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Reduction of UPOPs emissions by improving waste management practices at landfills

Design upgrade reports for 3 hazardous waste storage facilities

Resources & Waste Advisory Group SCE

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Contents

List of Acronyms

ADR	The European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR for short)
ANU	Antigua and Barbuda
APC	Antigua Power Company
BCRC-Caribbean	Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean
BFR	Brominated Flame Retardant
BM	Brian McCarthy (Team Leader)
CRT	Cathode-ray Tube
DG	Diana Gheorghiu (Deputy Team Leader)
EC	Electrical conductivity
GEF	Global Environment Facility
GHS	UN Globally Harmonized System of Classification and Labelling of Chemicals
HWISF	Hazardous Waste Interim Storage Facility
HZW	Hazardous waste
IPE	Metal “I beam” with I = I-section beam, P = parallel flanges, E = European (UNI 5398).
kW	kilo Watt
NSWMA	National Solid Waste Management Authority (Antigua and Barbuda)
O&M	Operation and Maintenance
PBB	Polybrominated biphenyls
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyls
PCT	Polychlorinated terphenyls
POPs	Persistent Organic Pollutants
Pc	Piece (as a single unit of measurement)
PVC	Polyvinyl Chloride (plastic polymer)
RWA	Resources and Waste Advisory Group (consultants)
TDG	UN Transport of Dangerous Goods Model Regulations
UN	United Nations
UPOPs	Unintentionally produced Persistent Organic Pollutants
USD	United States Dollar
VOC	Volatile Organic Compounds
WEEE	Waste Electrical and Electronic Equipment
WR	Wolfgang Robrecht (Key International Expert)
XCD	Eastern Caribbean Dollar

Background and Introduction

The RWA Group team along with representative of BCRC-Caribbean, conducted an in-country fact finding assignment in Antigua and Barbuda during the week of 8th to 11th October 2019. This report presents the findings related to project Component C “Assess existing hazardous waste facilities in three (3) countries (Antigua & Barbuda, Barbados and Saint Lucia)”. This design upgrade report for Antigua and Barbuda’s hazardous waste storage facilities incorporates:

- Design report (including technical specifications, cost breakdown, layout drawings and details)
- Includes a determination of the current and future capacity needs for hazardous waste storage facilities.
- The design for the upgraded hazardous waste storage facilities in the three countries will be elaborated according to local conditions and international standards for hazardous waste.

With this report the base for tender specifications is established. Tender specifications are presented in a subsequent report.

1 General design principles

1.1 Definition and Classification of Hazardous Substances and hazardous waste Concerning HZW Storage

A substance is classified as hazardous if it has a hazardous characteristic (physical, chemical or infectious properties) that poses a substantial present or potential hazard to human health or the environment when improperly treated, stored or disposed of, or otherwise mismanaged.

The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) and the UN Recommendations on the Transport of Dangerous Goods Model Regulations (TDG) are the most important guidance documents on chemical hazard communication in the world. Most of countries have adopted GHS and TDG via their own national regulations. Table 1 below presents the correlations between GHS and TDG, and Table 2 compares GHS with TDG in terms of classification criteria and labelling requirements (source: chemsafetypro.com).

Table 1 Comparison of TDG and GHS

Item	UN TDG	GHS
Scope	Both chemicals and articles	Mainly chemicals
Classes	Nine dangerous goods classes: • Class 1 Explosives • Class 2 Gases • Class 3 Flammable Liquids • Class 4 Flammable solids; substances liable to spontaneous combustion; substances which, in contact with water, emit flammable gases • Class 5 Oxidizing substances and organic peroxides • Class 6 Toxic and Infectious substances • Class 7 Radioactive material • Class 8 Corrosive substances • Class 9 Miscellaneous dangerous substances and articles, including environmentally hazardous substances	27 hazard classes
Hazard communication	Labelling & marking, placarding, dangerous goods declaration	Pictogram, GHS labels and safety data sheets

To fully understand the correlations between TDG and GHS, one needs to know the definitions of hazardous chemicals, GHS classified chemicals and dangerous goods

- Chemicals meeting GHS classification criteria are hazardous chemicals;
- Chemicals and articles on the UN dangerous goods list or meeting dangerous goods classification criteria are dangerous goods;
- Not all dangerous goods are chemicals or GHS classified (i.e., batteries, airbags, etc.);
- Chemicals that belong to dangerous goods are usually GHS classified/hazardous chemicals.

Table 2 Comparison of GHS Classification and Transport Classification

GHS Classification	Dangerous Goods Classification
Unstable explosives	Not allowed for transport
Explosives, Division 1.1, 1.2, 1.3, 1.4, 1.5, 1.6	Class 1 explosive substances and articles, Division 1.1, 1.2, 1.3, 1.4, 1.5, 1.6
Flammable gases category 1//Pyrophoric gases category 1/	Class 2 Division 2.1: Flammable gases
Flammable gases category 2/Chemically unstable gases category A/B	Not dangerous goods
Aerosols category 1 and 2	Class 2 Division 2.1: Flammable gases
Aerosols category 3	Class 2 Division 2.2: Non-flammable, non-toxic gases
Oxidizing gases category 1	Class 5 Division 5.1: Oxidizing substances
Gases under pressure	Class 2 Division 2.2: Non-flammable, non-toxic gases
Flammable liquids, category 1, 2, 3	Class 3 Flammable liquids, packing group I, II, III
Flammable liquids, category 4	Not dangerous goods
Flammable solids category 1, 2	Class 4 Division 4.1: Flammable solids, packing group II, III
Self-reactive substances, Type A	See explosives. May not be allowed for transport.
Self-reactive substances, Type B, C, D, E, F	Class 4 Division 4.1: Flammable solids
Self-reactive substances, Type G	Not dangerous goods
Pyrophoric solids category 1	Class 4 Division 4.2: Substances liable to spontaneous combustion
Pyrophoric liquids category 1	Class 4 Division 4.2: Substances liable to spontaneous combustion
Self-heating substances and mixtures, category 1, 2	Class 4 Division 4.2: Substances liable to spontaneous combustion, Packing group II, III
Substances which on contact with water emit flammable gases category 1, 2, 3	Class 4 Division 4.3: Substances which, in contact with water, emit flammable gases, Packing group I, II, III
Oxidizing liquids category 1, 2, 3	Class 5 Division 5.1: Oxidizing substances, Packing group I, II, III
Oxidizing solids category 1, 2, 3	Class 5 Division 5.1: Oxidizing substances, Packing group I, II, III
Organic peroxides type A	See explosives. May not be allowed for transport.
Organic peroxides type B, C, D, E, F	Class 5 Division 5.2: Organic peroxides
Organic peroxides type G	Not dangerous goods
Corrosive to metals category 1	Class 8 corrosive substances, Packing group III
Acute toxicity category 1, 2, 3	Class 6 Division 6.1: Toxic substances, Packing group I, II, III
Acute toxicity category 4,5	Not dangerous goods
Skin irritation/corrosion category 1 (1A/1B/1C)	Class 8 corrosive substances, Packing group I, II, III
Skin irritation/corrosion category 2 & 3	Not dangerous goods
Serious eye damage/eye irritation category 1/2A/2B	Not dangerous goods
Respiratory or skin sensitization category 1	Not dangerous goods
Germ cell mutagenicity category 1A/1B/2	Not dangerous goods
Carcinogenicity category 1A/1B/2	Not dangerous goods
Reproductive toxicity category 1A/1B/2	Not dangerous goods

Serious eye damage/eye irritation category 1/2A/2B	Not dangerous goods
Target organ systemic toxicity - single exposure category 1, 2 and 3	Not dangerous goods
Target organ systemic toxicity - repeated exposure category 1 and 2	Not dangerous goods
Aspiration toxicity category 1 and 2	Not dangerous goods
Hazardous to aquatic environment (acute) category 1	Class 9 miscellaneous dangerous goods: marine pollutant or environmentally hazardous substances, packing group III
Hazardous to aquatic environment (acute) category 2 and 3	Not dangerous goods
Hazardous to aquatic environment (chronic) category 1 and 2	Class 9 miscellaneous dangerous goods: marine pollutant or environmentally hazardous substances, packing group III
Hazardous to aquatic environment (chronic) category 3 and 4	Not dangerous goods
Hazardous to the Ozone layer	Not dangerous goods

Note 1: Most health hazards in GHS are not covered by dangerous goods regulations. Class 6 division 6.2 infectious substances and class 4 radioactive substances in TDG are not covered by GHS.

Note 2: The correlations between GHS hazard classes and dangerous goods classes above are general cases. There are exceptions.

TDG and GHS are important in this study as waste containing substances with characteristics as described are subject to regulations regarding the type and organization of their storage.

For the storage of hazardous wastes with varying characteristics – e.g. highly flammable or explosive – certain rules have to be applied.

For example, in the event of a fire with solids which may not be hazardous themselves, dangerous gases may be produced. In this way, substances which are immobile and/or are considered to be harmless can still cause air pollution and may contaminate soil and waters e.g. through the fire-extinguishing water and the washing out of the combustion gases. In addition, extinguishing additives, which serve as solvents, can dissolve substances adsorbed on soot particles, which when in the extinguishing water pathway, poses a hazard to water.

Almost all substances are capable of adversely changing the physical, chemical and biological characteristics of the environment.

As well as considering the GHS and TDG guidance, hazardous wastes that are temporarily stored in the proposed HWISF in Antigua that require to be shipped abroad for appropriate treatment or disposal facilities, will have to do so in accordance with Basel Convention[1] provisions. Although the Convention does not address storage conditions for hazardous waste prior to shipment, it does provide a definition and classification of hazardous waste which has been adopted and enacted in Antigua and Barbuda within the “The National Solid Waste Management Authority [NSWMA] Act” 2005 amendment.

The Basel convention defines “hazardous waste” as being any waste that belongs to the categories contained in the Convention’s Annex I, unless they do not possess any of the characteristics contained in Annex III. In

[1] Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, revised in 2019, available at http://www.basel.int/TheConvention/Overview/TextoftheConvention/tabid/1275/Default.aspx, last accessed August 2020.

addition to this, the Convention allows signatory countries to extend the list of hazardous waste with any other wastes which they define or consider to be hazardous through domestic legislation.

As Basel Convention scopes out radioactive wastes and waste arising from normal operations of ships, as these are subjected to international control systems and international instruments, these are also excluded from the scope of this report and the future HWISF.

Table 3 below presents the categories of waste considered hazardous and requiring control under Basel Convention, thus also being subjected to storage in the HWISF prior to shipment for treatment/disposal, if no environmentally sound treatment/disposal means are available nationally.

Table 3 Categories of wastes to be controlled, as per Basel Convention Annex I

Waste steams

Code	Description
Y1	Clinical wastes from medical care in hospitals, medical centers and clinics
Y2	Wastes from the production and preparation of pharmaceutical products
Y3	Waste pharmaceuticals, drugs and medicines
Y4	Wastes from the production, formulation and use of biocides and phytopharmaceuticals
Y5	Wastes from the manufacture, formulation and use of wood preserving chemicals
Y6	Wastes from the production, formulation and use of organic solvents
Y7	Wastes from heat treatment and tempering operations containing cyanides
Y8	Waste mineral oils unfit for their originally intended use
Y9	Waste oils/water, hydrocarbons/water mixtures, emulsions
Y10	Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)
Y11	Waste tarry residues arising from refining, distillation and any pyrolytic treatment
Y12	Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish
Y13	Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives
Y14	Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known
Y15	Wastes of an explosive nature not subject to other legislation
Y16	Wastes from production, formulation and use of photographic chemicals and processing materials
Y9	Waste oils/water, hydrocarbons/water mixtures, emulsions
Y10	Waste substances and articles containing or contaminated with PCBs and/or PCTs and/or PBBs
Y11	Waste tarry residues arising from refining, distillation and any pyrolytic treatment
Y12	Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish
Y13	Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives
Y14	Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known
Y15	Wastes of an explosive nature not subject to other legislation
Y16	Wastes from production, formulation and use of photographic chemicals and processing materials
Y17	Wastes resulting from surface treatment of metals and plastics
Y18	Residues arising from industrial waste disposal operations

Wastes having as constituents

Code	Description
Y19	Metal carbonyls
Y20	Beryllium; beryllium compounds
Y21	Hexavalent chromium compounds
Y22	Copper compounds
Y23	Zinc compounds

Y24	Arsenic; arsenic compounds
Y25	Selenium; selenium compounds
Y26	Cadmium; cadmium compounds
Y27	Antimony; antimony compounds
Y28	Tellurium; tellurium compounds
Y29	Mercury; mercury compounds
Y30	Thallium; thallium compounds
Y31	Lead; lead compounds
Y32	Inorganic fluorine compounds excluding calcium fluoride
Y33	Inorganic cyanides
Y34	Acidic solutions or acids in solid form
Y35	Basic solutions or bases in solid form
Y36	Asbestos (dust and fibres)
Y37	Organic phosphorus compounds
Y38	Organic cyanides
Y39	Phenols; phenol compounds including chlorophenols
Y40	Ethers
Y41	Halogenated organic solvents
Y42	Organic solvents excluding halogenated solvents
Y43	Any congenor of polychlorinated dibenzo-furan
Y44	Any congenor of polychlorinated dibenzo-p-dioxin
Y45	Organohalogen compounds other than substances referred to in Annex I of Basel Convention (e.g. Y39, Y41, Y42, Y43, Y44)

The list of hazardous characteristics, as contained in Basel Convention Annex III are presented in Table 4 below. In case wastes do not possess any of the characteristics included in the table below and are not otherwise deemed hazardous by national legislation, they can be exempt from storage in the HWISF prior to shipment to an authorized treatment/disposal facility and treated as non-hazardous waste.

Table 4 List of hazardous characteristics, as per Basel Convention Annex III

UN Class*	Code	Characteristics
1	**H1**	**Explosive**
		An explosive substance or waste is a solid or liquid substance or waste (or mixture of substances or wastes) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.
3	**H3**	**Flammable liquids**
		The word “flammable” has the same meaning as “inflammable”. Flammable liquids are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (for example, paints, varnishes, lacquers, etc., but not including substances or wastes otherwise classified on account of their dangerous characteristics) which give off a flammable vapour at temperatures of not more than 60.5°C, closed-cup test, or not more than 65.6°C, open-cup test. (Since the results of open-cup tests and of closed-cup tests are not strictly comparable and even individual results by the same test are often variable, regulations varying from the above figures to make allowance for such differences would be within the spirit of this definition.)
4.1	**H4.1**	**Flammable solids**
		Solids, or waste solids, other than those classed as explosives, which under conditions encountered in transport are readily combustible, or may cause or contribute to fire through friction.
4.2	**H4.2**	**Substances or wastes liable to spontaneous combustion**

		Substances or wastes which are liable to spontaneous heating under normal conditions encountered in transport, or to heating up on contact with air, and being then liable to catch fire.
4.3	**H4.3**	**Substances or wastes which, in contact with water emit flammable gases**
		Substances or wastes which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.
5.1	**H5.1**	**Oxidizing**
		Substances or wastes which, while in themselves not necessarily combustible, may, generally by yielding oxygen cause, or contribute to, the combustion of other materials.
5.2	**H5.2**	**Organic Peroxides**
		Organic substances or wastes which contain the bivalent-o-o-structure are thermally unstable substances which may undergo exothermic self-accelerating decomposition.
6.1	**H6.1**	**Poisonous (Acute)**
		Substances or wastes liable either to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact.
6.2	**H6.2**	**Infectious substances**
		Substances or wastes containing viable microorganisms or their toxins which are known or suspected to cause disease in animals or humans.
8	**H8**	**Corrosives**
		Substances or wastes which, by chemical action, will cause severe damage when in contact with living tissue, or, in the case of leakage, will materially damage, or even destroy, other goods or the means of transport; they may also cause other hazards.
9	**H10**	**Liberation of toxic gases in contact with air or water**
		Substances or wastes which, by interaction with air or water, are liable to give off toxic gases in dangerous quantities.
9	**H11**	**Toxic (Delayed or chronic)**
		Substances or wastes which, if they are inhaled or ingested or if they penetrate the skin, may involve delayed or chronic effects, including carcinogenicity.
9	**H12**	**Ecotoxic**
		Substances or wastes which if released present or may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/or toxic effects upon biotic systems.
9	**H13**	**Capable, by any means, after disposal, of yielding another material, e.g., leachate, which possesses any of the characteristics listed above.**

*As per TDG regulation

Antigua and Barbuda National Solid Waste Management Authority Act (as amended)

Under the NSWMA Act, “hazardous waste” is defined in Antigua and Barbuda as meaning “any substance or preparation which by reason of its chemical or physicochemical or biological properties or handling, is liable to cause harm to human beings, other living creatures, plants, microorganisms, property or the environment; and includes but is not limited to the category and characteristics contained in Annexes I or II of the Second Schedule”.

NSWMA Act Annex I transpose the Basel convention list as presented above in Table 3 with the addition of the following two items:

Y46	Wastes collected from households
Y47	Residues arising from the incineration of household wastes, other

The NSWMA Act Annex II replicates the Basel convention list as presented about in Table 4 with the addition of radioactive materials (as item 7) which, as previously mentioned, has been excluded from the scope of the HWISF planning.

The NSWMA Act therefore largely directly transposes the Basel convention definition into domestic legislation.

1.2 General Options for Temporary Hazardous Waste Storage

Taking into consideration the definition of Hazardous Waste in Antigua and Barbuda, the possible options to be considered for medium-term hazardous waste storage include:

1. Open storage (fenced in area for storage of packaged hazardous waste which is not susceptible to temperature influence and weathering);
2. Housed storage (mainly for radiant and outgassing hazardous waste);
3. Open storage with basic shelter (mainly wastes susceptible to direct sunlight and weathering).

Due to climate conditions in Antigua and Barbuda with heavy rains, Option 1 is immediately considered inappropriate and as such this option is not further considered in the report

Table 5 evaluates Options 2 and 3, indicated according to the above definition what type of storage would be required for the major identified hazardous waste groups identified during the baseline study as being generated in Antigua and Barbuda.

Table 5: Storage Options for HZW

HZW Type	Housed Storage	Open Storage Basic Shelter
Waste oil and oil sludge in barrels	X	X
Other chemicals in tin cans or plastic cans	X	X
Paint and ink in cans	X	X
Acids in cans or barrels	X	X
Batteries and accumulators	X	X
Solvents in cans or barrels	X	X
Agrochemicals & pesticides in cans or barrels	X	X

Housed storage incurs the highest investment cost because it requires an independent ventilation system, fire detection and fire prevention equipment and storage equipment for outgassing and highly flammable materials. All types of hazardous waste identified as being generated in Antigua and Barbuda would be suitable for housed storage.

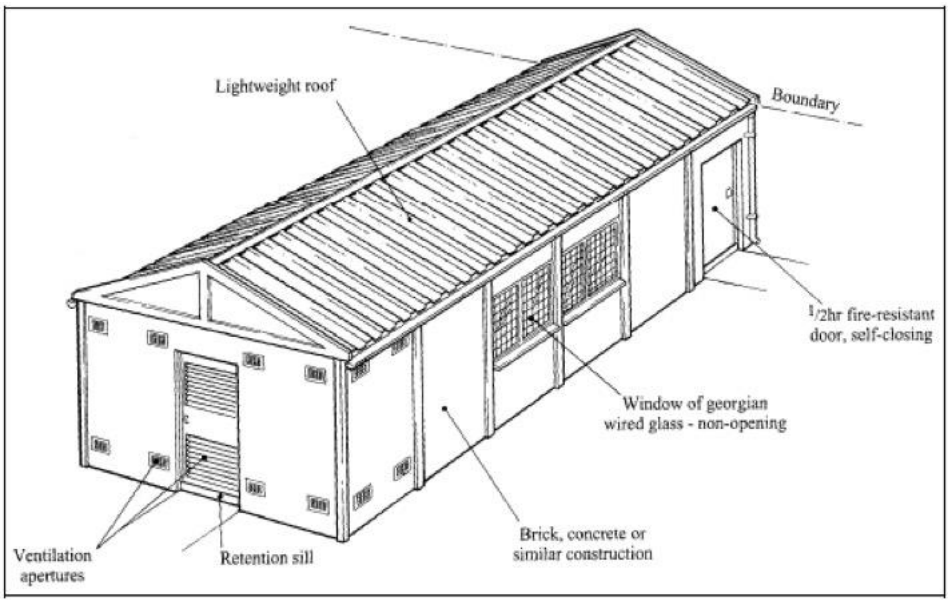

Figure 1: Example housed storage facility for hazardous materials / waste

An **open storage with a basic shelter** combines the above-mentioned storage facilities e.g. a steel frame building protecting stored waste from adverse weather conditions and extreme sunlight, with partition walls for waste with incompatible classification, but natural ventilation. Fire detection and prevention equipment is also required. All types of waste generated in Antigua and Barbuda which have been identified as arising and requiring to be stored would be suitable for open storage with basic shelter.

1.3 Location for Temporary HZW Storage

In principle a temporary storage facility should be located in the geographical centre of the Antigua and Barbuda, easily accessible from all areas of the country. However, the centre of hazardous waste generation is not equivalent to the centre of hazardous waste generation which are predominately the industrial zones and the capital.

In order to optimize the construction and operation of the proposed hazardous waste storage and to achieve synergy effects it is recommended to place the storage at Cooks landfill. Reception building, staffing rooms, changing rooms, hygiene units as well as a weighbridge and other infrastructure like access roads, power- and water supply are available at the landfill. In addition, it is not necessary to hire a complete set of staff.

The location of the hazardous storage facility within the area of Cooks landfill, as proposed by the NSWMA to the consultant team during the site visit in October 2019, is indicated in the following Figure 2.

Figure 2: Proposed location of the Hazardous Waste Interim Storage Facility

1.4 Proposal for Hazardous Waste Storage

Due to the local weather conditions - being hot humid with intermittent substantial rainfall – for the type of hazardous wastes to be stored, an open storage with basic shelter is recommended for Antigua. Based on the findings during the mission to Antigua and Barbuda in October 2019, the hazardous waste storage shall be designed to allow for the storage of wastes with the following characteristics, based on the classification according to Basel Convention, Annex 3, which includes:

- Flammable liquids and solids;
- Wastes liable to spontaneous combustion
- Oxidizing waste
- Poisonous waste
- Corrosive waste
- Toxic and Eco-toxic waste

Explosives are required to be excluded from the hazardous waste storage and instead stored at a separate place provided by the owner of the waste.

As directed by the beneficiary, the treatment and storage of WEEE (Waste of Electrical and Electronic Equipment) will be managed under a separate initiative and facility and is therefore not considered further here.

Infectious waste from hospitals and surgeries belong to a different waste stream and are also excluded from the proposed hazardous waste storage.

For the design of the storage and the required equipment the following aspects have been taken into account:

- Required storage capacity and equipment;
- Type of storage containers;
- Design of the storage building and manoeuvring area;
- Ventilation;
- Building services (water and electricity supply, wastewater discharge);
- Fire prevention and firefighting equipment (fire extinguishers);
- Technical safety equipment for personnel.

Best practice dictates that the storage should be partitioned by fire resistant walls into three sections for safe keeping of 1) highly flammable chemicals in section one, 2) other chemical waste in section two, and 3) all remaining types of waste intended for storage in the third compartment.

The recommended storage must also house a reception point to register delivered wastes and if necessary, sort/prepare and repack wastes for storage in the storage building. Furthermore, the storage facility has to be equipped with fire detection and prevention equipment in form of a foam extinguisher system (as some wastes may adversely react with a water system). Also, health and safety measures by means of emergency showers with an independent water supply will have to be installed. For the staff changing rooms, hygiene units (ablutions) and rest rooms must be available. At the proposed facility for Antigua, these facilities shall be shared with those currently established and in use at Cooks landfill site.

Storage facilities are primarily designed to hold hazardous wastes until they have amassed enough quantities to make onward treatment or disposal more economical and effective. They are not prepared for final or long-term storage of hazardous waste. A review of select international regulations and guidelines related to storage and handling of Hazardous waste presented in Annex A was conducted for the Assessment Report on the existing hazardous waste storage in Antigua & Barbuda. This identified certain design criteria as being identical or similar in each regulation which formed the basis for the criteria used by this consultancy team for conducting our assessment of existing and design of the proposed facility for hazardous waste storage in Antigua and Barbuda:

- The storage area should be designed to provide adequate space to store all scheduled wastes generated or managed by the premise.
- The design capacity should consider the following:
    1. Providing extra storage capacity of the actual maximum amount of waste generated (e.g. 25% reserve)
    2. Storage duration for a certain time (not more than 180 days or as prescribed by the Department of Environment).
    3. The entire storage area must be fenced-in and regarded as restricted area. Adequate signage should be put up clearly and visible with the word “DANGER” and “SCHEDULED WASTES STORAGE”
- The floor of the storage area and loading and unloading area must be covered with concrete or equivalent suitable lining material, free of cracks and gaps.
- The storage place should be sheltered or roofed or covered with suitable covering material.
- The entire storage area should be surrounded by a concrete dike or other equivalent structure designed to contain any spillage of the waste under the worst-case scenario. The capacity of the containment should be 110% of the largest container stored in the storage area.
- There should not be any opening in the dike to prevent any leakage of waste from the storage area.
- The dike area should be graded to a sump.
- The storage area should be properly managed to prevent rainwater or surface water from entering the storage area.
- Any surface water run-off should be channelled to a proper drainage system to avoid the water from entering the storage area.
- The loading and unloading area should be designed to contain any spillage.
- The storage area should be equipped with ventilation system for volatile wastes.

- Separate compartments should be provided for different groups of incompatible wastes.
- Storage area should be designed to provide adequate emergency escape route.
- The storage area should be equipped with fire-fighting system and other emergency response equipment as well as spill kit and comply fully with the requirements of the Fire and Rescue Department of Antigua

1.5 Required Waste Storage Capacity

Chapter 2.2 – of *ANU Report 1 Baseline Assessment and Training Needs Analysis*, gives a brief assessment of the current waste streams including hazardous waste for Antigua and Barbuda. The major hazardous waste groups of interest for temporary storage were assessed to be a relatively targeted and include:

- Reactive and inorganic chemicals, organic solvents arising from laboratories;
- Acids;
- Used oil sludge and oily wastes (rags, filters, contaminated absorbent material, etc - with regards to used oil filters the oil will have to be removed by crushing and metal housing recycled or disposed to landfill);
- Plastic (PVC, BFR) housings of electronic wastes;
- Cathode Ray Tubes (CRT);
- Mercury and mercury lamps
- Packaging containers for pesticides and hazardous chemicals

Based on information provided and gathered during site visits, an estimation of the hazardous waste currently being generated and the quantities likely to be generated during the period 2020 to 2024, using a 2 % growth rate in quantity, was carried out. It is unlikely that the amount generated will all be captured. Furthermore, some other treatment outlets may be found during the period of the construction and operation of a storage facility. Based on international experience and likely percentage capture, it was assumed that in the initial years only 25 % of the hazardous wastes generated will be captured and this will increase incrementally subject to aggressive awareness campaigns and enforcement. It is thus assumed that for 2020 and 2021 the capture rate will be 25 %, whereas in 2022 onwards there will be an annual increase of 5 % to reach a capture of 40 % in 2024.

Table 6: Summary of storage capacity for hazardous waste

Hazardous waste	Description	Annual amount requiring storage in kilogram or litres				
Year		**2020**	**2021**	**2022**	**2023**	**2024**
Chemical wastes/ pesticides residues in empty containers *	Inorganic wastes, wastes organic solvents (may contain halogenated solvents) - Solutions containing heavy metals	51 00	5 202	6 367	7 577	8 832
Used oil Sludge	Organic solid	86 700	88 434	108 243	129 080	150 144
Acids	Inorganic liquid	45 90	4 681	5 730	6 819	7 948
Total Storage requirements		**124 440**	**126 928**	**155 360**	**185 149**	**215 503**

Table 7: Estimated volume of hazardous solids and liquids that require storage for 2020 to 2024

Year wastes collected in	Amount solids, tonnes	Amount liquids, Cubic metres	Total amount of solids and liquids	Approximate number of 210 litre drums
2020	119.3	5.1	124.4	593
2021	121.7	5.2	126.9	605
2022	148.9	6.4	155.3	740
2023	177.5	7.6	185.1	882
2024	207.2	8.8	216.0	1029

1.5.1 Storage of Oil Sludge

The Baseline study identified that a significant quantity of hazardous waste arising in Antigua is oil sludge. It is mainly produced by Antigua Power Company (APC). Expected quantity in 2024 is 150 tons of sludge. A hazardous waste interim storage facility (HWISF) is designed for storing smaller quantities of hazardous waste collected from several small producers who are not able to facilitate environmental sound storing capacities, lack the scale to make shipment to appropriate treatment economically viable, or be expected to follow health and safety standards for their staff. It is therefore apparent that an oil sludge production of 150 tons per year from mainly one location is not a waste stream immediately intended for the proposed HWISF at Cooks landfill.

This could be stored and exported directly from the generator's premises, but only if the waste is properly stored, packed & labelled. A container would therefore be loaded with the waste and shipped without being stored at the proposed HWISF. However, in order to ensure packaging, labelling and transport of the oil sludge is in compliance with the Basel Convention, it is highly advisable that shipment procedures, securing treatment and disposal facilities and shipment be entrusted to the operator of the HWISF.

It is therefore recommended that APC should establish their own adequate storage capacities which fulfil environmental and health and safety standards and utilise the expertise and connections of the proposed HWISF for any shipment logistics coordination.

Based on this recommendation, further design and storage volume calculations of the HWISF, do not consider oil sludge from the APC.

1.6 Environmental Aspects

The main potential environmental impacts arising from the operation of the proposed HWISF are:

- Spillage of any liquid substances may contaminate sounding soil and water courses;
- Fire within the facility may result in air pollution and soil/water pollution from fire fighting foams/water.

In order to minimize any such environmental impacts that might be caused by the operation of the storage facility, the installation of the following appropriate equipment requires to be undertaken as part of risk mitigation measures:

- Special fire prevention and firefighting equipment, e.g. fire extinguishing agent;
- Special storage equipment (containment system) e.g. with collection trays in case of spillages.

In comparison to the quantities of municipal and commercial solid waste going to Cooks Landfill, the quantity of hazardous waste to be handled at the proposed Cooks Landfill HWISF are relatively small. The risks for disturbances of operations at the existing Cooks Landfill site and immediate vicinity that might lead to significant negative impacts on the environment are therefore very low.

2 Proposed Design

2.1 Size and layout of the HWISF

As detailed previously, consideration has been given to the estimated types and quantities of hazardous wastes predicted to arise annually in Antigua and Barbuda over the coming 30 years (designed economic life if building) as previously summarised in chapter 1.5 of this report. Additional consideration is given to appropriate storage and containment systems (presented in the following sub-chapter 2.2). The interim storage nature of this facility is also considered with the understanding that wastes are stored for no longer than one year. Based on these considerations, the required size of the proposed HWISF is calculated and designed to be 270m^2 net, plus 10m^2 of additional roofed storage for gas cylinders and aerosols.

As mentioned, the conceptual design and sizing of the facility and each storage room is based on the concept that the facility is partitioned by fire resistant walls into three sections for safe keeping of 1) highly flammable chemicals in section one, 2) other chemical waste in section two, and 3) all remaining types of waste intended for storage in the third compartment. Additional buffer space has been provided in each storage room to allow for flexibility of use which also requires correct containment and distancing of the materials as described below.

It is therefore proposed that the HWISF be comprised of four distinct sections as illustrated in Figure 3. This includes three separate storage sections for the interim storage of hazardous waste and one separate section for waste reception and sorting, as well as accommodating equipment storage for facility operations.

Sections 1-3 (approximately 73 m^2 each) are the designated areas for hazardous waste materials with the most relevant quantities. These substances will be stored in special containers as described in sub-chapter 2.10.

The fourth section is sized as the waste Reception Area where waste is received, separated, labelled and placed in the appropriate container as well as storage area for specific facility equipment (e.g. forklift, etc.).

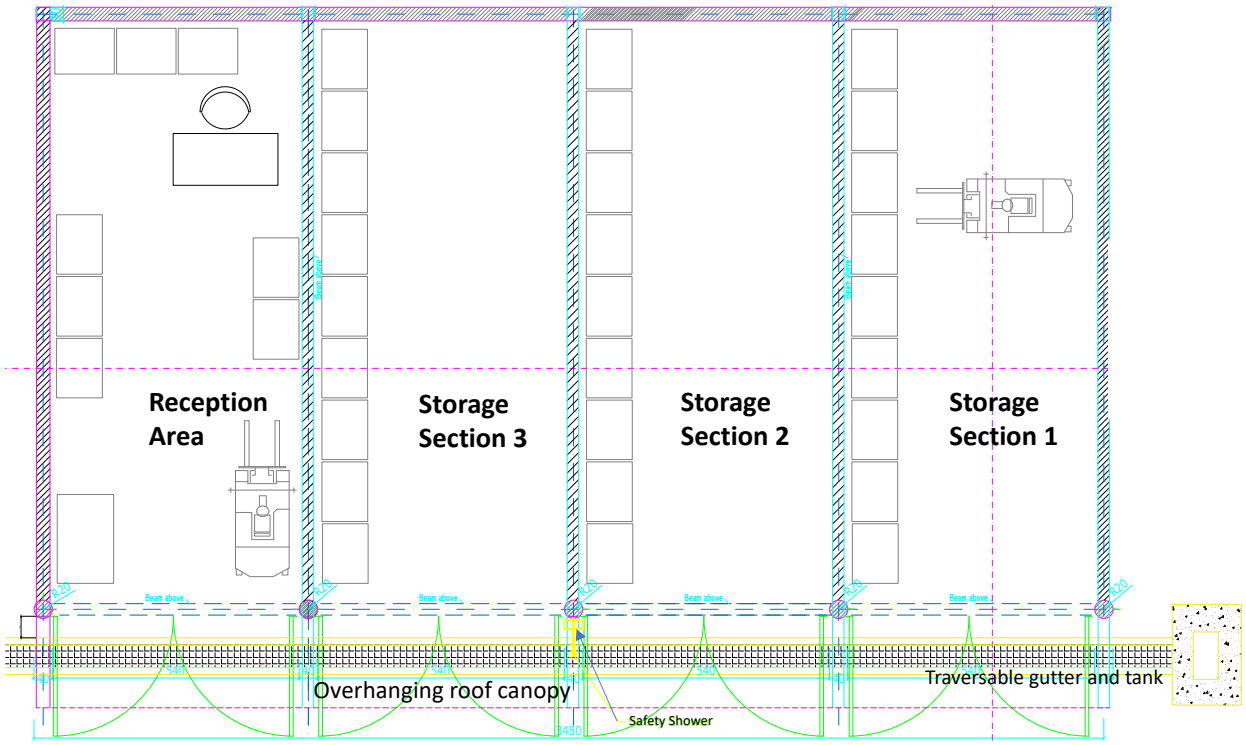

Figure 3: Proposed layout of the HWISF

Segregation of hazardous waste in sections 1 to 3 will be conducted in accordance with compatibility, in order to avoid adverse reactions which would endanger the safety of workers and environment in case of accidental

mixing or fires. Specific division of materials between the three sections will be dependent upon specific quantities of waste being stored at the facility and containment vessel availability which may change overtime (this is further discussed in the following sub-chapter 2.2).

Organizing the types of wastes to be stored in the same section will be undertaken based on the UN class (as introduced in Chapter 1) of the specific waste as specified in the MSDS when composition is known or based on the composition determined by laboratory analysis. Each different type of waste is to be stored in separate safe packaging with no incompatible wastes sharing the same container or spill catchment tray (see following sub-chapter 2.2). Compatibility and segregation rules in Table 8 will be adhered to when deciding where to place a certain waste type within the HWISF. The table was adapted based on UN Model regulations on Dangerous Goods and International Maritime Dangerous Goods Code.

Table 8. Dangerous goods (substances and waste) compatibility table and segregation rules.

UN Class/division*		3	4.1	4.2	4.3	5.1	5.2	6.1	6.2	8	9
3	Flammable liquid	X	X	2	1	2	2	X	3	X	X
4.1	Flammable solids (including self-reactive substances)	X	X	1	X	1	2	X	3	1	X
4.2	Substances liable to spontaneous combustion	2	1	X	1	2	2	1	3	1	X
4.3	Substances which, in contact with water, emit flammable gases	1	X	1	X	2	2	X	2	1	X
5.1	Oxidizing agents	2	1	2	2	X	2	1	3	2	X
5.2	Organic peroxides	2	2	2	2	2	X	1	3	2	X
6.1	Toxic substances	X	X	1	X	1	1	X	1	X	X
6.2	Infectious substances	3	3	3	2	3	3	1	X	3	X
8	Corrosive substances	X	1	1	1	2	2	X	3	X	X
9	Miscellaneous hazardous substances/wastes	X	X	X	X	X	X	X	X	X	X

* Substances / wastes pertaining to the following UN classes would not be accepted at the HWISF:

Class 1 – Explosives – not admitted at the HWISF: to be managed by the military/defense force.

Class 2 – Gases and aerosols – cans of pressurized gasses and aerosols are recommended to be stored in a separate shed with ventilated sides, described below.

Class 6.2 – Infectious substances – are intended to be handles and destroyed by the medical waste management units at the hospital.

Class 7 – Radioactive material – not admitted at the HWISF, to be managed by responsible authorities according to specific international protocols.

Segregation code	Meaning
X	No segregation required (unless specific segregation provisions are provided in the Dangerous Goods List). Most dangerous goods of the same class (division) have similar primary hazards and are usually considered to be compatible. Please note, however, that there are a number of different types of solid 'pool chlorine' materials within Division 5.1 which are mutually incompatible – refer to MSDS for further information. With a few exceptions, which should be indicated on MSDS, goods of these classes (divisions) are usually non-reactive with each other. However, in an emergency such as a spill, leak or fire, the presence of the second class (division) may lead to different hazards or increased risk such that additional control measures are required. Refer to MSDS for guidance. In case of class 8, if one material is a concentrated, strong acid and the other is a concentrated, strong alkali, than these should not be stored in the same section.
1	'Away from' - the distance between the packages to be at least 3 meters. While goods of these two classes (divisions) are usually non-reactive with each other, a fire involving the fire risk goods may lead to the release of large clouds of toxic gases or vapors.
2	'Separated from' - the distance between the packages to be at least 6 meters. In some cases, interaction may result in fire or evolution of toxic vapors. For those that do not interact, a fire involving one may be violently accelerated by the presence of the other. These classes (divisions) should not be kept in the same area unless it can be demonstrated that the risks are fully controlled.
3	'Separated by a complete compartment or hold from' (at least 12 meters.) Store in different section, together with compatible wastes.

A gas cylinders and aerosols containment store will be constructed outside of the main HWISF building for UN Class 2 waste materials. It will have a size of around 10m² and a height of 2.4m. The roof will be a single metal sheet. All sides are closed with a fixed mesh wire construction including a lockable door of mesh wire. It is to be located at a minimum distance of 7 metres from any open sides of the HWISF and at least 1.5m from walled sides (i.e. a non-combustible barrier at east 1.5m high with a fire-resistance rating of at least one hour). It is preferrable to locate it in a shaded area to avoid direct sub exposure on the gas canisters to minimise temperature ranges. Groundwater protection measures in the storage are not necessary for the gaseous wastes. The specific location of this containment store will be determined by the design-build contractor in consultation with the NSWMA to determine most suitable location. Further construction details for the gas cylinder containment store will be included in Deliverable 10 – Technical specifications.

The HWISF shall be constructed under environmentally sound considerations and fulfil all international and local standards.

2.2 Storage system layout of the HWISF

As previously described, various types of hazardous waste will be delivered in varying quantities at any one time which, inevitably, will not always be packaged adequately. Furthermore, it is expected that waste fractions in bigger quantities will not be stored over long periods but shall be released from storage as soon as possible. Therefore, the hazardous waste storage facility needs to be equipped with a flexible storage system that allows storing different types of hazardous waste safely but at the same time being easily accessible.

It is common practice to use shelving units on which pallets packed with barrels for liquid wastes or special storage boxes are kept. By using pallets, the hazardous waste will be lifted onto the shelving units by a forklift with no manual lifting required (reducing risk of personal injury and or spillage).

Based on the estimated types and quantities of hazardous wastes predicted to arise in Antigua and Barbuda, as presented in the "Assessment Report on the existing hazardous waste storage", the Consultant calculated the required shelving meters for each storage sections. This considers a maximum height of shelving system that does not exceed 5 m, which is equivalent to two shelves, one above another.

Further, based on the Consultants experience, it is assumed that, for instance, "Paint and Ink" will be delivered in 1 kg – 10 kg cans and plastic bins, which will then have to be repacked into larger storage barrels or boxes, of which a certain number may be then packed on a pallet and stored. With consideration of these assumptions, Table 9 presents a calculated estimation of the minimum number of storing units required per section.

Table 9: Minimum Number of Storage Units per Section

No.	Name of Provisioned Room	Expected quantity per year (litre)	Surface of storage room [m^2]	Storing Positions for Minimum)*	Capacity of the storage room in months
1	Section 1	8,832	73.0	11 pallets for 44 barrels	19-20
2	Section 2	Unknown	73.0	Max. 5 pallets and 6 collecting tanks for liquids	unknown
3	Section 3	7,948	73.0	10 pallets for 40 barrels	21-22
4	Reception area	n.a.	73.0	n.a.	n.a.

* capacity is based on 200 litre plastic drums

Storage of waste in the HWISF should not be more than 1 year. However, for the safety of the system, the storage capacity is predicted and designed to vary between 16 and 22 months for the different waste fractions.

Table 10 presents the total number of shelving units (equal to pallets 1,200mm x 800mm) calculated as being required to be provided for:

Table 10: Number of Storage Units per Storage Room

No.	Name of Provisioned Room	Surface [m^2]	Minimum Storing Positions
1	Section 1	73.0	18 pallets
2	Section 2	73.0	18 pallets
3	Section 3	73.0	18 pallets
4	Reception area	73.0	n.a.

For the storage space calculation, in addition to the maximum height, the minimum required width of the aisle between the shelving has to be taken into account to ensure the forklift can manoeuvre pallets and containers onto the shelves safely. For the operation of a 3 t-load capacity forklift truck with a turning radius of about 2.40m (depending on manufacturer), a minimum aisle width of about 3.9 – 4.3 m will be required.

Table 11 presents the spacing required for the three sections assuming two shelves per unit with two pallets per shelving unit:

Table 11: Calculation of shelving metres per section

No.	Name of provisioned room	Storing positions for minimum	No. of shelving units * [no.]	Total shelving length [m]	No. of rows of shelving [no.]
1	Section 1	18 pallets	9	10.8	1
2	Section 2	18 pallets	9	10.8	1
3	Section 3	18 pallets	9	10.8	1

* Required size for 1 shelving unit: length 1,200 mm x depth 800 mm.

The total interior length of the building is calculated based on the sections 1 - 3 being equipped with 1 row of shelving with a 4.3 m aisle width plus an additional 1 m for each shelf.

2.3 Building Construction

The HWISF building is proposed to be constructed close to the existing reception area of Cook landfill constructed in 2002 under an OECS funded project. For the design it is assumed that necessary soil parameters of the subbase are available from the design of the landfill /reception area and that the subbase is stable and special foundations are not required.

The building will be open on one side for direct access to the different storage areas by forklift trucks. Double wing wire mesh metal gates prevent access outside official opening hours. Areas above the gates between the gates and up to the roof will be equipped with fixed wire mesh to allow free air flow but prevent animal or other unwanted visitor access.

After defining the arrangement of the different storage sections, taking into account the maximum height for the planned shelving and minimum width of aisles in order for the forklift to manoeuvre safely, the overall dimensions of the building are calculated to be as follows:

- Length x width: 23.20 m x 13.35 m
- Height inside the building: 5.40 m – 6,86 m
- Max. height outside (ridge of roof): 7.25 m
- Total surface inside the building net (without walls): 270.6 m2

Figure 4 to 7 illustrate the conceptual design of the HWISF. A full set of drawings will be included to Deliverable 10 – Technical Specifications.

The storage facility has been designed as a high-quality hollow concrete blocks structure with a metal roof construction. Originally proposed cast in place reinforced concrete walls have been descoped to ensure the facility is cost appropriate. Walls will be plastered and painted on the outer sides of the building as protection against wind-driven rain.

The construction of the building sits on strip foundations and a reinforced concrete floor, based on a layer of compacted rubble with a moisture barrier in-between. The concrete floor is sealed and protected by an antistatic epoxy coating.

The dividing walls between the sections and the outside walls are also made from high quality hollow concrete blocks.

The roof construction consists of steel trusses (IPE beams) with steel roof battens and covered by a single metal sheet. The roof will be equipped with a gutter, which is connected to a drainage ditch for rainwater water infiltration and deviation.

The facility will have a concrete floor with a declination of 1% directed to the front side. Along the floor at the front side of the facility there will be a traversable gutter (Figure 8) connected to a containment tank.

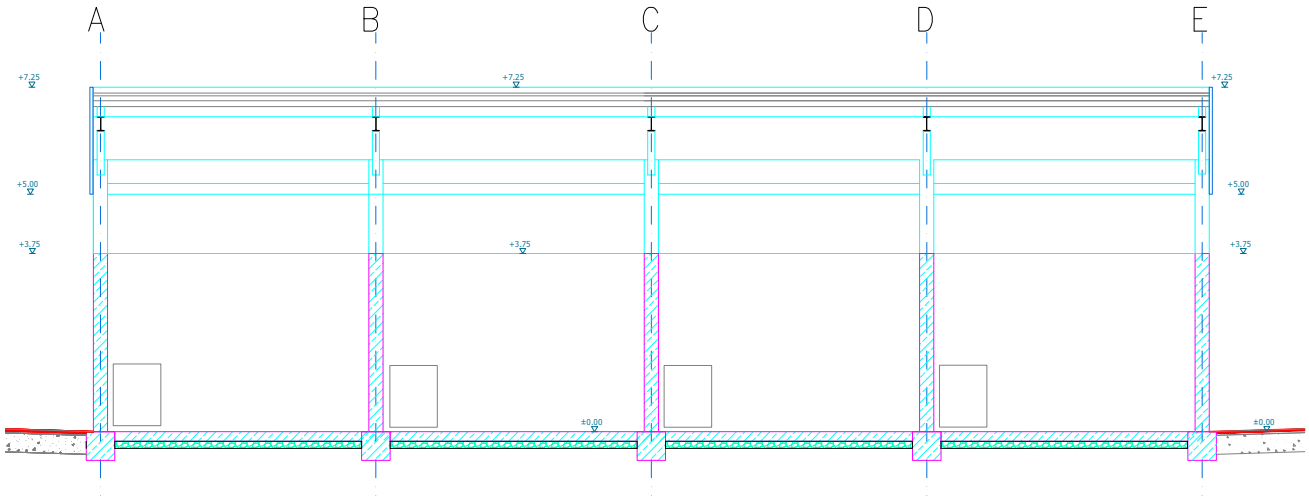

Figure 4: Front cross section of the HWISF

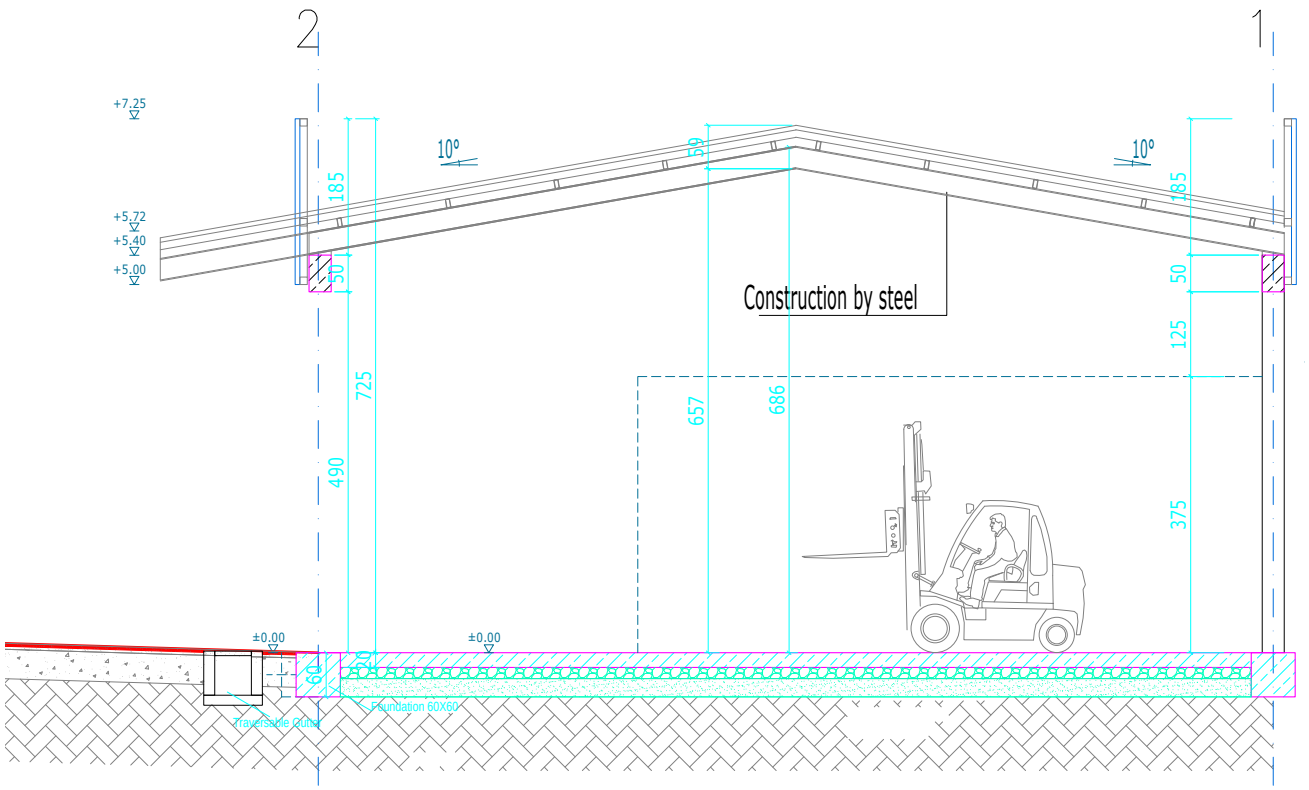

Figure 5: Side section of the HWISF

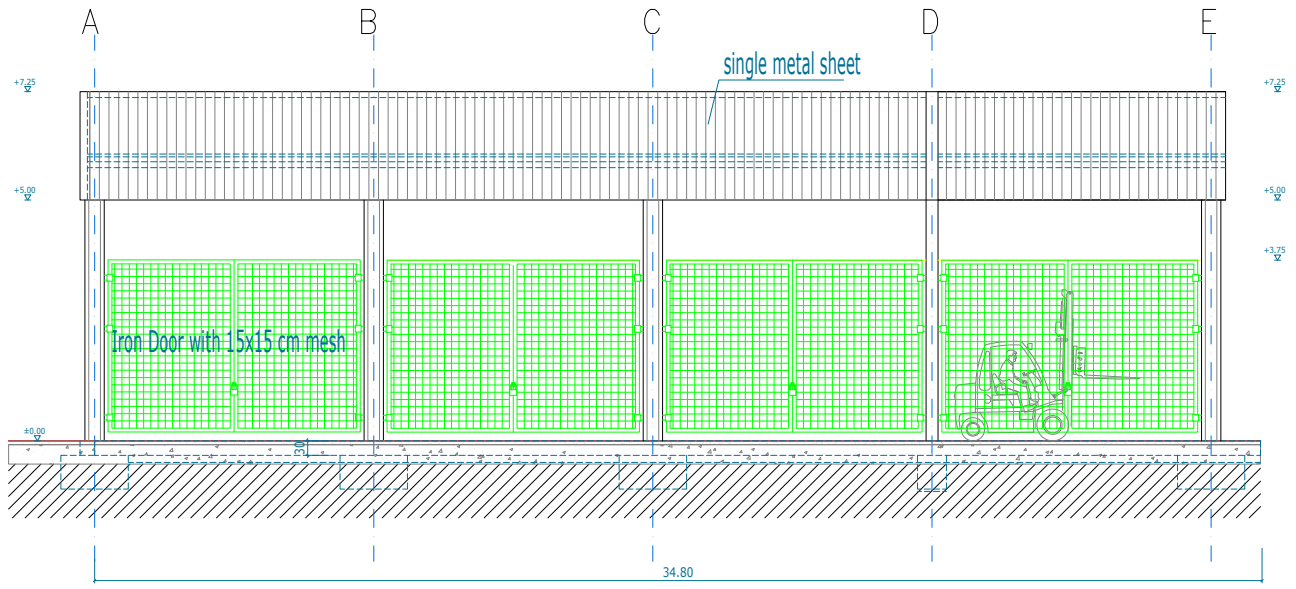

Figure 6: Front view of the HWISF

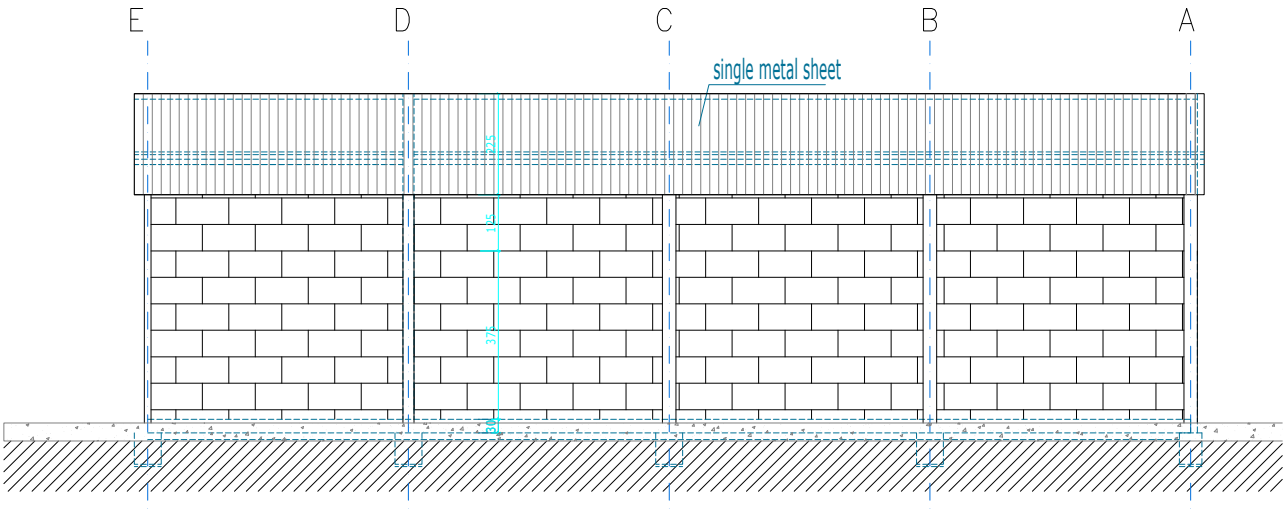

Figure 7: Rear view of the HWISF

At the front side of the storage, the roof and the concrete floor will be extended by 2.0m in order to carry out all loading and unloading procedure of waste under the roof and on the concrete floor. This makes sure that in case of an accident no liquids can leave the storage.

The concrete floor outside the storage will have a declination of 1% towards the above-mentioned traversable gutter along the front side of the storage. The gutter itself is connected to containment with a minimum capacity of 1,100liter following the requirement of having a capacity of 110% of the largest container, which is designed to not be larger capacity than 980liters. The container will be resistant to chemicals and has no overflow outlet, though shall have an inspection and clean-out opening on top.

Figure 8: Example of traversable gutter to be installed along the front side of the HWISF

The HWISF will be equipped inside with energy efficient and low heat LED lights and sockets incl. all necessary additional components.

2.4 Manoeuvring area

For the waste delivery trucks access and manoeuvrability, it is proposed that the area in front of the HWISF be prepared as a gravel platform. The recommended size is

- Length x width: 23.20 m x 15.00 m
- Total surface: 348 m^2

The platform shall have a declination of 1% - 1.5% away from the storage, with rainwater being collected in a soakaway ditch surrounding the platform for infiltration and deviation.

The manoeuvring area will be equipped with 3 energy efficient and low heat LED streetlamps on poles, located on each side of the manoeuvring area.

2.5 Material Balance

For the construction of the HWISF, the materials itemised in Table 12 are required (only the most significant materials have been listed).

Table 12: Material balance for hazardous waste storage

Description	Quantities
Gravel for base course (0.5m)	160m^3
Concrete for foundations	60m^3
Hollow concrete blocks for external and dividing walls	131m^3
Concrete floor 20cm reinforced	320m^2
Structural steel	16t
Steel trusses for roof construction	5pc
Metal sheet	270m^2
Wall plaster (outside)	288m^2
Paint for walls (outside)	288m^2
Gates (max. 550 x 375 cm^2)	4pc

Platform outside the building (manoeuvring area) of gravel	348m^2
Traversable gutter along the front line of the storage	23.2m
1,100liter tank for spillage liquids with cover and lid	1set
Perimeter fence 2.5m high	45m
Gate	1 set
Electricity line between landfill office and HWISF	80m
Water supply between landfill office and HWISF	80m

2.6 Building Equipment

2.6.1 Ventilation of the Building

To prevent dangerous concentrations of flammable vapours accumulating in a building or storage area as a result of a leak, the space needs to be adequately ventilated.

It is therefore proposed to construct the HWISF as an open storage building with roof, side and separation walls, leaving the front separated only by metal mesh walls and gates in order to protect the stored hazardous waste from adverse weather.

Due to the “open design” no additional technical ventilation will be required.

2.6.2 Fire Prevention and Fire Fighting

For fire prevention, smoke detectors to set off an alarm in a case of smoke will have to be installed. The fire behaviour of the stored materials cannot be clearly predicted as probably mixtures of various substances might be delivered to the HWISF in various quantities and times. Because some HZW react with water, which may lead to an aggravation of the situation, the installation of a water sprinkling system would rather represent a risk than an aid and therefore will not be installed. In order to stop fire jumping between the sections and across the building, the sections are separated by concrete hollow block walls.

To furthermore avoid the chance that flames from a potential fire jump to and affect another building, the HWISF is set well apart from other facilities at the landfill.

It is hence recommended to use fire extinguishers for a first attack of a fire. A corresponding amount of solid extinguishing agent will also have to be stored at the facility. A sufficient number of mobile 50 kg fire extinguishers and several wall mounted hand fire extinguishers will be placed in the hazardous waste storage facility following local standards.

2.6.3 Technical Safety

Apart from appropriate protective clothing, (protective suit, safety boots, gloves, eye protection and, where required, a hard hat), in case of direct skin or eye contact with chemicals a combined safety/eye shower is required to be installed at the entrance gate of section 3. The safety shower (see example in Figure 9) has to be accessible from HZW handling location within less than 10 seconds.

Figure 9: Example of a safety shower and eye wash

Prior to start of operations at the facility the following equipment must be made available on site:

- First aid kits
- Signage (operating procedures, existing risks and personal protective equipment to be used)
- Spill kit (absorbent materials and clean-up tools)
- Identification billboard at the entrance

No additional installations will be required. Lockers to store protective clothing and hygiene facilities are available to the staff of the HZW storage facility within the landfill office building.

2.7 Access to Site

Access to Cooks landfill site as well as to the proposed HWISF will be via an existing access road. Delivery trucks for the hazardous waste storage facility will have to pass over the existing weighbridge for registrations first. Afterwards the trucks will have to turn around and drive to the HWISF. The road from the landfill access road to the HWISF is a gravel road. Due to the low traffic volume an upgrade of the road is not needed. Currently the area is used as storage or waste vehicle tyres. The tyres need to be removed before the HWISF can be constructed (Figure 10). This will also reduce the risk of fire around the HWISF significantly.

Figure 10: Proposed location of the Hazardous Waste Interim Storage Facility, currently used for storage of waste vehicle tyres.

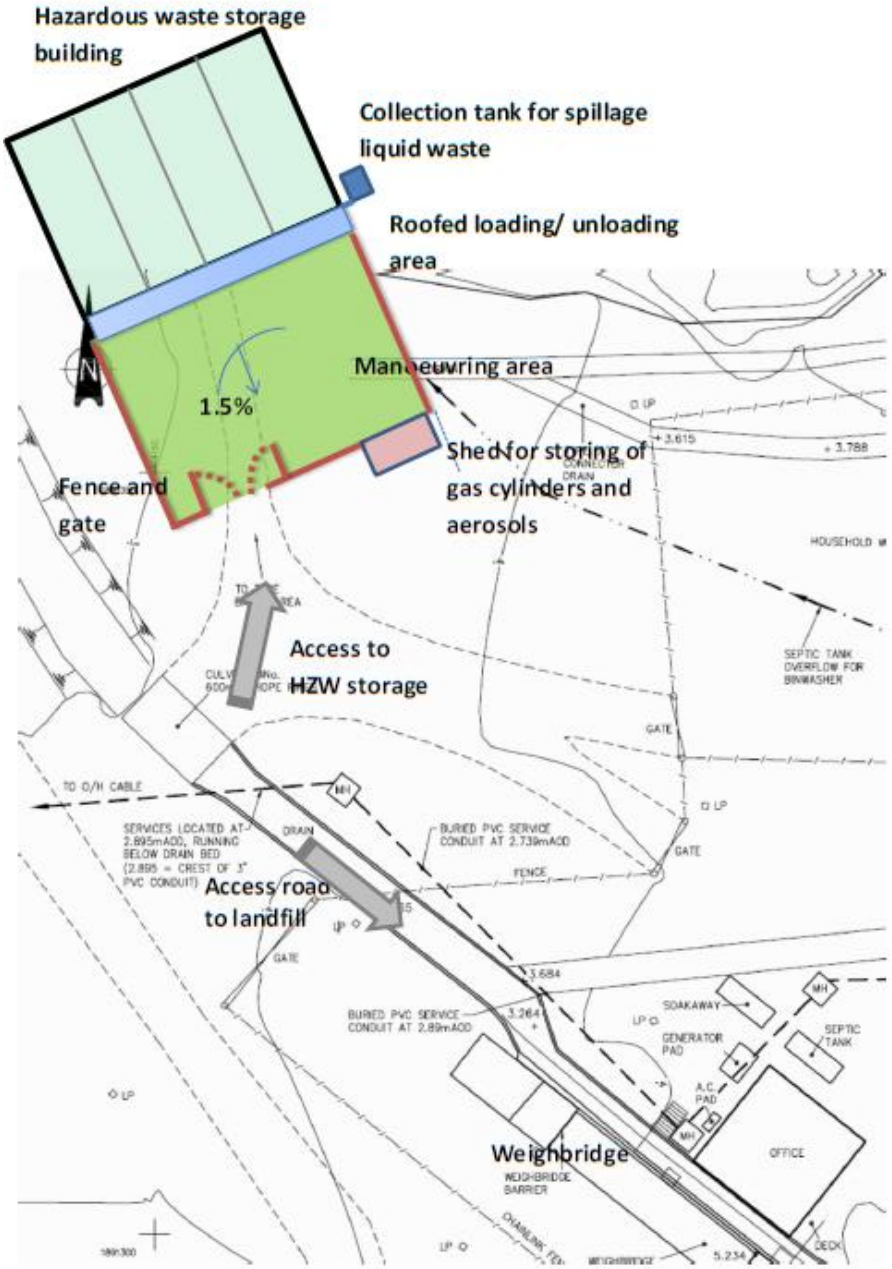

Figure 11: Proposed location of the HWISF beside the existing administration area of Cooks Landfill

The HWISF and its personnel shall require sharing the access road, the weighbridge including office, the office building and the parking with the landfill staff as indicated in Figure 11, hence no further infrastructure is required.

2.8 Fencing

As the landfill is not fenced it is recommended to install a dedicated perimeter fence / gate around the HWISF area of minimum 2.50m height. The fence is necessary to avoid unauthorized access and it prevents larger animals from entering the site.

The gate at the access point is opened only during the opening hours of the landfill and of the hazardous waste storage facility.

2.9 Building Services (Electricity and Water Supply)

The following recommendations are conceptual with the precise dimensioning of cables, other electrical devices and all pipework to be carried out with the detailed construction design. They are therefore not included in the conceptual design drawings as previously presented.

2.9.1 Electricity

The site will be provided with power by a new cable from the Landfill administration/ reception area and will be connected to a main distribution board next to the entrance of the Reception Area section. The total power supply for the HZW storage facility will amount to about 2.5 kW (mainly fire detection system and lighting).

2.9.2 Water Supply

Water will be used mainly for the emergency showers. A water pipe between the Landfill office building and the HWISF has to be installed including a small distribution network to the shower in front of the hazardous waste storage.

Detailed information about the internal distribution lines for water and electricity inside the building will be presented in Deliverable 10 – Technical specification (including drawings)

2.10 Storage Equipment for HZW Storage

Table 13 presents equipment for the storage of hazardous waste that should be supplied in order to operate the facility efficiently and effectively. It is an initial supply only. Items requiring to be reordered regularly will be identified during the operation of the storage, this is likely to mainly be pallets and plastic barrels.

Table 13: Type and Quantity of Storage Equipment

Description	Quantity [Pc.]
Euro pallet	100
Plastic barrel 200 l with lid	200
Fluorescent lighting tubes collecting box	10
Collecting box used lead acid batteries	3
Storage box with lid for used lead acid batteries	10
Collecting tank HZW liquids 400 l + 980 l	4 + 4
Special HZW collecting barrel/box	10
Mobile box 170 l + 250 l	40 + 40

Key elements of the storage equipment are the shelves. Shelves will be used to store hazardous waste on euro- or industrial pallets, large bundles up to 1000 liters lying, or standing barrels for secure storing (Figure 8). Shelving units should be a screwless construction for a fast and simple assembly with additional splash guards between the walls installed on each level as illustrated in Figure 9. The shelves will be equipped with a collection tank under the lower shelf to catch any spills and certified for flammable, easily flammable and highly flammable liquids.

Figure 12: Examples of different types of storage equipment

Figure 13: Examples of different types of shelving for hazardous waste containers

In addition to the shelving the following transport equipment will be required:

Table 14: Required Transport Equipment

No.	Description	Unit	Quantity
1	Forklift 3t	Pc	1
2	Hand forklift (2 tons)	Pc	1
3	Hand barrel lift	Pc	1
4	Pushcart (200 kg)	Pc	1

2.11 Testing Equipment for HZW Storage

Materials arriving at the HWISF shall require to be tested to identify and qualify their content and nature. Results of the tests have to accompany the waste materials.

Testing and identifying the incoming waste is a substantial part of the storage to make sure that only compatible wastes are stored together. Waste identification is essential for transport and final treatment and disposal or incineration.

The following lab equipment will be required at the facility or be available to the facility via third party laboratory (Government's Analytical Laboratory or private):

- UV-Vis spectrophotometer for chlorine
- pH/EC meter
- Calorimeter for determining calorific value
- Atomic Absorption Spectroscopy (ASS), for quantitative determination of chemical elements
- Total Organic Carbon (TOC) analyser;
- Ion chromatography equipment for determination of anions;
- Flash point tester;
- Muffle Furnace (1100°C) for volatiles
- Gas Chromatography – Electron Capture Detector (ECD)

These will be required for the testing of heavy metals, flammability (and if so the flash point), pH, calorific value, anion levels such a chlorine and organics.

2.12 Equipment for Reception Area

The reception area is located in the fourth Section of the HWISF and shall contain the following equipment for operating the storage adequately as shown in the following Figure 14.

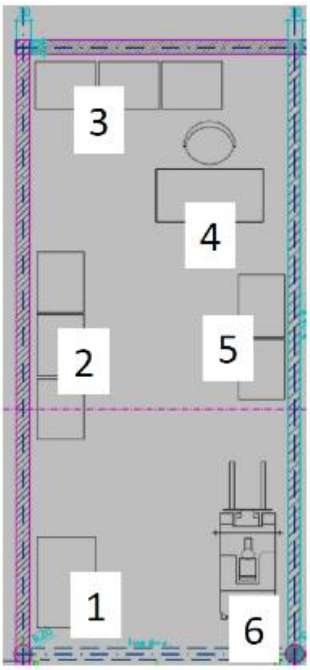

Figure 14: Layout of the reception area

1 Main distribution board (electricity) and oil filter press
2 Laboratory and waste sorting tables
3 Shelves for storing smaller waste quantities to be identified
4 Desk and chair
5 Boards for documents
6 Parking area for the fork lifters

3 Operation of HWISF

3.1 Staffing

The HWISF must be operated by staff adequately qualified for the particular tasks assigned and required. The entire staff must be reliable and have available relevant expertise and practical experience. Education and further training of the staff for their specific tasks is desirable. Suggested minimum personnel are listed in Table 15.

Table 15: List of minimum required HWISF Staff

Type of Staff	No. of Staff
Site manager / supervisor	1
Technician / driver	1
Lab technician (or adequately budgeted third party)	1
Worker / labourer	1
Total	4

3.2 Operation, Maintenance and Monitoring

The trained staff will handle the delivered waste at the HZW facility as described in detail in the O&M manual (Deliverable 11). In general, the procedures will involve:

- Waste delivery registration and inspection including weighing, checking of the delivery documentation. The required weighbridge belongs to Cooks landfill and is shared with the HZW storage facility.
- Checking if the accepted waste has been packaged in appropriate containers for the storage inside the HWISF. If the packing does not correspond to the regulations set for the HZW storage, the HZW has to be re-packaged into suitable storage vessels by the facility personnel. For liquid waste these are watertight and gas-firm containers according to the ADR regulations or approved alternate.
- The delivered small quantities of hazardous waste should be placed in larger containers and surrounded with a bonding agent. In case of a liquid spill or leak the bonding agent absorbs the liquids. The bonding agent works also for fire-retardment. If the delivered waste requires re-packing, suitable containers plus bonding agent are required.
- According to the waste declaration, after registration and inspection, assign appropriate areas within the facility for the storage of the received HZW.
- Maintain a detailed log of all HZW contained on site, their location and quantity, ensuring all materials and equipment are stored in correct locations at all time.
- Operate and maintain all equipment and infrastructure safely.
- Identify suitable quantities to make shipment to appropriate treatment/disposal economical, compile consignments and arrange for shipment in accordance with Basel Convention guidelines.

At present it is not known, which types of HZW in which volumes will be stored in the future. For this reason, it is highly recommended to use the highest container-standards according to the ADR Directives for the proper storage and domestic transport of the HZW. Also, regarding onward shipment for treatment / disposal in an appropriate facility abroad, using the highest container standard early on ensures the storage vessels always correspond to the regulations of the ADR for future onward transport of HZW on road and / or sea.

Monitoring of the HZW storage can be limited to regular visual inspections and water samples from the gutter containment vessel and perimeter ditch. Results should be summarized in an annual inspection report submitted to the NSWMA and the Analytical Services Division. Any additional monitoring of parameters in connection with

the HWISF has not been identified as being required and should therefore be coordinated with the NSWMA and Ministry of Health, Wellness and Environment.

In comparison to the quantities of municipal and commercial solid waste going to Cooks Landfill, the quantity of hazardous waste to be handled at the proposed Cooks Landfill HWISF are relatively small. The risks for disturbances of operations at the existing Cooks Landfill site and immediate vicinity that might lead to significant negative impacts on the environment are therefore negligible.

The danger that groundwater and surface water will be contaminated with hazardous substances is not foreseen during normal procedures at the storage facility as a corresponding amount of special binding material will be stored in the facility to protect the environment, bunded catchment trays under shelves shall be installed, and the concrete floor will be sealed to prevent liquid seepage through the floor.

However, the HWISF involves some specific risks to the environment. Especially the risk of leaks, spills, fire and explosion from some small amounts of hazardous materials predicted to be stored within the storage facility. This must be addressed in the final operational manual. Written instructions for storing and disposing of each type of waste will be provided and handed out to all employees and suppliers. In addition, all staff will receive instructions to be followed.

4 Cost Estimates

Figure 16 presents a summary of the estimated costs to establish the HWISF with additional detail presented in the following sub-section. Facilities that can be used from the existing landfill infrastructure (office, social rooms etc.) are not considered in the cost estimation. Costs are based on similar projects using unit costs per m^3, m^2 or m length. Minor changes may occur during the preparation of the detail design and technical specification. 15% shipping costs on average are considered for items that come from outside Antigua.

Table 16: HZW Storage Facility – Summary of Investment Costs

Item	Cost [USD]	Cost [XCD] *)
HZW facility construction works	151 400	408 800
HZW storage equipment	138 288	373 380
Unforeseen, rounding	5 312	17 820
Total Investment Costs	**295 000**	**800 000**

*) Average exchange rate: 2.7 XCD/USD.

4.1 Construction Costs

Table 17 presents the estimated cost of constructing the HWISF.

Table 17: HZW Storage Facility – Cost of Construction Works

Item	Cost [USD]	Cost [XCD]
Earthworks	8 800	23760
Concrete works	22 000	59400
Walls	34 000	91800
Structural works	16 500	44550
Wall plaster and paint (outside walls)	9 900	26730
Gates	7 900	21330
Roofing	9 600	25920
Electrical installations	10 000	27000
Mechanical and other installations	5 500	14850
Water supply and distribution	1 600	4320
Fence /gate	9 000	24300
Platform	6 600	17820
Spillage container	2 500	6750
Traversable gutter	3 500	9450
Separate shed for gas cylinders and aerosols	4 000	10 800
Total Investment Costs	**151 400**	**408 800**

*) Average exchange rate: 2.7 XCD/USD

4.2 Equipment Costs

For the operation of the HZW storage facility, various floor trucks as well as storage and protection equipment will be needed as detailed in Table 18.

Table 18: HZW Storage Facility – Cost of Equipment

Item No.	Description	Unit	Quantity	Unit Price [USD]	Total Price [USD]	Total Price [XCD]
A	**Storage Equipment**					
A1	Pallet shelf with collection tank	Pc	27	350	9 450	25 515
A2	Euro pallets	Pc	100	10	1 000	2 700
A3	Plastic barrels 200 l with lid	Pc	200	18	3 516	9 495
A4	Fluorescent light tube collecting box	Pc	10	875	8 750	23 625
A5	Collecting box used lead acid batteries	Pc	3	545	1 635	4 415
A6	Storage box with lid for used lead acid batteries	Pc	8	280	2 800	7 560
A7	Collecting tank HZW liquids 400 l	Pc	4	2 925	11 700	31 590
A8	Collecting tank HZW liquids 980 l	Pc	4	3 245	12 980	35 046
A9	HZW collecting point 400 l	Pc	1	1 650	1 650	4 455
A10	Special HZW collecting barrels / boxes	Pc	5	2 750	13 750	37 125
A11	Mobil box 170 l	Pc	20	150	3 000	8 100
A12	Mobil box 250 l	Pc	20	190	3 800	10 260
A13	Laboratory and waste sorting tables	Pc	3	110	330	890
A14	Oil filter press (manual)	Pc	1	495	495	1 335
A15	Aerosol can disposal system	Pc	1	1 500	1 500	4 050
B	**Personnel Protection Equipment**					
B1	Coveralls	Pc	15	55	824	2 225
B2	Safety footwear	Pc	6	65	390	1 053
B3	Safety gloves	Pc	15	5	82	223
B4	Helmets	Pc	5	25	125	338
B5	Safety box	Pc	3	170	511	1 380
B6	HZW binding agent	Pc	30	25	750	2 025
B7	HZW emergency box	Set	1	1 650	1 650	4 455
B8	First aid box DIN13169	Set	4	175	700	1 890
C	**Floor Trucks**					
C1	Forklift 3 t	Pc	1	22 000	22 000	59 400
C2	Hand forklift (2 tons)	Pc	1	825	825	2 228
C3	Hand barrel lift	Pc	1	660	660	1 782
C4	Pushcart (200 kg)	Pc	1	65	65	176
D	**Fire Protection Equipment**					
D1	50 kg mobile fire extinguisher	Pc	6	270	1 350	3 645
D2	6 kg fire drencher	Pc	12	50	500	1 350
D3	Chemical bonding agent	Pc	120	25	3,000	8,100
E	**Laboratory Equipment**					
E1	Laboratory equipment for testing	Set	1	27 500	27 500	74 250
F	**Equipment for reception area (Furniture)**					
F1	Furniture(desk, chair, boards)	Set	1	1 000	1 000	2 700
Total HZW Storage Equipment (A + B + C + D + E)					**138 288**	**373 380**

*) Average exchange rate: 2.7 XCD/USD

4.3 Operation and Maintenance Costs

Operation and maintenance costs have to include:

- Cost of consumables;
- Labour costs;
- Depreciation of tangible assets.

Consumables

Annual consumables with regard to electric power, water and general maintenance, costs cannot be calculated at this stage of the project. Derived from other project of similar size and structure approximately 14,000USD (37,800XCD) should be considered.

Labour Costs

Labour costs are calculated and presented in Table 19 with the positions and salaries for each assumed to be correct for Antigua. The site manager / supervisor must be full time and responsible for all facility activities, including identifying and coordinating shipments of waste to authorised treatment / disposal in line with Basel Convention guidelines. The Laboratory technician can potentially be substituted by a working agreement and dedicated budget for Government Analytical Laboratory to undertake the appropriate tests as and when required and requested by the site manager and technician.

Table 19: HZW Storage Facility – Labour Costs

	Monthly Wages [XCD/Month]	Months Paid per Year	Annual Wages [XCD/a]	Annual Wages [USD/a]
Site manager / supervisor	8 050	12	96 600	35 800
Laboratory technician	7 000	12	84 000	31 100
Technician / driver	6 000	12	72 000	26 700
Workers	5 500	12	66 000	24 400
Total [XCD]	19 550		318 600	118 000

Depreciation of Tangible Fixed Assets

The depreciation as presented in Table 20 is according to the standards from International Financial Reporting Standards (IFRS) and US generally accepted accounting principles (GAAP).

Table 20: HZW Storage Facility – Depreciation of Tangible Assets

	[USD]	[XCD] *)
Total investment cost	295 000	800 000
Life span	30	30
Annual Depreciation Cost	**9 833**	**26 666**

*) Average exchange rate: 2.7 XCD/USD

A summary of the total estimated facility annual operating and maintenance costs are presented in Table 21. This is an estimated cost which requires the NSWMA and associated stakeholders to review all sections of this report and associated design drawings to adjust costs items to the specific Antigua market.

Table 21: HZW Storage Facility – Total Annual Cost of Operation and Maintenance

	[USD]	[XCD] *)
Consumables	14 000	37 800
Labour Costs	118 000	318 600
Depreciation	9 700	26 000
Total Annual O&M Cost	**141 700**	**382 400**

*) Average exchange rate: 2.7 XCD/USD

5 Project Implementation Schedule

According to international procurement rules time for tendering, tender evaluation and preparation of the contract is estimated to be 4 four months. The construction time for the HZW storage building is predicted to not be longer than six months. The equipment is also predicted to be obtainable within this period of time.

For commissioning of the HWISF as well as for the on-the-job training of assigned staff, an additional period of about three months has to be considered. These predicted timelines are presented in Table 22.

Table 22: Implementation Schedule for HZW Storage Facility

Month	1	2	3	4	5	6	7	8	9	10	11	12	13
Tendering, tender evaluation, preparation of contract													
Construction works & Supply of equipment													
Commissioning & Staff training													

It is strongly recommended to conduct training on-the-job in parallel to the operation during the first three months. This training should be given by an expert with practical experience in handling HZW and operating a similar HWISF. Training-on-the-job should also include identification, contacting, selection and negotiating with potential treatment / disposal facilities for the various waste streams, preparation of hazardous waste shipment manifests from Antigua to the final treatment facilities in compliance with Basel Convention guidelines, and information about international regulations regarding the transport. More details will be presented in Deliverable 11 – Operation and Maintenance Manuals.

Annex A - Selection of regulations related to hazardous waste storages

The following list is a selection of regulations regarding technical specifications for the design, construction and operation of hazardous waste storages. The list makes no claim to be complete. The regulations are listed in alphabetical order of the publishing country.

Country	Title
Worldwide	Basel Convention General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants, Section F - Handling, collection, packaging, labelling, transportation and storage
Australia	National Occupational Health and Safety Commission, Sydney Storage and Handling of Workplace Dangerous Goods NATIONAL CODE OF PRACTICE [NOHSC:2017(2001)] March 2001
Australia	Western Australian Waste Management Board Collection and Storage Facilities for Household Chemical Waste at Landfills and Solid Waste Depots **- Draft Design Guidelines -** SEPTEMBER 2006
Australia	Government of Western Australia, Department of Environment Regulation Guidelines for the design and operation of facilities for the acceptance and storage of household hazardous waste 2013
European Union	Council Directive 75/442/EEC of 15 July 1975 on waste (Waste Framework Directive);
European Union	Council Directive 91/689/EEC of 12 December 1991 on hazardous waste (Hazardous Waste Directive);
European Union	Council Directive 94/31/EC of 27 June 1994 amending Directive 91/689/EEC on hazardous waste;
European Union	List of Waste consolidated by the Commission from the Hazardous Waste Directive in Decision 200/532/EC
Belize	Hazardous Waste Regulations, 2009 Arrangement of regulations
Malaysia	Guidelines for Packaging, Labelling and Storage of Scheduled Wastes In Malaysia
United States of America	Environmental Protection Agency EPA Introduction to Containment Buildings (40 CFR Parts 264/265, Subpart DD) September 2005
United States of America	Unified Facilities Criteria (UFC) 16 January 2004 Design: Hazardous Waste Storage - **INACTIVE -**
South Africa	Ministry of Water and Environment, Department of Environmental Affairs 29.11.2013 National Environmental Agreement; Waste Act, 2008 National Norms and Standards for the Storage of Waste

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