Baseline Study for the Pacific Hazardous Waste Management Project - Healthcare Waste

The collection, collation and review of data on the management of healthcare waste and best-practice options for its disposal in participating Pacific Island Countries

Papua New Guinea (PNG)

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Executive Summary

Introduction

The Secretariat of the Pacific Regional Environment Programme (SPREP) is the Pacific region's major intergovernmental organisation charged with protecting and managing the environment and natural resources. SPREP works with and on behalf of its 21 member countries and territories to promote cooperation in the Pacific islands region, providing assistance to protect and improve the Pacific environment and to ensure sustainable development for present and future generations.

SPREP is implementing the Pacific Hazardous Waste Management (PacWaste) Project, a four year, €7,850,000 (2013 – 2017) project funded by the European Union and administered through SPREP. The project will provide fundamental on-ground improvement in the way priority high risk wastes are managed in Pacific island countries to help build a healthy, economically and environmentally sustainable Pacific for future generations. The PacWaste project is funded by the European Union under its 10th European Development Fund (EDF 10). The project focuses on three priority hazardous waste streams including asbestos, E-waste and healthcare waste.

ENVIRON was engaged by SPREP to collect and collate information on the regional management of healthcare waste and its disposal, as part of their broader strategy of improving waste management in Pacific Island countries, and specifically to assist in establishing sustainable healthcare waste management. This report presents the findings of the assessment conducted for Port Moresby General Hospital (PMGH) in Papua New Guinea (PNG).

Current Healthcare Waste Management at PMGH

One hospital was assessed in PNG which was the Port Moresby General Hospital (PMGH), located in the capital city of Port Moresby. It is the major referral and teaching hospital in PNG. Information regarding the waste management process occurring, from ward-level waste generation through to ultimate treatment and disposal was collected during an audit of the hospital conducted on 8-9 April 2014.

A minimum standards framework has been developed to set a benchmark for the sustainable management of healthcare waste in the Pacific Island region. This framework is drawn from the *Industry code of practice for the management of biohazardous waste (including clinical and related) wastes*, Waste Management Association of Australia (2014), Draft 7th edition, taking into account the Pacific Island hospital and environmental context.

Using information obtained from the audit, PMGH was assessed against this framework. Table ES1 highlights the key areas of concern in terms of health services delivery by the hospital, as part of this assessment.

A full description and definitions of minimum standards applicable for healthcare waste management, as well as a comprehensive assessment against each of the criteria is presented in **Appendix C**.

Target areas have been rated as follows:

	Meets minimum standards assessment criteria
	Partially meets minimum standards assessment criteria.
	Does not meet minimum standards assessment criteria.

Table ES1: Healthcare Waste – Key issues for PMGH

Scale	Category	Item	Minimum Standard Criterion	PMGH
Healthcare Facility	Signage		Signs are located in all wards/department areas where waste bins are located indicating the correct container for the various waste types	
Healthcare Facility	Segregation		Waste are correctly segregated in all wards/departments with use of containers that are colour coded for the different waste types	
Healthcare Facility	Containers		All areas have dedicated waste containers are suitable for the types of waste generated. All waste containers are colour coded and have correct wording on them. Sharps are deposited into containers that reduce potential for needle-stick injury	
Healthcare Facility	Storage	Interim storage in healthcare facility	Storage areas at ward/department level should be secure and located away from public areas. Storage areas should be sufficient in size to allow waste to be segregated and so as to avoid waste of different classifications being stored together.	
		Storage before treatment	Meets the standards stated in Appendix E, Recommendation 2, Correct Storage.	
Healthcare Facility	Training	Planning and implementation	A structured waste management education program has been developed with a clear delivery structure	
Healthcare Facility	Training	Training responsibility	A hospital officer has responsibility for ensuring all training occurs as required and that records are maintained of all training and attendance.	
Healthcare Facility	Waste Audits		A program has been implemented to ensure waste audits are conducted of all waste materials/systems in all wards/departments on an annual basis and reports are provided to the waste management committee. Effective systems are in place to ensure that any non-conformances (with the hospital waste management strategy) are remedied.	
Healthcare Facility	Healthcare waste management emergencies	Spill Prevention and Control	Spill kits are provided or all types of healthcare waste in all wards/departments, storage areas and on trolleys and vehicles. Staff are trained on the use of spill kits. All incidents of spills of healthcare waste are investigated and where appropriate remedial actions implemented.	

Key Issues at PMGH

The following key issues were identified at PMGH:

- Healthcare waste is poorly segregated which was evident during the site visit in which mixing of healthcare waste and general waste was occurring inside the various wards (**Photo 8**). This is due to poor signage and labelling; lack of formal training or auditing; and poor attitudes towards segregation of healthcare waste.
- No consistency in the colour coding of waste bin and liners. Sometimes yellow bins were used for general waste (**Photo 10**) and sometimes yellow 'hazardous waste' liners were used for general waste (**Photos 7-8)** which created confusion in which waste goes in which bin.

- Training and auditing and staff commitment to good healthcare waste management practices are in their infancy.
- The waste storage facilities for both healthcare waste and general waste are not fenced off; enclosed or bunded however waste is brought to paved area and the healthcare waste is enclosed in the yellow wheelie bins (**Photos 2-3**).
- Residential properties that neighbor the facility and in particular the ones that are close to the former incinerator have previously complained about the fumes which is the reason the incinerator ceased operation in 2003. A new diesel incinerator was donated by a local business man to PMGH in 2009 which has a stack height of approximately five metres, however, due to the incinerator's capacity to emit fumes, it was not approved by the DEC. PMGH has funding set aside to identify an incinerator that does not emit any fumes and that will be approved by the DEC.
- No accountability of the waste contractor in relation to how they treat healthcare waste and dispose of the ash post incineration.

Analysis of Options for Sustainable Healthcare Waste Management at PMGH

Where non-treatment waste management aspects were observed to be performing below the Minimum Standards Framework, this framework is referenced for recommended actions.

For treatment of healthcare waste, various options used around the world were considered in the Pacific Islands context, via a two stage process:

- Stage 1: High-level costs and benefits (cost, lifespan, technical feasibility and how that relates to the Pacific Island regional context); and
- Stage 2: PNG specific feasibility assessment, using an analysis of 10 criteria (**Appendix D**)

Wastes should be treated and disposed of accordingly to ensure the infectious hazard is destroyed. PMGH generates comparably large quantities of healthcare wastes which is currently taken off site for treatment (incineration) by a waste contractor. The previous on-site incinerator was ordered to stop operating by the Department of Environment and Conservation (DEC) in 2003 due to fumes affecting the nearby residents. PMGH is currently in the process of procuring an incinerator for the hospital however this will need to be approved by the PNG Department of Environment and Conservation (DEC) to ensure it does not affect the nearby residents.

Recommendations

Table ES2 provides a summary of the recommendations for PMGH.

Table ES2: Recommendations for PMGH

Recommendation 1: Provide a Sustainable Training and Auditing Program	
Description	• Review the development and delivery of the infectious control (incorporating waste management) training and auditing program currently being developed by the PMGH. • Develop a training and auditing program that can be rolled out to other major hospitals in PNG (i.e. Lae, Madang and Mt Hagan). • Development of a waste management committee from the hospitals trained to track the success of the training and auditing program.
Output	• Review of the development and delivery of a structured healthcare waste training program to all hospital personnel as well as personnel from other stakeholders (e.g., government health and environment agencies). • Development of a successful healthcare waste training and auditing program that can be applied Nation-wide. • Improvement of personnel skills and competency in managing healthcare waste. • Promotion of the advantages of sustainable segregation and storage techniques for the different waste streams and an understanding of the health and safety risks resulting from the mismanagement risks of healthcare waste. • Train-the-Trainer approach where the Infection Control Unit Officer at PMGH to be provided with resources (travel costs) to roll out the infectious control (incorporating waste management) training and auditing program in other hospitals throughout PNG.
Monitoring & Evaluation Indicators	• Peer review of infectious control (incorporating waste management) training and auditing program by a skilled healthcare waste management consultant. • Waste management committee of the various hospitals to track each other success in the training and auditing program. • Refresher Training • No/very little cross contamination between waste streams demonstrated by waste audits.
Establishment Costs ($US)	• Establishment – medium: - US$10,000-$20,000 for engagement of a healthcare waste consultant. - US$5,000 - Travel costs for the Infection Control Officer to perform Task 3. • Ongoing – Low - to be incorporated into the day to day running of the hospitals
Costs ($US)	To be incorporated into the day to day running of the hospitals.
Recommendation 2: Procurement of Consumables	
Description	• Procurement of in-hospital healthcare waste management resources including: • Classification and segregation signage - Supply of signage to explain the colour-coded segregation system as well as posters to promote it. • Instructional posters to promote good healthcare waste management practices.

Table ES2: Recommendations for PMGH	
	• Spills kits.
Output	• Adequate and sustainable supply of healthcare waste management training resources and spill kits.
Monitoring & Evaluation Indicators	• Wastes are segregated at their place of production. • Infection wastes, general wastes and used sharps are stored in separate colour coded containers and locations within designated waste areas. • PPE is provided to all staff and staff are aware on how to protect themselves from injuries and infectious wastes
Costs ($US)	Establishment – Low; Ongoing - Low, sustainably funded by country
Recommendation 3: Appropriate Storage Facilities	
Description	• Procure contractors to design and develop healthcare waste storage facilities at the PMGH. • Upgrade healthcare waste storage facility areas to meet minimum standards outlined in **Appendix C and Appendix E** to eliminate the risk of ongoing public risk and environmental harm.
Output	A disposal system that reduces the potential hazard posed by health-care waste, while endeavoring to protect the environment (meet minimum standards outlined in Appendix C and Appendix E).
Monitoring & Evaluation Indicators	Suitability of storage areas regularly assessed by 'responsible officer' of waste management committee.
Costs ($US)	• Establishment – Medium $US7,000. • Ongoing – low – monitoring and maintenance.

Implementation actions are suggested for each recommendation, classified as short, medium and long-term priorities.

1 Introduction and Background

The Secretariat of the Pacific Regional Environment Programme (SPREP) is the Pacific region's major intergovernmental organisation charged with protecting and managing the environment and natural resources. SPREP works with and on behalf of its 21 member countries and territories to promote cooperation in the Pacific islands region, providing assistance to protect and improve the Pacific environment and to ensure sustainable development for present and future generations.

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ENVIRON was engaged by SPREP to collect and collate information on the regional management of healthcare waste and its disposal, as part of their broader strategy of improving waste management in Pacific Island countries, and specifically to assist in establishing sustainable healthcare waste management. This report presents the findings of the assessment conducted for Papua New Guinea (PNG).

1.1 Project Scope

This report covers the approach specified in the Request for Tender AP 6/5/6/2 '*The collection, collation and review of data on the management of healthcare waste and best practice options for its disposal in selected Pacific Island communities'* as it specifically relates to PNG and includes:

- Collection and collation of data on the current practice(s) used to dispose of hazardous healthcare waste at Port Moresby General Hospital (PMGH) in PNG. Data collected includes:
  - Basic background data on the operation of the site (number of beds, population served, current and projected rates of hazardous healthcare waste generation;
  - Healthcare waste separation and infection control practices;
  - Adequacy of supply of hazardous healthcare waste collection equipment;
  - Hazardous healthcare waste storage;
  - Hazardous healthcare waste transportation;
  - Hazardous healthcare waste disposal practice and annual operating costs;
  - Frequency and adequacy of infection control training;
  - Frequency and adequacy of waste disposal training; and
  - Adequacy of supply of personnel protective equipment.

- Consultation with national authorities to review and identify best-practice option(s) and preferences for national hazardous healthcare waste management by considering technical feasibility within the existing health infrastructure (including review of existing local institutional, policy and regulatory arrangements).
- Identification of local contractors who may have the expertise and capacity to potentially partner with regional or international expert's in future hazardous healthcare waste management including infection control training.

1.2 Report Structure

This report is structured as follows:

- an introduction to the project (**section 1**)
- discussion of current healthcare waste management at PMGH, including the current regulatory framework and hospital details (**section 2**)
- a summary of existing waste management practices, waste streams and quantities, waste management and infection control framework, the waste management process that were reviewed, training and education programs and identified healthcare waste management issues (**section 3)**
- key healthcare waste management issues and any county-wide or regional themes that were identified (**section 4**)
- a summary of hospital and national authority consultation outcomes (**section 5**)
- an assessment of contractor roles and their capacity to sustainably manage and treat healthcare waste, including any training or education capacity (**section 6)**
- an analysis of the healthcare waste management and treatment options available, both regionally and specific to PNG, to address the key issues identified (**section 7**)
- recommendations and prioritization of actions necessary to enable sustainable hazardous healthcare waste management and disposal in PNG (**section 8**)

2 Healthcare Waste Management at PMGH

2.1 National Regulatory Framework

PNG currently does not have any policies/guidelines for disposal of medical wastes except *The Public Health Act 1972.* There is a draft Medical Waste Policy developed by The National Department of Health (DOH) which at this stage is not yet ready to be released to the general public yet. The person we contacted said that special permission will have to be sought from their Director before this document is released.

The Environmental Protection Branch of the Department of Health (DOH) is responsible for the management of health care waste in PNG.

A summary of relevant legislation is provided in Table 1.

Table 1: National Environmental Legislation Summary

Legislation	Type	Summary	References to Solid/HCW	Regulator/ Agency
Environment Act 2000	Act	Mechanism for regulating the importation, distribution, and discharge of contaminants into the environment. The Act gives power to the Department of Environment & Conservation to be the lead government Agency, and policy maker on issues relating to the environment protection	General waste hierarchy to be followed.	Department of Environment and Conservation
Public Health Act 1973	Act	Regulation of health, sanitation, cleaning, scavenging and waste disposal; and the control and prosecution of illicit dumping practices	This is the Act in which medical waste is managed under.	The National Department of Health (DOH)
Organic Law on Provincial and Local Level Governments 1995	Law	Empowers provincial and local Governments to formulate policies, legislation and by-law in solid waste management	-	
Draft Medical Waste Policy	Law	Copy not available as it is currently in draft format.	Unable to comment	The National Department of Health (DOH)

2.2 Hospital Assessed

The Port Moresby General Hospital (PMGH), located in the capital city of Port Moresby, was the only hospital assessed in PNG. It is the major referral and teaching hospital nationally. It is also a centre for AIDS treatment in PNG, one of only a few facilities in the country equipped to treat HIV/AIDS and also houses a hyperbaric recompression chamber for diving emergencies. The hospital is the only hospital in the country to have a CT scanner, and the expense of travel to the capital means that not all of the population can take advantage of the facilities offered by the hospital.

Services include: ambulance; physiotherapy; radiology; orthopaedics; neurosurgery; ENT (ear, nose and throat); emergency; surgery; anaesthetics; paediatrics; gynaecology; intensive care; medicine; psychiatry; and pathology.

The table below summaries PMGH key contact personnel and key hospital administrative statistics.

Table 2: Hospital Details for PMGH Hospital	
Hospital/Region	PMGH, National Capital District
Contact Name, Position	Bobby Tau, Operations Manager
Pop Served	325,000 (Port Moresby)
No. of Beds	758
Annual Average Occupancy Rate (%)	Not provided
OBD's [1]	Not provided
No. Operations	7,928
No. of Births	17,082
Emergency Patients Attended	27,963
Out-Patients Attended	17,000
Total No. of staff	1,300
No. of staff per function	
Nursing/ Medical	Not provided
Infection Control	4
Dedicated Waste Management – Internal Management	Not provided
Dedicated Waste Management – Treatment Operation	0
Administration	Not provided
Other	Not provided

Notes:

1. OBDs = Occupied Bed Days (previous 12 months)

3 Existing Waste Management Practices

This section describes waste management practices observed during the hospital audit. Information regarding the waste management process occurring, from ward-level waste generation through to ultimate treatment and disposal is described in Table 3.

Audit observations are then elaborated upon further for the remaining issue headings:

- Waste streams and associated costs
- Waste Management and Infection Control Framework and
- Training.

A comprehensive list of all data collected from the site audit of PMGH is located in **Appendix B**.

Table 3: Waste Management Process - Observations

	Hospital Name	PMGH			
Generation & Segregation	Dedicated Containers/ Bags	Y			
	Colour Coding	Y			
	Sharps segregated & secure	Y			
	Signage Present	N			
Internal Handling	Degree of manual handling of bags	High			
	Internal Transport Mode	Wheelie Bin			
	Spill Kit Present	Y			
Storage	Dedicated & Appropriate Area	N			
	Loading/unloading acceptable	Y			
	Spill Kits Present	N			
	Monitoring & record keeping occurs	Y			
Treatment	Treatment per Waste Stream		Tech. Type	Volumes (kg/week)	Stockpile Volume (kg)
	Healthcare Waste	✓	Incinerate (external)	~3,500[1]	NA
	Sharps	✓	Incinerate (external)	Included above	NA
	Pharmaceutical	✓	Chemical/Maceration	Not measured	NA
	Cytotoxic	✓	Incinerate (external)	very low	NA
	General	✓	Landfill (without treatment)	7,500[2]	NA

[1] Based on number of medical waste bin loads a day taken by the waste contractor.
[2] General waste estimates are based on visual assessment and hospital staff interviews

Table 3: Waste Management Process - Observations			
	Hospital Name	PMGH	
	If incinerator present		
	Make, Model, Year commissioned	Never used	
	Operating Temp (^{0}C)	1000+	
	No. chambers	2	
	Condition	New	
	Comments	Incinerator not in use due to not been approved by the Department of Environment and Conservation (DEC). Need to source a new one with lower emissions.	
	Operational statistics	Per week	Per year
	Waste Throughput (kg)	Not known	Not known
	Operating Hours (hr)	Not in use	Not in use
	Fuel	Diesel	
	Fuel use (kg/litres)	Not known	
	Fuel use per kg waste burnt	Not known	
	Technology siting and operation issues	Incinerator is not approved by the DEC. The DEC is requiring a 'smokeless' incinerator.	
	Offsite transport assessment	Fair	

3.1 Wastestreams, Treatment Constraints and Costs at PMGH

Port Moresby General Hospital (PMGH) generates general waste and healthcare wastes (including infectious waste, sharps, pharmaceutical wastes and small quantities of cytotoxic waste) in the approximate quantities described in Table 3.

Healthcare waste is taken off site by a waste contractor (3 Sun Group) and incinerated at an average weekly cost of $US4,000.

General waste is taken off site to landfill at an average weekly cost of $US4,000.

3.1.1 Waste Management and Infection Control Framework

The National Department of Health has developed "*Infection Prevention Policy Guidelines for Health Facilities*" (October 2008) which is comprehensive in content and completed in consultation with Australian Guidelines. During the hospital visit the Infection Control Officer at PMGH was able to produce a copy of the *Infection Prevention Policy Guidelines* as well as demonstrating how the *Infection Prevention Policy Guidelines is* being used to develop infection control audits and infection control training workshops.

Structures and frameworks are currently being put in place for training schedules; audit schedules and data tracking as per the *Infection Prevention Policy Guidelines.*

3.1.2 Training

Infectious Control Unit has recently commenced infectious control training workshops to all hospital staff. The workshops usually take about 1-2 hours and incorporate healthcare waste

management. Most of the content of the training course was gathered from the training the Infection Control Officer received in Sydney, Australia and the "*Infection Prevention Policy Guidelines for Health Facilities*" (October 2008).

There was no identified specific infection control training courses in PNG (or healthcare waste management). Anecdotally, waste management training is communicated informally upon new staff employment by senior nurses at a hospital as well as training received during the three year registered nurses university courses which includes units on infection control and waste management.

4 Key Healthcare Waste Management Issues at PMGH

This section takes the collected information from Section 3 and summarises and critically assesses it in the context of a Minimum Standards Framework.

A key issues summary is also provided.

4.1 Minimum Standards Framework

A minimum standards framework has been developed to set a benchmark for the sustainable management of healthcare waste in the Pacific Island region. This framework is drawn from the *Industry code of practice for the management of biohazardous waste (including clinical and related) wastes*, Waste Management Association of Australia (2014), Draft 7th edition, taking into account the Pacific Island hospital and environmental context.

A full description and definitions of minimum standards applicable for healthcare waste management, as well as a comprehensive assessment against each of the criteria is presented in **Appendix C**. Target areas have been rated as follows:

Table 4: Assessment criteria rating system	
	Meets minimum standards assessment criteria
	Partially meets minimum standards assessment criteria.
	Does not meet minimum standards assessment criteria.

Table 5 highlights the key areas of concern, both per PMGH and in terms of health services delivery at PNG, as part of this assessment.

Table 5: Healthcare Waste – Key issues for PMGH

Scale	Category	Item	Minimum Standard Criterion	PMGH
Healthcare Facility	Signage		Signs are located in all wards/department areas where waste bins are located indicating the correct container for the various waste types	
Healthcare Facility	Segregation		Waste are correctly segregated in all wards/departments with use of containers that are colour coded for the different waste types	
Healthcare Facility	Containers		All areas have dedicated waste containers are suitable for the types of waste generated. All waste containers are colour coded and have correct wording on them. Sharps are deposited into containers that reduce potential for needle-stick injury	
Healthcare Facility	Storage	Interim storage in healthcare facility	Storage areas at ward/department level should be secure and located away from public areas. Storage areas should be sufficient in size to allow waste to be segregated and so as to avoid waste of different classifications being stored together.	
		Storage before treatment	Meets the standards stated in Appendix E, Recommendation 2, Correct Storage.	
Healthcare Facility	Training	Planning and implementation	A structured waste management education program has been developed with a clear delivery structure	
Healthcare Facility	Training	Training responsibility	A hospital officer has responsibility for ensuring all training occurs as required and that records are maintained of all training and attendance.	

Table 5: Healthcare Waste – Key issues for PMGH				
Scale	**Category**	**Item**	**Minimum Standard Criterion**	**PMGH**
Healthcare Facility	Waste Audits		A program has been implemented to ensure waste audits are conducted of all waste materials/systems in all wards/departments on an annual basis and reports are provided to the waste management committee. Effective systems are in place to ensure that any non-conformances (with the hospital waste management strategy) are remedied.	
Healthcare Facility	Healthcare waste management emergencies	Spill Prevention and Control	Spill kits are provided or all types of healthcare waste in all wards/departments, storage areas and on trolleys and vehicles. Staff are trained on the use of spill kits. All incidents of spills of healthcare waste are investigated and where appropriate remedial actions implemented.	

4.1.1 PMGH Hospital – Key Issues

The following key issues were identified at PMGH:

- Healthcare waste is poorly segregated which was evident during the site visit in which mixing of healthcare waste and general waste was occurring inside the various wards (**Photo 8**). This is due to poor signage and labeling; lack of formal training or auditing; and poor attitudes towards segregation of healthcare waste.
- No consistency in the colour coding of waste bin and liners. Sometimes yellow bins were used for general waste (**Photo 10**) and sometimes yellow 'hazardous waste' liners were used for general waste (**Photos 7-8)** which created confusion in which waste goes in which bin.
- Training and auditing and staff commitment to good healthcare waste management practices are in their infancy.
- The waste storage facilities for both healthcare waste and general waste are not fenced off; enclosed or bunded however waste is brought to paved area and the healthcare waste is enclosed in the yellow wheelie bins (**Photos 2-3**).
- Residential properties that neighbor the facility and in particular the ones that are close to the former incinerator have previously complained about the fumes which is the reason the incinerator ceased operation in 2003. A new diesel incinerator was donated by a local business man to PMGH in 2009 which has a stack height of approximately five metres, however, due to the incinerator's capacity to emit fumes, it was not approved by the DEC. PMGH has funding set aside to identify an incinerator that does not emit any fumes and that will be approved by the DEC.
- No accountability of the waste contractor in relation to how they treat healthcare waste and dispose of the ash post incineration.

5 Consultation

Table 6: Summary of key issues raised during consultation and suggested response / actions	
Key consultation personnel	**Response**
Bobby Tau Operations Manager Port Moresby General Hospital	Needs an on-site incinerator that does not emit fumes so it can be approved by the DEC.
Julie Weau Infection Control Officer Port Moresby General Hospital	Focused on implementing the *Infection Prevention Policy Guidelines for Health Facilities* (October 2008) through training of hospital staff and auditing. Needs more time and assistance.
Ray Facilities and Cleaning Manager Port Moresby General Hospital	As facilities and cleaning manager Ray has noticed that waste is poorly segregated by nursing staff which was led to some cleaning staff catching infections.
Grant R. Muddle Chief Executive Officer Port Moresby General Hospital	Needs an on-site incinerator that does not emit fumes so it can be approved by the DEC.
Joshua Sam Acting Manager – Waste Management NCDC	The NCDC has made numerous attempts at putting in place a health care waste management system for Port Moresby's health clinics and hospitals however is waiting of the finalisation of the Draft Medical Waste Policy for that they can be properly implemented.

6 Contractor Roles and Capacity

Waste contractor: There are a number of in country waste contractors in Port Moresby that can collect healthcare waste for incineration. The PMGH use a 3 Suns Limited for the collection healthcare waste.

There are a number of engineers in Port Moresby that would potentially have the expertise to service and repair any motor operated incinerators.

Training: There are no known specialised training courses in Port Moresby relating to healthcare waste management or infection control. Infection control training has previously being completed in Australia by the Infection Control Officers.

Waste Consultants: No in-country contractors were identified as providing or having the capacity to provide healthcare waste management support services. This includes training (in areas like waste management, infection control, technology operation and maintenance) and risk management.

7 Analysis of Options for Sustainable Healthcare Waste Management at PMGH

Section 4 identifies key issues that need to be addressed in improving healthcare waste management at PMGH. This section evaluates the potential options that could be employed to respond to these key issues.

Table 7 categorizes these key issues (A – E) against potential options that could be adopted to tackle them, as a collated list of high-level responses.

Table 7: Options for Sustainable Healthcare Waste Management at PMGH

Key Issue Category	Key Issue	Options to address the issue
A. Signage, Segregation & Containers	**Segregation and containment** practices are generally below minimum standard in that: • There is virtually no wall signage present. Signage is limited to bins and not always present. • Waste segregation is intended however is generally poorly implemented. • Colour coded bags (liners) were rarely available. • Some colour coded bin were available but usually there was a shortage which prevented consistency across the individual hospital.	Improve segregation practices by: • Supply of colour-coded waste bins and plastic liners in quantities sufficient to serve all wards/departments for a period of time sufficient to allow bedding down of the segregation process. • Supply of small number of colour-coded wheelie bins (where required) per hospital to act as both in-ward/department storage and internal transport trolleys. • Supply of signage to explain in words and illustrations the colour-coded segregation system as well as posters to promote it.
B. Training & Audit	There is only the beginnings of a structured **training** program in place. There is no waste auditing occurring.	Development and delivery of a structured healthcare waste training program to all hospital personnel as well as personnel from other stakeholders (e.g., government health and environment agencies). This could be facilitated/ delivered by: 1. SPREP staff, **or** 2. International technical training providers (or a combination of both), - as no competent healthcare waste management training capability were identified in PNG.
C. Healthcare Waste Storage Facility	Healthcare waste storage facilities at PMGH generally did not meet minimum standard	• Ensure there is a waste storage facility that meets the requirements detailed in Appendix E. • Regular checks and maintenance of waste storage facilities.
D. Treatment	**Treatment** is intended to be done at the hospitals visited however the incinerator has not been approved to operate at the hospital due to fumes.	Treatment using one (or a combination) of the following for each hospital: 1. Rotary kiln (highest temperature) 2. Incineration (high, medium temperature) 3. Low temperature burning (single chamber incinerator/ pit/ drum/ brick enclosure/ land) 4. Autoclave

Table 7: Options for Sustainable Healthcare Waste Management at PMGH		
		5. Chemical 6. Microwave 7. Encapsulation 8. Landfill (without disinfection) 9. Onsite burial 10. Shredding
E. Occupational Health and Safety	Waste handlers generally wore appropriate **PPE** including, gloves and face masks. Generally overalls /protective clothing and eye protection was not worn. **Spill control kits** were not observed anywhere.	Procurement of Consumables (PPE): • Supply spill kits and appropriate PPE including overalls/protective clothing, gloves and eye protection for all waste handlers. • Incinerator staff are provided with additional PPE such as face masks and noise protection.

7.1 Options for (Non-Treatment) Waste Management Aspects

Those options that do not relate directly to the waste treatment process tend to have limited alternatives that can address their respective key issue, given they typically relate to the fundamentals of hazardous waste management. These are:

- The waste management process, from generation to transport up to the treatment location (A and C in Table 7)
- Training systems for sustainable healthcare waste management (B in Table 7)
- OHS related protection for waste handlers (E in Table 7)

These areas have not been subjected to an options analysis, because the minimum standards framework has clear requirements with limited variation options.

7.2 Options for Treatment of Healthcare Waste

Healthcare waste treatment (key issue category D) has a range of alternative approaches, as summarized in Table 7. These have strengths and weaknesses that need to be considered in the context of criteria such as performance and cost of the technology itself, the waste types and volumes it is required to process, the environment it would be operating in and a range of factors specific to the Pacific Islands region and in some cases an individual country's circumstances.

Treatment solutions may involve a single technology, more than one technology for sub-categories of healthcare waste or combination of the technologies listed in Table 7. These alternatives have been assessed using a two stage process:

Stage 1: High-level costs and benefits

- Cost (capital, operating, maintenance)*
- Lifespan

- Technical feasibility (advantages and disadvantages) and how that relates to the Pacific Island regional context

* Costs are estimated at a high level for relative comparison purposes. Detailed quotations, particularly for equipment purchase and associated operating and maintenance costs will be required as part of any future procurement process to be managed by SPREP.

Stage 2: Local feasibility assessment (per country)

- comparative cost to implement
- comparative effectiveness across all HCWs
- health and safety considerations
- sustainability
- institutional and policy fit
- cultural fit
- barriers to implementation
- environmental impact
- durability and
- ease of operator use.

The stage 1 treatment technology options assessment is generic to the Pacific region so is included in the *Whole of Project – Summary Report*, Appendix E. This analysis highlights the following technologies as worthy of consideration for PMGH Stage 2 assessment:

1. Incineration (high temperature: >1,000^{0}C [3])
2. Incineration (medium temperature: 800 – 1,000^{0}C [4])
3. Low temperature burning (single chamber incinerator/ pit/ drum/ brick enclosure/ land: <400^{0}C [4])
4. Autoclave
5. Encapsulation (of sharps only, in combination with a form of disinfection).

7.2.1 Waste Treatment Systems Relevant for PMGH

These criteria are explored qualitatively in **Appendix D**. Table 8 takes these qualitative descriptions and assigns a quantitative score from 1 – 5, to prioritise local applicability of technology options to the PMGH context, on a relative basis as follows:

1. Very low
2. Low
3. Moderate
4. High
5. Very High.

[3] As defined in *Management of Solid Health-Care Waste at Primary Health-Care Centres - A Decision-Making Guide*, WHO (2005)

The treatment technologies suitable for the PMGH context are ranked in order of preference

Table 8: Quantitative Treatment Technology Options Assessment - Local Feasibility (PMGH)

Stage 1-Approved Technology Options	Comparatively low cost to implement	Comparative effectiveness across all HCWs	Local Feasibility								Total Score out of 50	Rank
			Health & safety to workers & community	Sustainability of solution	Institutional and policy fit	Cultural fit	Implementation barriers can be overcome?	Receiving environment protected	Durability	Ease of operation		
Incineration at high temperature (>1000^{0}C)	3	5	4	4	4	4	3	3	3	3	36	1
Autoclave with shredder	3	2	4	3	3	3	2	3	2	2	27	2
Incineration at med. temperature (800 - 1000^{0}C)	4	3	3	3	1	2	1	2	2	4	25	3
Low temperature burning (<400^{0}C)	5	2	1	1	1	1	1	1	5	5	23	4

Notes:
- Scored on a scale of 1-5, where 1= very low; 2 = low; 3= moderate; 4 = high and 5 = very high
- Criteria given equal weighting
- Possible maximum score: 50

In support of Table 8's ranking:

- ***High Temperature Incineration*** is the promoted disinfection practice where units are modern, maintained, have sufficient waste volumes and locked in supplier maintenance and training contracts.
- ***Autoclaving*** is an acceptable disinfection practice for most infectious healthcare waste (where units with shredder are affordable and locked in supplier maintenance and training contracts are in place), but it is not ideal for PMGH because:
    - It can't adequately treat the small cytotoxic waste volumes.
    - Autoclaving (and shredding) doesn't reduce waste volume as much as incineration and PMGH has large waste volumes. This would create an environmental risk because of the lack of lined landfills in Port Moresby.
    - The increased complexity of machinery could lead to more breakdown risk than other technology.
- ***Medium Temperature Incineration*** is not acceptable for PMGH due to identified community concerns about smoke.
- ***Low temperature burning*** is not acceptable for PMGH due to identified community concerns about smoke.

A substantial amount of data exists on the emissions generated from incinerators, but conversely, little studies have been conducted on all aspects of alternate technologies performance. While the literature is inconclusive on the requirements needed to effectively manage the blood and body fluid contaminated and infectious components of the waste streams, there does seem to be consensus that hazardous components such as

pharmaceuticals and cytotoxic wastes do need to be treated prior to final disposal to ensure there is no risks to the environment or health of humans and other species. No publication from a government environmental or health agency, or any article reviewed advocated any other preferred form of treatment for pharmaceuticals and cytotoxic wastes than incineration. In most instances the preference for anatomical waste was also incineration.

PMGH generates small quantities of cytotoxic wastes, in purple bags, which are taken off site for treatment by the waste contractor (3 Suns Group), who most likely incinerate it as they do with yellow bags of healthcare waste.

7.2.1 Treatment Options for PMGH

Wastes should be treated and disposed of accordingly to ensure the infectious hazard is destroyed. PMGH's feasibility assessment above concludes that high temperature incineration is the most appropriate for of treatment for PMGH, which supports current practice.

PMGH generates comparably large quantities of healthcare wastes which is currently taken off site for treatment (incineration) by 3 Suns Group. The previous on-site incinerator was ordered to stop operating by the Department of Environment and Conservation (DEC) in 2003 due to 'fumes' affecting the nearby residents. PMGH is currently in the process of procuring an incinerator for the hospital however this will need to be approved by the DEC to ensure it does not affect the nearby residents.

Accordingly, there are no investment options recommended for treatment infrastructure associated with the wastes at PMGH.

8 Recommendations

The following section outlines recommendations and a proposed implementation plan for each recommendation to achieve sustainable management of healthcare waste at PMGH. Further details and guidance on each recommendation are provided in **Appendix E**.

Table 9 provides a summary of the recommendations for PMGH. A colour coding system is used to describe the degree of applicability of each recommendation to each hospital as follows:

	Fully Applicable
	Partially applicable
	Not applicable

In terms of relative priorities of the five recommendations, they are all high, based on the deficiencies addressed against the minimum standards framework. They are also highly inter-related, for example: segregation practices cannot be sustainably improved without the requirements and responsibility of the waste management framework; which in turn cannot be turned into active policies and procedures without the understanding and reinforcement that comes from training. Effective treatment and use of PPE cannot be sustained without the reinforcement of training, effective segregation and the procedures and monitoring spelled out in the waste management framework.

However, the staggered timing of actions required to implement the recommendations, as outlined for each hospital in section 8.1, and their different short, medium and long term approaches give an indication of priority of the recommendation actions themselves.

Table 9: Recommendations for PMGH

Recommendation 1: Provide a Sustainable Training and Auditing Program	
Description	• Review the development and delivery of the infectious control (incorporating waste management) training and auditing program currently being developed by the PMGH. • Develop a training and auditing program that can be rolled out to other major hospitals in PNG (i.e. Lae, Madang and Mt Hagan). • Development of a waste management committee from the hospitals trained to track the success of the training and auditing program.
Output	• Review of the development and delivery of a structured healthcare waste training program to all hospital personnel as well as personnel from other stakeholders (e.g., government health and environment agencies). • Development of a successful healthcare waste training and auditing program that can be applied Nation-wide. • Improvement of personnel skills and competency in managing healthcare waste. • Promotion of the advantages of sustainable segregation and storage techniques for the different waste streams and an understanding of the health and safety risks

Table 9: Recommendations for PMGH	
	resulting from the mismanagement risks of healthcare waste. • Train-the-Trainer approach where the Infection Control Unit Officer at PMGH to be provided with resources (travel costs) to roll out the infectious control (incorporating waste management) training and auditing program in other hospitals throughout PNG.
Monitoring & Evaluation Indicators	• Peer review of infectious control (incorporating waste management) training and auditing program by a skilled healthcare waste management consultant. • Waste management committee of the various hospitals to track each other success in the training and auditing program. • Refresher Training • No/very little cross contamination between waste streams demonstrated by waste audits.
Establishment Costs ($US)	• Establishment – medium: - US$10,000-$20,000 for engagement of a healthcare waste consultant. - US$5,000 - Travel costs for the Infection Control Officer to perform Task 3. • Ongoing – Low - to be incorporated into the day to day running of the hospitals
Costs ($US)	To be incorporated into the day to day running of the hospitals.
Recommendation 2: Procurement of Consumables	
Description	• Procurement of in-hospital healthcare waste management resources including: • Classification and segregation signage - Supply of signage to explain the colour-coded segregation system as well as posters to promote it. • Instructional posters to promote good healthcare waste management practices. • Spills kits.
Output	• Adequate and sustainable supply of healthcare waste management training resources and spill kits.
Monitoring & Evaluation Indicators	• Wastes are segregated at their place of production. • Infection wastes, general wastes and used sharps are stored in separate colour coded containers and locations within designated waste areas. • PPE is provided to all staff and staff are aware on how to protect themselves from injuries and infectious wastes
Costs ($US)	Establishment – Low; Ongoing - Low, sustainably funded by country
Recommendation 3: Appropriate Storage Facilities	
Description	• Procure contractors to design and develop healthcare waste storage facilities at the PMGH.

Table 9: Recommendations for PMGH	
	• Upgrade healthcare waste storage facility areas to meet minimum standards outlined in **Appendix C and Appendix E** to eliminate the risk of ongoing public risk and environmental harm.
Output	A disposal system that reduces the potential hazard posed by health-care waste, while endeavoring to protect the environment (meet minimum standards outlined in Appendix C and Appendix E).
Monitoring & Evaluation Indicators	Suitability of storage areas regularly assessed by 'responsible officer' of waste management committee.
Costs ($US)	• Establishment – Medium $US7,000. • Ongoing – low – monitoring and maintenance.

8.1 Implementation Priorities

8.1.1 Recommendation 1: Provide a Sustainable and Training and Auditing Program

Development and delivery of a structured healthcare waste training program to all hospital personnel as well as personnel from other stakeholders (e.g., government health and environment agencies).

All staff and contractors should attend a waste management training session. This is to be conducted during all induction programs in the first instance. For those staff and contractors currently employed on-site, they will be required to attend a dedicated training session so that they are fully aware of their roles and responsibilities in respect to waste management. Records shall be maintained of all staff and contractors attendance at a training session to ensure that all personnel attend.

The training and auditing program could be facilitated/ delivered by SPREP staff, or outside trainers, or a combination of both, as no competent healthcare waste management training capability exists in PNG. Training should be coordinated with other countries' needs in the region.

8.1.1.1 Short Term (0-6 months)

- Peer review by a healthcare waste consultant of the development and delivery of the infectious control (incorporating waste management) training and auditing program currently being developed by the PMGH. Assist in the review and editing as well as planning to roll out the infectious control training and auditing program to other hospitals in PNG.
- Develop training program in consultation with the Infection Control Unit Officer from PMGH that is to be rolled out to other major hospitals in PNG (i.e. Lae, Madang and Mt Hagan). This will be a 'train-the-trainer' type approach.

8.1.1.2 Medium Term (6 months-1 year)

- Infection Control Unit Officer to perform infectious control (incorporating waste management) training and auditing program.

- Development of a waste management committee from the hospitals trained to track the success of the training and auditing program.

8.1.1.3 Long Term (1 year-3 years)

- As above

8.1.2 Recommendation 2: Procurement of Consumables (Segregation & Storage)

Procure in-hospital classification and segregation signage, instructional posters to promote good healthcare waste management practices and spills kits.

Waste should be collected in accordance with the schedules specified in the Waste Management Plan. The correct segregation of healthcare waste is the responsibility of the person who produces each waste item, regardless of their position in the organisation. The healthcare facility is responsible for making sure there is a suitable segregation, transport and storage system, and that all staff adhere to the correct procedures. Labeling of waste containers is used to identify the source, record their type and quantities of waste produced in each area, and allow problems with waste segregation to be traced back to a medical area.

8.1.2.1 Short Term (0-6 months)

- Procurement of in-hospital healthcare waste management consumables including:
    - Classification and segregation signage - Supply of signage to explain the colour-coded segregation system as well as posters to promote it.
    - Instructional posters to promote good healthcare waste management practices.
    - Spills kits.

8.1.2.2 Medium Term (6 months-1 year)

As per short term above.

8.1.2.3 Long Term (1-3 years)

Consumables to be supplied from in-country health agency budgets.

8.1.3 Recommendation 3: Appropriate Storage Facilities

Storage areas for healthcare waste should be designated within the healthcare facility. Storage facilities should be labeled in accordance with the hazard level of the stored waste and should be designed to prevent the risk of infection risk and environmental harm. Spill Kits for healthcare and cytotoxic waste should also be located in the storage areas.

PMGH is a large hospital in which public access is generally unrestricted and feral animals and vermin such as dogs and rats are common therefore it is important that waste is storage is kept in a manner that restricts access to such beings.

The storage areas should be fenced, lockable, paved and suitably designed and isolated from patients, public and animals (as described in **Appendix E**).

8.1.3.1 Short Term (0 – 6 months)

- Procure contractors to design and develop a healthcare waste storage facility at the PMGH.
- Upgrade central storage areas to meet minimum standards outlined in **Appendix C** to eliminate the risk of ongoing public risk and environmental harm.

8.1.3.2 Medium Term (6 months – 1 year)

- Procure spill kits for each central storage area.

8.1.3.3 Long Term (1 year – 3 years)

- Implement an ongoing healthcare waste facilities audit program to monitor the condition of central storage areas.

Appendix A

Photo Log

Appendix B

Collected Data from Hospital Audits at PMGH

Table B1: Collected Data from Hospital Audits at PMGH

HOSPITAL DETAILS	Region		National Capital District	
	Facility Name & Contact Information	Hospital Name	Port Moresby General Hospital	
		Contact Name & Position	Bobby Tau	Operations Manager
		Email	bobby_tau@pomgen.gov.pg	
		Phone	+675 70309875	
	Key Services Data	Summary of Services Provided	National Reference Hospital Tertiary/Specialist Health Services. Services include: ambulance; physiotherapy; radiology; orthopaedics; neurosurgery; ENT (ear, nose and throat); emergency; surgery; anaesthetics; paediatrics; gynaecology; intensive care; medicine; psychiatry; and pathology.	
		Pop Served	1,00,000	
		No. of Beds	758	
		OBD's [1]	TBC	
		No. Operations	7928	
		No. of Births[2]	17,082	
		Emergency Patients Attended[2]	27,963	
		Out-Patients Attended[2]	17,000	
		No of Staff	1,300	
WASTE MANAGEMENT PROCESS	Waste Streams Managed	Estimates	Volumes (kg/wk)	Cost ext. ($US)
		Healthcare Waste	3,500	4,000.00
		Sharps	refer above	refer above
		Pharmaceutical	Not known	Not known
		Cytotoxic	Not known	Not known
		General	7,500	1,000.00
		Recycling	None	N/A
		TOTAL	11,000	5,000.00
	Generation & Segregation	Dedicated Containers/ Bags	Y	
		Colour Coding	Y	
		Sharps segregated & secure	Y	
		Signage Present	N	
	Internal Handling	Degree of manual handling of bags	High	
		Internal Transport Mode	Wheelie Bin	
		Spill Kit Present	Y	
	Storage	Dedicated & Appropriate Area	N	
		Loading/unloading acceptable	Y	
		Spill Kits Present	N	
		Monitoring & record keeping occurs	Y	
	Treatment	Treatment per Waste Stream	Tech. Type	Int/Ext
		Healthcare Waste	Incinerate (external)	External
		Sharps	Incinerate (external)	External
		Pharmaceutical	Chemical/Maceration	External
		Cytotoxic	Incinerate (external)	External
		General	Landfill (without treatment)	External

Table B1: Collected Data from Hospital Audits at PMGH

		If incinerator present	Yes - not in use due to not been approved by the Department of Environment and Conservation (DEC). Need to source a new one with no emissions.	
		Make, Model, Year commissioned	Never used	
		Operating Temp (^{0}C)	1000+	
		No. chambers	2	
		Condition	New	
			Per week	Per year
		Waste Throughput (tonnes)	Not known	
		Operating Hours (hr)	N/A	
		Fuel	Diesel	
		Fuel use (kg/litres)	Not known	
		Fuel use per kg waste burnt	Not known	
		Technology siting and operation issues	Location is not suitable	
		Offsite transport assessment	Fair	
WASTE MANAGEMENT FRAMEWORK	Waste Management Documents	Waste Management Policy	N	
		Waste Management Plan	N	
		Waste Management Procedure	N	
		Waste Management Committee	Y	
	Infection Control	Infection Control Policy	Y	
		Infection Control Procedures	Y	
	Auditing and Record Keeping	Audit Program	Y	
		What is audited	Segregation	Y
			Compliance P&P	N
			Int. transport	Y
			Storage	Y
			Treatment/ disposal	N
		Frequency		
	Training	Training Program	Y	
		Curricula	Infection Control	Y
			Waste Mgt	Y
			PPE	Y
			Treat. Tech operation	Y
		Duration / frequency of training	1 hr	Quarterly
		Records of who has been trained	Y	
		Monitoring or refresher courses	Y	
PROJECTED ISSUES	Forecasting	10 year projections for waste management	Installation on an incinerator that does not generate emissions.	
		Barriers to change	Neighbours complain about fumes.	
		Other issues		
LOCAL CONTRACTORS		Potential in-country contractors	Who	Key Capability
			3Suns	Treatment

[1] *Occupied Bed Days (previous 12 months) annual average occupancy rate (as %)*

[2] *Previous 12 months*

Appendix C

Minimum Standards Assessment

HEALTHCARE WASTE - MINIMUM STANDARDS FRAMEWORK & ASSESSMENT FOR PMGH				
Scale	**Category**	**Item**	**Minimum Standard Criterion**	**PMGH**
National Authority	National Legislation	Definitions	A clear definition of hazardous health-care wastes and its various categories has been developed and used by generators.	
National Authority	National Legislation	Annual Compliance Reporting	Hospitals required to annually report on waste generation and management	
	National Legislation	Technical Guidelines	Practical and directly applicable technical guidelines	
National Authority	Regulations	Annual Compliance Reporting		
National Authority	Policy	National health-care waste management plan	A national strategy for management of healthcare waste has been published and is up to date (i.e., within 5 years) and hospitals required to adhere to its requirements	
Healthcare Facility	Policy	Infection Control	Infection control policy incorporates principles of waste management within it	
Healthcare Facility	Policy	Waste Management Plan	Has been developed by the hospital and is based on a review of healthcare waste management and is current (within 5 years)	
Healthcare Facility	Responsible Person		An officer has been appointed to assume responsibility for waste management within the hospital, and has been allocated sufficient time and resources - this person could have waste management as part of other duties	
Healthcare Facility	Management Committee		A waste management committee has been formed that has representatives from a broad range of departments and meets at least twice per year. A clear set of objectives has been developed for this committee. It reports to the senior management of the hospital.	
Healthcare Facility	Signage		Signs are located in all wards/department areas where waste bins are located indicating the correct container for the various waste types	
Healthcare Facility	Segregation		Waste are correctly segregated in all wards/departments with use of containers that are colour coded for the different waste types	
Healthcare Facility	Containers		All areas have dedicated waste containers are suitable for the types of waste generated. All waste containers are colour coded and have correct wording on them. Sharps are deposited into containers that reduce potential for needle-stick injury	
Healthcare Facility	Storage	Interim storage in healthcare facility	Storage areas at ward/department level should be secure and located away from public areas. Storage areas should be sufficient in size to allow waste to be segregated and so as to avoid waste of different classifications being stored together.	
		Storage before treatment	Meets the standards stated in Appendix E, Recommendation 2, *Correct Storage*.	
Healthcare Facility	Internal Handling	Transport Trolley	A dedicated trolley is used for waste transport. The trolley is designed so that any spills are contained.	
	Internal Handling	Routing	Healthcare waste is not transported where clean linen and/or food are transported	
Healthcare Facility	Training	Planning and implementation	A structured waste management education program has been developed with a clear delivery structure	
Healthcare Facility	Training	Curricula	A structured waste management training program has been developed that targets the different roles within the hospitals.	
Healthcare Facility	Training	Follow-up & refresher courses	All staff receive waste management education during induction. All staff receive refresher training annually. Waste management training is delivered following an adverse incident to the relevant staff/ward/department.	
Healthcare Facility	Training	Training responsibility	A hospital officer has responsibility for ensuring all training occurs as required and that records are maintained of all training and attendance.	

Healthcare Facility	Waste Audits		A program has been implemented to ensure waste audits are conducted of all waste materials/systems in all wards/departments on an annual basis and reports are provided to the waste management committee. Effective systems are in place to ensure that any non-conformances (with the hospital waste management strategy) are remedied.	
Healthcare Facility	Transport - External		A dedicated vehicle is used to transport untreated healthcare waste. This load carrying area of the vehicle is enclosed and constructed so that any spilt material is contained within this area. A split kit is provided.	
Healthcare Facility	Treatment	Suitability of treatment for healthcare waste	The method for treating healthcare waste is in accord with required standards - this includes operating parameters and location of the treatment unit.	
Healthcare Facility	Economics	Cost Effectiveness	A process has been developed that cost all aspects of waste management and these costs are reported annually to the waste management committee.	
Healthcare Facility	Occupational Health and Safety	PPE	All waste handlers are provided with and use appropriate PPE including overalls/protective clothing, gloves and eye protection. Incinerator staff are provided with additional PPE such as face masks and noise protection. A system is in place to monitor correct use of PPE.	
Healthcare Facility	Occupational Health and Safety	Staff risk	Waste containers, locations, storage and management procedures for healthcare waste incorporate identified risks to staff in accessing the waste and/or having needle-stick injuries.	
Healthcare Facility	Occupational Health and Safety	Patient/Visitor risk	Waste containers, locations, storage and management procedures for healthcare waste incorporate identified risks to patients and visitors in accessing the waste and/or having needle-stick injuries.	
Healthcare Facility	Healthcare waste management emergencies	Spill Prevention and Control	Spill kits are provided or all types of healthcare waste in all wards/departments, storage areas and on trolleys and vehicles. Staff are trained on the use of spill kits. All incidents of spills of healthcare waste are investigated and where appropriate remedial actions implemented.	
Healthcare Facility	Future Planning	Planning for change	Hospitals have developed a process to benchmark waste generation so as to (amongst other requirements), plan of future hospital development in terms of services and numbers of patients.	
Local Council	Waste Treatment Facility	Landfill	Healthcare waste is disposed of at a dedicated location and covered immediately on arrival. Scavengers cannot access untreated healthcare waste.	

* The minimum standard is drawn from the *Industry code of practice for the management of biohazardous waste (including clinical and related) wastes*, Waste Management Association of Australia (2014), Draft 7th edition, taking into account the Pacific Island hospital and environmental context

Appendix D

Qualitative Local Feasibility Assessment – Treatment Technology

Table D1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (PNG)

Remaining Technology Options	Comparatively low cost to implement	Comparative effectiveness across all HCWs	Local Feasibility							
			Health & safety to workers & community	Sustainability of solution	Institutional and policy fit	Cultural fit	Implementation barriers can be overcome?	Receiving environment not impacted	Durability	Ease of operation
Incineration at high temperature (>1000^{0}C)	$211,460 USD over 10 years (ref Whole of Project – Summary Report, Appendix E) Compared to the cost of treating healthcare waste off site (as required by the DEC) the cost of an incinerator is moderate.	Most effective – can treat all waste types and achieves complete sterilization, complete combustion and destroys waste	Some issues for operators (requires training & PPE); some potential issues for community (potential for smoke, some controlled emissions)	Equipment lifespan ~ 10 years plus; sustainability dependant on maintaining operator skills plus proper operation and maintenance	No legal barriers to incineration; loses a point for potential for smoke nuisance and the potential for minor contribution to combustion derived POPs – PNG is a party to Stockholm	Incinerators were previously used at PMGH as well as other locations in Port Moresby	DEC has indicated that it does not want any smoke to be emitted from an incinerator at the PMGH – HTI has the best chance of more efficient (low smoke) burning but this depends on operational factors.	Emissions of air pollutants and leaching from ash disposal to receiving environment are potential impacts. High temp operation minimises pollution & proper landfilling of ash restricts leaching.	Equipment lifespan ~ 10 years plus but will only last if maintained. High temperature equipment is prone to require a moderate level of maintenance	Requires skilled operators but modern equipment combined with training simplify operation
Incineration at med. temperature (800 - 1000^{0}C)	$69,820 USD over 10 years (ref Whole of Project – Summary Report, Appendix E)	Can treat all waste types, achieves complete sterilization, incomplete combustion, may not destroy	Some issues for operators (requires training & PPE); potential issues for community (smoke, emissions not	Equipment lifespan ~ 5 years; sustainability dependant on maintaining operator skills plus proper operation and	DEC will not approve burning healthcare waste at lower temperatures at PMGH due to smoke nuisance	Incinerators were previously used at PMGH as well as other locations in Port Moresby, but the local	DEC will not approve burning healthcare waste at low temperatures at PMGH	Emissions of air pollutants/ smoke and leaching from ash disposal to receiving environment are potential impacts. Med.	Equipment lifespan typically less ~ 5 years but will only last if maintained. Equipment is prone to require a	Requires less skilled operators than high temperature equipment - training simplifies operation

Table D1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (PNG)										
Remaining Technology Options	**Comparatively low cost to implement**	**Comparative effectiveness across all HCWs**	**Local Feasibility**							
			Health & safety to workers & community	**Sustainability of solution**	**Institutional and policy fit**	**Cultural fit**	**Implementation barriers can be overcome?**	**Receiving environment not impacted**	**Durability**	**Ease of operation**
		needles. Loses a point because PMGH has small cytotoxic waste quantities that are not safely destroyed by these temperatures	fully controlled)	maintenance		community is concerned about smoke		temperature operation increases risks of air pollution, but likely to only be an option in isolated small communities.	moderate level of maintenance	
Low temperature burning (<400^{0}C)	$6,485 USD over 10 years (ref Whole of Project – Summary Report, Appendix E)	Not applicable for all waste types, relatively high disinfection efficiency, incomplete combustion, will not destroy needles. Inappropriate for small cytotoxic quantities	Some issues for operators (requires training & PPE); issues for community (smoke, emissions not controlled at all)	No equipment; sustainability dependant government & community acceptance – which they have shown they will not	DEC will not approve burning healthcare waste at low temperatures at PMGH due to smoke nuisance	Likely to be unacceptable to community due to smoke in denser population area around hospital.	DEC will not approve burning healthcare waste at low temperatures at PMGH	Emissions of air pollutants/ smoke and leaching from ash disposal to receiving environment. Low temp operation provides no controls on air pollution. Risk of fire impact.	Simple, zero technology so there is nothing that can break down	Simple, zero technology so there is nothing that can break down and no specific training is required other than health and safety.
Autoclave with	$158,000 USD	Cannot treat all	Some issues	Equipment	No legal	Community	Equipment	No emissions of	Equipment will	Requires

Table D1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (PNG)										
Remaining Technology Options	**Comparatively low cost to implement**	**Comparative effectiveness across all HCWs**	**Local Feasibility**							
			Health & safety to workers & community	**Sustainability of solution**	**Institutional and policy fit**	**Cultural fit**	**Implementation barriers can be overcome?**	**Receiving environment not impacted**	**Durability**	**Ease of operation**
shredder	over 10 years (ref Whole of Project – Summary Report, Appendix E). Compared to the cost of treating healthcare waste off site (as required by the DEC) the cost of an incinerator is moderate.	waste types, such as PMGH's cytotoxics; achieves complete sterilization of HCW when correctly operated, no combustion required, shredder destroys needles	for operators (requires training & PPE); small potential for odours and wastewater discharge (community)	lifespan ~ 10 years; sustainability dependant on maintaining operator skills plus longevity of equipment use given technology complexity	barriers; no potential for smoke; some potential for odour; no air pollution (no combustion-POPs) and some potential for waste water management issues. Additional landfill load a concern due to lack of lining. Cytotoxics issue – not a sustainable form of treatment	not familiar with shredded autoclaved waste but PMGH currently uses autoclaves and has staff trained to operate and maintain them.	breakdown and lack of local skills to maintain equipment – real barrier but can be managed through skills training & supplier support. Increased complexity of equipment (compared to incineration) increases barrier	air pollutants/ smoke; some potential for odour impacts; still requires landfill disposal of residue (of significant quantity); potential for leaching on burial. Landfills are not lined. Some potential for waste water management issues	only last if maintained. Adding shredder to autoclave technology increases mechanical parts that can go wrong. May require moderate level of maintenance	skilled operators to achieve best level of disinfection.
Encapsulation (only post-disinfection sharps assessed)	Virtually zero additional cost to disinfection system costs	Not applicable to non-sharps waste. In the context of pre-sterilised	Encapsulation has handling issues for operators (requires	No equipment; sustainability dependant burial space available.	No legal barriers; no smoke nuisance; no odour	No particular cultural fit concerns as hospital staff are familiar	PMGH would find it difficult to dispose of treated but not destroyed sharps.	Encapsulation itself poses no smoke nuisance; no odour nuisance; no air	Highly durable due to its simplicity.	Simple procedure once operator understands

Table D1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (PNG)

Remaining Technology Options	Comparatively low cost to implement	Comparative effectiveness across all HCWs	Local Feasibility							
			Health & safety to workers & community	Sustainability of solution	Institutional and policy fit	Cultural fit	Implementation barriers can be overcome?	Receiving environment not impacted	Durability	Ease of operation
		sharps only: no combustion required and completely removes downstream needle injury risk	training & PPE) and no community issues	Quantities are very small in PNG.	nuisance; no air pollution and some potential for leachate to groundwater, although limited inherent hazard	with autoclaves– however healthcare waste volumes are very large at PMGH.		pollution and some potential for leachate to groundwater, although limited inherent hazard		and manages the risk of sharps handling and knows how to mix cement correctly. However large volumes will make it difficult to manage.

Legend: Descriptions equate to the following scores:

	1. very low agreement with feasibility criteria
	2. low agreement with feasibility criteria
	3. moderate agreement with feasibility criteria
	4. high agreement with feasibility criteria
	5. very high agreement with feasibility criteria

Appendix E

Recommendation Guidelines

Recommendation 1: Provide a Sustainable Training and Auditing Program

All waste management strategies (particularly resource management programs), rely on all staff to participate and co-operate in order to ensure that objectives are met. Staff therefore should receive appropriate training/education to understand the inherent hazard and risks posed of healthcare waste, and the importance of its management from generation to final treatment and disposal.

The Waste Management Committee (apart from ensuring staff education programs are developed and implemented), should also address other methodologies in order to ensure that staff receive information on waste reduction programs (eg., signage, information sheets and flow charts).

One of the initial steps for developing a structured training program is to gain management support from hospital administration. The development of a training program can be facilitated by establishing core competencies related to healthcare waste management.

In the development of a training program, the following should be considered:

- Conduct of a training needs analysis
- Identification and prioritisation of employees that need to be trained.
- Defining the specific learning objectives for each target audience.
- Develop a detailed curriculum specifying the training plan for each session.
- Incorporate pre-evaluation and post evaluation of learners, evaluation of trainers, follow-up activities, and documentation into the training program.
- Develop training content or adapt available training materials, tailor training content to specific target audiences.
- Identify potential trainers and build training skills
- Develop a budget and secure funding
- Explore incentives for training (e.g. training in collaboration with a health professional society or university that can award certificates or professional credentials)

The following is an outline of a Staff Waste Management Education Program that could be developed:

- Introduction to the session
- Importance of good waste/environment management/ infection control
- Waste management hierarchy
- Waste minimisation principles
- Brief overview of legislation pertaining to waste management
- Hospital policies on environment/waste management/ infection control/ needle stick injuries

- Overview of waste types
- Issues relating to waste reduction
- Management responsibilities
- Identification of, and hazards associated with the different types of wastes generated Importance of effective waste segregation
- Infection control and sharps management
- Waste, handling, packaging and disposal routes for the different types of wastes generated
- Questions

All staff and contractors should attend a waste management training session. This should be conducted during all induction programs in the first instance.
For those staff and contractors currently employed on-site, they should attend a dedicated training session so that they are fully aware of their roles and responsibilities in respect to waste management. Records should be maintained of all staff and contractors attendance at a training session to ensure that all personnel attend.

At a national and regional level, training programs could be in the form of train the trainer. The training of trainers approach allows rapid capacity building and widespread training outreach.

Training of Waste Disposal Treatment Operators

Incinerator/ healthcare waste treatment system operators should receive training in the following:

- Overview of healthcare waste management including risks and management approaches
- General functioning of the incinerator, including basic maintenance and repair training.
- Health, safety and environmental implications of treatment operations
- PPE, its correct use and removal and cleaning (if appropriate)
- Technical procedures for operation of the plant.
- Recognition of abnormal or unusual conditions
- Emergency response, in case of equipment failures.
- Maintenance of the facility and record keeping
- Surveillance of the quality of ash and emissions.
- Disposal of residues

Recommendation 2: Procurement of Consumables (Segregation & Storage)

The correct segregation of healthcare waste is the responsibility of the person who produces each waste item, regardless of their position in the organisation. The healthcare facility is responsible for making sure there is a suitable segregation, transport and storage system, and that all staff adheres to the correct procedures.

Ideally, the same system of segregation should be in force throughout a country, and many countries have national legislation that prescribes the waste segregation categories to be used and a system of colour coding for waste containers. Colour coding makes it easier for medical staff and hospital workers to put waste items into the correct container, and to maintain segregation of the wastes during transport, storage, treatment and disposal. Colour coding also provides visual identification of the potential risk posed by the waste in that container.

Labeling of waste containers is used to identify the source, record they type and quantities of waste produces in each area, and allow problems with waste segregation to be traced back to a medical area.

Waste containers specification and siting

Containers should have well-fitting lids, either removable by hand or preferably operated by a foot pedal. Both the containers and the bags should be of the correct colour for the waste they are intended to receive and labeled clearly.

All containers should be able to adequately contain the wastes deposited into it – to prevent the possibility of spills.

Sharps should be collected in puncture proof and impermeable containers that are difficult to open after closure.

The appropriate waste receptacle (bags, bins, sharps containers) should be available to staff in each medical and other waste-producing area in a healthcare facility. This permits staff to segregate and dispose of waste at the point of generation, and reduces the need for staff to carry waste through a medical area. Posters showing the type of waste that should be disposed of in each container should be displayed on the walls to guide staff and reinforce good habits.

Segregation success can be improved by making sure that the containers are large enough for the quantities of waste generated at the location during the period between collections, as well as a collection frequency that ensures no container is overfilled.

Setting and Maintaining Segregation Standards

Segregation requirements and methods should be clearly set out in the waste-management policy of a healthcare facility. It is important that the waste-management policy is supported and enforced by senior staff and managers. Managers and medical supervisors should know the relevant legislation and understand how to implement waste audits.

The 'Responsible Person' or Waste Management Committee should be responsible for seeing that segregation rules are enforced and waste audits are carried out to quantify the amount of waste produced.

Correct Signage

Signage indicating correct waste segregation practices is a valuable tool to provide ongoing guidance to staff. The success of the waste/recycling system will depend on having a clearly identified container for each type of material. This is achieved by the use of colour coded containers, symbols and wording. In addition, signage must be placed so that those wanting to dispose of materials can clearly and readily identify which container to deposit such materials into.
Once designed, signs should be located on walls above all waste containers as well as on the container itself.

Correct Storage

The storage area should be signposted with the bio-hazard symbol and other labeling appropriate to the types of waste stored in the area (eg healthcare) and includes the following:

- The base should be an impervious surface (eg. concrete) surrounded by a bund appropriate to contain any spill.
- All loading/ unloading takes place within the bunded area in such a manner to ensure any spills are appropriately managed.
- The base and walls of bunded areas are free of gaps or cracks.
- No liquid waste, wash down waters or stormwater contaminated with biohazardous wastes are disposed of via the stormwater drainage system; and
- The bunded area drains to a sump or sewer to collect spills and wash waters. Cut-off drains, which drain to a sump, should be used instead of bunds if approved by the relevant authority.
- Loading/ unloading of waste is carried out in accordance with designated safe procedures, and relevant records are completed and maintained.
- Containers in which biohazardous waste are stored secured when loading/unloading is not taking place.
- Spill Kits for biohazardous waste located in the storage areas.

Storage for larger generators may involve a dedicated room that is constructed specifically for waste management, or could be via the use of appropriately sized mobile garbage bins (eg., 240 or 660 litre).

Conditions related to security of healthcare waste include the following:
(a) The operator shall ensure that loading/ unloading of waste is carried out in accordance with designated safe procedures, and relevant records are completed and maintained.
(b) Containers in which healthcare waste are stored shall be secured when

loading/unloading is not taking place.

Spill Kits for healthcare and cytotoxic waste shall be located in the storage areas.

Recommendation 3: Appropriate Storage Facilities

The following guiding principles should be applied for healthcare waste storage facility:

- Minimises the threat to health, safety or the environment. In particular preventing public and wildlife access and prevention and containment of any spills.

Specifically the following measures should be implemented

- Storage areas prior to disposal or treatment should be secure, lockable, hygienic and appropriately sign posted.
- Storage area is paved and bunded.
- Weather elements such as rain is prevented from making contact with healthcare waste. This could be in the form of a roofed facility or bins with lids.
- Siting is strategically selected to minimize any health risks. I.e. away from patients, the general public and healthcare activities such as laundry and the kitchen.
- Ensure all necessary equipment required to clean and disinfect the area in case of accidental spillage is easily available and accessible.