste is disposed of to landfill.

The management of liquid wastes in the quarantine and related waste stream would need to be further examined as some plastics and adhesives degrade in the presence of gamma irradiation and therefore post treatment there may be an issue with disposing of the treated waste to landfill.

There are some potentially emotive issues regarding the establishment of such large radiation sources.

There are no emissions to atmosphere produced and no liquid wastes, only the treated waste product that can go to landfill. However as the waste is unchanged there could be an additional requirement to shred and compact the waste prior to transport and disposal to landfill. Any liquids produced through compaction would need to be managed and disposed of appropriately.

The buffer distance requirements for such a plant, given its unique nature, would need to be determined on a site specific basis.

4.4.5 Plasma Arc

The emerging technology of Plasma Arc destruction has been considered in this review because of its potential application to quarantine and related wastes.

Plasma is basically a material in which the temperatures are so high that electrons are separated from their atoms causing chemical substances to breakdown into simpler compounds. Direct and alternating current electrical arcs are used to create a plasma and a significant amount of electrical energy is required initially to generate it.

Plasma arcs are generated by the electrical discharge in the gas, usually between high voltage electrodes. The pressure of the gas involved determines the temperature and transport properties of the plasma, allowing it to be tailored to meet the demands of various waste materials.

With core temperatures of the plasma capable of exceeding 15,000°C, and side stream temperatures of 5,000°C to 8,000°C, plasma can break down hazardous organic and inorganic materials almost instantly, therefore residence time requirements are very small.

Plasma gasification is considered to be a non-incineration thermal process that uses extremely high temperatures in an oxygen-starved environment to completely decompose input waste material into simple molecules.

The extreme heat and lack of oxygen results in pyrolysis of the input waste material. Pyrolysis is the decomposition of matter in the absence of oxygen whereas incineration ultimately results in the burning of waste materials in the presence of oxygen. Pyrolysis provides for virtually complete gasification of all volatiles in the source material, while non-combustible material, including glass and metal, is reduced to an inert slag.

The by-products of pyrolysis are a flammable gas (typically high in hydrogen and carbon monoxide with traces of methane, acetylene and ethylene), which can be used as a fuel to generate electricity, and an inert slag, which is a vitrified glassy rock, primarily composed of silicon. Emissions have to be treated in a similar fashion to incineration following combustion of fuel gases.

The application of plasma technology to the treatment of quarantine wastes could not be found in the literature even though this technology could process this waste stream. As with any newer technology, or a new application of an existing technology, there are some risks associated with ensuring that plant is appropriately designed and able to be operated and maintained to produce the anticipated and desired performance characteristics.

4.4.6 Electrothermal Sterilisation

There are two main types of electrothermal techniques that have been developed, these are microwave and radiowave.

Microwaves work by causing the vibration of the atomic bonds (usually -H bonds) within chemical structures generating heat that denatures any proteins. Radiowaves are of lower frequency than microwaves but have a similar net effect of bond vibration and denaturing of protein. The effect of denaturing the proteins associated with various microbes and fungal spores is to kill them.

As with disinfection and steam based techniques the waste is automatically loaded via a hydraulic lift/load mechanism into feed hopper which is then sealed before the waste is shredded. Shredding typically reduces the waste volume by up to 80%. Air from the infeed hopper is drawn by a fan through a series of filters including a High Efficiency Particulate Air (HEPA) filter and a carbon filter to control odours.

Waste is then picked up by a stainless steel screw conveyor, moistened with steam, and passed by a series of microwave or radiowave units. Microwave energy is extremely efficient at thermally treating each individual waste particle from the inside out, assuring thorough disinfection.

Batch fed designs are also available though many commercial units favour a continuous feed.

Treated waste is then transported outside the unit by a secondary screw conveyor and is deposited into a waste compactor or dumpster. At this point, waste is considered safe for disposal in any municipal solid waste program.

The only risk to treatment efficacy is if the required electromagnetic field is not generated at sufficient intensity to penetrate the waste for long enough to ensure complete treatment. This can be manually adjusted as the waste is being processed. The skill of the operator is very important in this regard.

There is a risk associated with waste materials that cannot be processed by this technology being introduced in the waste stream designated for this type of treatment. This is a waste segregation issue.

If shredding does not occur penetration of electromagnetic radiation into the waste may not occur because of the insulating characteristics of wastes surrounding a potentially biohazardous article.

The process allegedly produces no liquid effluents. Minor emissions to atmosphere are essentially water vapour.

The treated waste can be compacted and disposed of to landfill as general waste.

A buffer distance of a few hundred metres has been suggested as sufficient due to the minimal emissions associated with such plant.

4.4.7 Disposal to Landfill

Quarantine wastes, whether treated or untreated, are ultimately disposed of to landfill.

The disposal of non-quarantine wastes to landfill is acceptable by AQIS provided they do not contain quarantine wastes that could present a threat to the environment.

AQIS does allow some low risk quarantine wastes to be disposed of to deep burial but there is an issue with adequate segregation and maintained separation.

Environmental protection agencies now have strict licensing requirements for landfill operations to minimise the impact of operations on the environment and surrounding properties. It is no longer acceptable to nearby residents to have blowing rubbish, odour, leachate, rodents and a generally untidy landfill operation.

A modern landfill in a capital city will involve the following:

» Transportation of waste to the landfill in sealed trucks;

» Segregation of different categories of waste into specific areas within the landfill and these areas being mapped for future reference;

» Minimum working faces to reduce litter, odour and vermin;

» Transfer stations for consolidation and segregation of waste prior to arrival at the main tip to prevent public access to workface;

» Secure fencing to avoid entry by scavengers, feral animals or stock;

» Immediate compaction following dumping of the waste to minimise odour, reduce litter and fire risk, control biodegradation and maximise the use of available space within the landfill; and

» Covering the work face with compacted soil or other inert cover material at the conclusion of the working face.

Landfills using these procedures are referred to in this document as ‘controlled’ landfills and burial in them as ‘controlled’ burial.

Design requirements for landfills accepting putrescible wastes are more stringent than for sites accepting solid inert waste because of the need to control odour, vermin, birds, insects, fires, litter and ground water contamination by leachate. In many situations it is necessary to line the landfill void with an impermeable material, such as clay to prevent pollution of the environment.

The condition of waste, especially moisture content, is optimised to obtain more rapid and complete degradation of the waste. Moisture content is controlled by extracting leachate from the base of the landfill and reintroducing it into higher and drier layers of waste and adding extra water into specific areas when necessary. By controlling the moisture content and density of the waste the production of methane gas can also be optimised.

4.4.8 Comparison of Alternative Treatment Systems

Table 1 Comparative Summary of Advantages and Disadvantages of Quarantine Waste Treatment Techniques

Technique	Advantages	Disadvantages and Limitations
Incineration	Eliminates both pathogenic and chemical hazards. Can effectively destroy almost all quarantine wastes, drugs and narcotics, and other contraband. No shredding required. Complete combustion of all organic matter to ash. Reduces volume and weight of waste 70-90%. Can recover heat and steam and/or hot water for cleaning bins and waste receival/handling areas. Simple waste segregation requirements for waste generator.	High capital cost, and relatively high operating and maintenance costs. Some quarantine waste may be of low calorific value. It is important that operational procedures are closely followed to ensure a clean burn. Discharges to atmosphere require sophisticated air pollution control devices that generate wastes (eg: carbon/lime scrubbing), and ash and residues should be disposed of to secure landfill. Environmental concerns regarding emissions to atmosphere. Expensive monitoring of air discharges required.
Chemical Disinfection (This technology requires shredding to 50 mm or less to ensure the efficacy of the treatment process)	Minimises pathogenic risks, relatively low initial capital cost, relatively simple technology, simple manual or automatic operation, volume decreases by up to 60-80%. Hammer mills can process large objects without issue and produce a finer particle size. Lime method can deal with animal tissue and usually generates little or no liquid wastes. No potentially hazardous emissions to atmosphere. Cost competitive to incineration and many other techniques.	Cannot properly treat chemical wastes, drugs or narcotics, etc. Hypochlorite method not suitable for animal tissue, etc. High performance shredders with safety interlocks would be required to avoid damage by larger metal objects or fouling (by textiles and/or plastic packaging). Hazardous chemicals storage and use required, Liquid waste is produced by hypochlorite method. Mass of waste will increase by 10-20%. Requires additional quarantine waste classification and segregation procedures by waste generator.

Technique	Advantages	Disadvantages and Limitations
Steam Sterilisation (This technology requires shredding to 50 mm or less to ensure the efficacy of the treatment process)	Minimises pathogenic risks. Effective on all important organisms including those that resist dry heat such as many spores and seeds, provided organisms are exposed to the required temperatures and times for their destruction. Moderately low capital cost and operating cost. Simple automated operation, relatively easily controlled and monitored. Volume decreased by up to 60-80%. No potentially hazardous emissions to atmosphere. Cost competitive to incineration and some other techniques.	Cannot treat chemical wastes, drugs or narcotics, etc. Special plastic bags are required and need to be opened (unless waste is shredded). Waste must be uncompacted. Steam penetration of wastes can be poor unless waste is shredded (e.g. animal wastes). Tissue is cooked by this technique, larger parts may not be entirely cooked. At the landfill insects, rodents, and avian scavengers may then consume this meat). Efficacy on items of large cross section is in question, due to time it takes to heat the interior of the item (unless shredded). High performance shredders with safety interlocks would be required to avoid damage by larger metal objects or fouling (by textiles &/or plastic packaging). Can be difficult to monitor progress of treatment in some materials. Can be problems with steam penetration where plastics melt over and protect/insulate some materials. Unevenness in composition of the load can result in uneven temperatures in the material being treated. Set time/temperature parameters may not always be effective for varying load compositions. Mass of waste may increase slightly. Liquid waste produced. Requires additional waste classification and segregation procedures by waste generator.
Gamma Irradiation	Eliminates pathogenic hazards. Kills all living organisms and renders seed unviable. Known to be effective against all organisms. Sizes of object, within reason, not a major problem, carriers are about $1m^3$. Does not co-radiate other materials. No change in the weight of waste. Relatively low operating cost.	Potentially dangerous gamma source requires significant safety protocols and engineering controls. Requires a lot of handling of material into special carriers for treatment. High security required. Cannot treat chemical wastes, drugs or narcotics. Waste remains recognisable and of same volume unless shredded. High initial capital cost.

Technique	Advantages	Disadvantages and Limitations
Plasma Arc	Eliminates both pathogenic and chemical hazards. Can effectively destroy almost all quarantine wastes, drugs and narcotics, and other contraband. No shredding required. Can also accept hazardous industrial and municipal wastes and produce a fuel gas (using pyrolysis) and inert vitrified slag. The fuel gas can be burnt to produce electricity. Simple segregation requirements for waste producers.	Potential disadvantage is that such a treatment plant for quarantine wastes is not known to have been established anywhere (except US Navy) and some technical issues currently remain unresolved. May not be feasible unless other hazardous waste streams are considered. Very high initial capital cost. Not within DPC responsibilities to provide other waste disposal services.
Electrothermal Sterilisation (microwave or radiowave) (This technology requires shredding to 50 mm or less to ensure the efficacy of the treatment process)	Virtually eliminates pathogenic hazard, can reduce volume by up to 60-80%. Allegedly no potentially hazardous emissions to atmosphere, or liquid wastes produced.	Complex plant and equipment, and complex semi-manual/automated operation. Cannot treat chemical waste, drugs or narcotics. May not be suitable for animal tissue. Produces uncharacterised air emissions. High initial capital and operating cost. Newer technologies not commonly utilised for quarantine wastes. More expensive than chemical disinfection or steam sterilisation techniques. Requires additional waste segregation procedures by waste generator.
Landfill (Deep Burial)	Low costs. Natural organic materials eventually biodegrade.	Does not address pathogenic or chemical hazards and associated risks, not suitable for chemical wastes, not suitable for bulk human tissue, scavenging by insects, rodents and birds will occur unless secure supervised burial occurs, insect and animal vectors may transmit disease, hazardous liquid leachate may be generated and contaminate surface and groundwater.

4.5 Preferred Waste Treatment Facility

Incineration remains the most useful and flexible of treatment and disposal techniques and simplifies segregation procedures for waste generators. All quarantine wastes can be effectively incinerated, whereas most alternative technologies have some inherent limitations with respect to the wastes they are able to treat.

Incineration is the preferred quarantine waste treatment facility due to:

» The efficacy of the process with respect to quarantine risks and the nature and composition of other wastes found in the quarantine waste stream;

» The simplification of required quarantine waste classification and segregation procedures and consequent greater likelihood of compliance;

» Achieves the greatest volume and weight reduction for subsequent transport and disposal to a secure landfill of non-combustible residues;

» Shredding or grinding of the wastes is not required for effective treatment or secure disposal;

» Essentially converts organic wastes into carbon dioxide and water, and ash;

» Emissions to the atmosphere are able to meet current environmental standards and air quality objectives: and;

» Is to be cited within a suitable zoned industrial area and a substantial distance from any sensitive receptor.

4.6 Locations

Two locations were considered in detail for placement of the incinerator, these being the existing site and East Arm Wharf. These were the only two sites considered in detail as any inland sites posed risks and costs relating to transport of the quarantine waste.

4.6.1 Existing Location

The current waste treatment incinerator is ageing and has not been designed to control emissions. It is currently located at Fort Hill Wharf and is in close proximity to a number of sensitive receptors including the Government House, Parliament House, Deckchair Cinema, Darwin CBD and Darwin City Waterfront.

The current incinerator is positioned on land that is scheduled to be developed in the later stages of the Darwin waterfront project.

4.6.2 East Arm Wharf

The proposed location at East Arm Wharf is approximately 7 kilometres from the Darwin city centre and is further from sensitive receptors than the “existing location”. The area is an industrial port and owned by DPC.

The location is central to the growing industrial area and developing East Arm Wharf, positioning it in an ideal location to receive quarantine waste. The type of facility proposed is typical of operations in the area. The surrounding land use is further discussed in Section 5.2.