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Environmental Protection Department

Agreement No. CE14/94

Low-level Radioactive Waste Storage Facility Consultancy Study

Environmental Impact and Safety Assessment Report (EISA)

June 1995

MAUNSELL CONSULTANTS ASIA LTD

in association with

Consultants in Environmental Sciences (Asia) Ltd.
Taylor Woodrow Management & Engineering Ltd.

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Environmental Protection Department
Waste Facilities Planning Group

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GLOSSARY OF TERMS AND UNITS

ALARP	As Low As Reasonably Practicable
ALI	Annual Limit of Intake
ANL	Acceptable Noise Level
APCO	Air Pollution Control Ordinance
AQO	Air Quality Objectives
ASR	Area Sensitivity Rating
BNL	Basic Noise Level
BSL	Basic Safety Limits
BSO	Basic Safety Objectives
DBO	Design, Build and Operate Contract
DBOER	DBO Contractor's Emergency Representative
DH	Department of Health (Hong Kong)
DHPD	DH Physicist on Duty
EPD	Environmental Protection Department (Hong Kong)
EISA	Environmental Impact and Safety Assessment
EMS	Environmental Monitoring System
HEPA	High Efficiency Particulate Air [Filter]
HAZOP	Hazards and Operability Study
HSE	The UK Health and Safety Executive
HKPSG	Hong Kong Planning Standards & Guidelines
IAEA	International Atomic Energy Authority
ICRP	International Commission on Radiological Protection
LRWF	Low-level Radioactive Waste Storage Facility
NCO	Noise Control Ordinance
NSR	Noise Sensitive Receiver
PAS	Personal Air Sampler
PPE	Personal Protective Equipment
PD	Principal chart Datum
QRE	Queens Road East (location of storage tunnels in Wan Chai)
RHU	Radiation Health Unit (of the Department of Health, Hong Kong)
RSP	Respirable Suspended Particulates
SFO	Superintending Fire Officer
TLD	Thermo-Luminescent Detector
TSP	Total Suspended Particulates
TM	Technical Memorandum
WCZ	Water Control Zone
WPCO	Water Pollution Control Ordinance
<u>Units</u>	
Ci	Curie, a unit of radioactivity
Bq	Becquerel, a unit of radioactivity (there are 3.7×10^{10} Bq in 1 Ci)
Sv	Sievert, a unit of radiation dose equivalent (includes a quality factor which is dependent upon the type of radiation)

1 INTRODUCTION

1 INTRODUCTION

1.1 Background to project

The Government has decided that storage of low-level radioactive waste in Hong Kong requires a dedicated, purpose-designed facility. Following a feasibility study to define the nature of the wastes and the requirement for storage and ultimate disposal [Ref. 1] an extensive site selection process was carried out by Government. Several inland and island potential sites were proposed and compared. Sites which did not meet the basic requirements of Government, or were otherwise unacceptable, were rejected at that stage. Two islands to the south of Lantau were chosen to provide candidate sites.

A consultancy study to select a suitable site for the low-level radioactive waste storage facility (LRWF), to assess the feasibility of such a facility and to recommend a suitable form of contract, is being carried out on behalf of EPD by Maunsell Consultants Asia Ltd. in association with Consultants in Environmental Sciences (Asia) Ltd. and Taylor Woodrow Management and Engineering Ltd.

The purpose of the second phase of the study is to develop an outline design and to undertake more detailed studies to further assess the suitability of the site chosen in the first phase. This report describes the Stage 1 Environmental Impact and Safety Assessment (EISA) study of the proposed outline design.

It is the current intention of Government, following studies of the in-principle acceptability of the proposed facility, to solicit tenders for the detailed design, construction and operation of the facility. Various contract options are being investigated in other parts of this study.

1.2 Site Selection Process

The objective of the first phase of the current project was to identify suitable alternative sites on the two shortlisted islands and to carry out a site selection process. The candidate sites were chosen on the basis of the feasibility of developing and operating a facility. Two sites were selected on the island of Shek Kwu Chau and two sites were selected on the island of Siu A Chau.

The site selection criteria used in the evaluation and assessment of the four candidate sites were designed by the consultants and took into account the views of the Client Department (EPD), as well as the Department of Health (the final operator of the facility and the regulatory authority under the Radiation Ordinance). The aim was to filter out and reject unacceptable sites at an early stage. The objective of the assessment was to identify an optimal site based upon defined criteria such that the preferred site would be a safe, secure and cost-effective site for a storage facility.

All four candidate sites are to some extent limited (that is, no site is perfectly well suited); however, none of the four sites have any overwhelming disadvantages such that it would be impossible or unwise to build a storage facility at that site. After a thorough evaluation, a preferred site was selected [Ref. 2].

The preferred site (referred to as site C) is located on the island of Siu A Chau in the Soko islands, adjacent to the small bay of Sum Wan on the eastern side of the island. Details of the proposed Low-level Radioactive Waste Storage Facility (LRWF) are provided in Section 3.

1.3 Need for the LRWF

Various industrial, educational and medical facilities in Hong Kong have, for a number of years, used radioactive materials and have generated waste. Most of the existing waste arisings are stored in disused air raid tunnels close to Queen's Road East in Wan Chai. Other arisings are stored temporarily (although in some cases for several years) at the point of use in educational institutions or hospitals.

The condition of the Queen's Road East tunnels has been found to be unsatisfactory and various parts of the tunnel system suffer from leakage and ingress of water. The condition of some of the waste packages has subsequently deteriorated and they are generally unsatisfactory for the safe long-term containment and storage of radioactive materials.

The existing facilities are unsatisfactory and in addition are located close to a high density of population, which make access to, and management of, the waste more problematic. As well as existing waste, there is also a continuing need to use radioactive materials in Hong Kong and a continuing predictable amount of future waste arisings. There is a need, therefore, for a dedicated, purpose-built facility capable of effective, economical and safe long-term storage of a variety of existing radioactive materials and a small amount of future arisings.

1.4 Study Brief and Objectives

The objectives of the Stage 1 EISA study based on the outline design, as laid out in the project Brief, are to:

- identify likely environmental impacts and safety problems arising from the project
- assess and evaluate safety problems, net environmental impacts and cumulative effects of the development, sufficient to identify and quantify those issues of key concern which are likely to influence the recommendations on the outline design, access and transport arrangements, contingency plan, contract options and operational constraints and the associated security, control/performance requirements, including assessment of the impact on fauna and flora of the island
- identify likely mitigation measures and the setting out of environmental and safety requirements of the project in quantitative terms such that no unacceptable environmental impacts or safety problems will result, together with recommendations of monitoring and post-implementation audit requirements
- an evaluation and recommendation on the requirement for the successful tenderer to undertake a Stage 2 EISA for the LRWF, and setting out of detailed issues and terms of reference for the Stage 2 EISA, if required.

1.5 Scope of Stage 1 EISA Report

This Stage 1 EISA report addresses all potential environmental impacts arising from construction and operation of the proposed LRWF. In addition, it covers all relevant radiological safety aspects and presents a justified safety case for such a facility. The detail of the assessment is sufficient to identify possible impacts and to evaluate their scale and significance. It should be noted, however, that because the LRWF design is only at the outline stage and is therefore still to be finalised, the assessment of impacts is necessarily limited. An important function of this report is to identify areas where further study may be required and to specify terms of reference for the Stage 2 EISA study to be carried out following award of contract to the successful tenderer.

Extensive consultation has been carried out and site visits have been made; relevant ecological data held by other individuals and organisations have been documented. A site reconnaissance survey on the rocky shore intertidal and subtidal habitats has been undertaken at the location where the jetty to the facility will be built. The objective is to determine if there are sensitive biota that may be impacted by placing the jetty at that location and during jetty construction. A terrestrial habitat survey was also undertaken using aerial photographs and WWF's Ecological Database followed by ground truthing.

Government bodies and other organisations known to have specific data have been consulted and are listed in Appendix A.

1.6 Content of Stage 1 EISA Report

The existing environment of the island of Siu A Chau, and of the proposed LRWF site in Sum Wan bay, is described in Section 2. The proposed LRWF facility is described in Section 3, including details (insofar as they are known) of the possible construction methods and timing and the possible operational methods to be employed.

Potential impacts of the proposed LRWF are identified, described and, where possible quantitatively evaluated in Section 4 (non-radiological impacts) and Section 5 (radiological impacts and safety assessment). Necessary mitigation measures are described in Sections 6 and 7 (non-radiological and radiological, respectively). The measures recommended for radiological protection in Section 7 also include an outline contingency plan to be adopted in the event of accidental spillage of contaminated waste.

An environmental and radiological monitoring and audit programme is specified in Section 8 and would form the basis for monitoring of construction activities, as well as operational radiological monitoring for protection of the workforce and the environment. The conclusions and recommendations of the Stage 1 EISA study are presented in Section 9, which also contains terms of reference for a Stage 2 EISA study and proposals for information management and in particular the dissemination of information to the public.

2 EXISTING ENVIRONMENT OF SITE OF SIU A CHAU

2 EXISTING ENVIRONMENT OF SITE ON SIU A CHAU

2.1 Location and Geographical Context

Siu A Chau is a small island to the south of Lantau and is the northernmost of the Soko Islands, which lie in the southwestern waters of Hong Kong. The island falls within an area identified by the Territorial Development Strategy as being a significant landscape and recreational asset, and being environmentally sensitive.

The island forms an hour-glass shape in plan form, with the western and eastern ends of the island dominated by hills rising to more than 120 metres and 77 metres, respectively. The central portion of the island is a thin strip of generally low-lying relief, formed in the main by a wide sand beach.

The proposed site on Siu A Chau is at the eastern side, adjacent to a small bay called Sum Wan. The bay is quite shallow with a generally rocky or shingle beach. The bay is enclosed by two south-easterly projecting promontories of up to 50 metres in height, which provide a degree of shelter and screening.

The proposed site is relatively low-lying at approximately 5 metres (above PD). Behind the site the hill side rises to a saddle-shaped part of the southernmost of the two promontories.

2.2 Planning Context

There is at present no Outline Development Plan (ODP) or Layout Plan covering the site at Siu A Chau. The South West New Territories Development Strategy Review (SWNT DSR) has been endorsed by the Development Progress Committee. The Interim Recommended Strategy (IRS) outlined in the SWNT DSR acknowledged the strong countryside heritage of the SWNT and designated Siu A Chau as a Conservation Area, a Landscape Protection Area and a Coastal Protection Area. The IRS also recommended the Soko islands be designated as Inshore Recreation and Inshore Water Protection Areas. The central part of the island was recommended in the IRS as a potential area for tourist development.

The landscape and general recreational amenity of the area should thus be protected and design considerations must be compatible with the existing landscape.

2.3 Location of Sensitive Receivers

The island of Siu A Chau is not inhabited. The closest potential receiver is the refugee camp located on Tai A Chau, at Ha Tsuen, which is 1.7 km away. There will be no direct line of sight from the facility and the camp. Ha Tsuen is sheltered behind Fei Kei Teng which has a maximum height of 85 m, and a minimum height of 20 m.

The only other potential receiver is Shek Pik Prison on Lantau Island. This is 5.5 km from the proposed site.

There are no known existing mariculture sites or seawater intakes in the vicinity of the Soko islands.

2.4 Ecology and Fisheries

2.4.1 Terrestrial Ecology

On Siu A Chau, there is evidence of a stable vegetation regime where the normal process of plant succession is observable. Natural correlation exists between terrain patterns and vegetation. The main factors limiting the development of vegetation on Siu A Chau appear to be salt winds, altitude and soil depth. In contrast, the general lack of hillfires, which are normally so prevalent in Hong Kong, has helped the vegetation develop to its natural climax.

A habitat survey of the island was undertaken using aerial photographs and WWF's Ecological Database [Ref. 3] and was verified by site survey. Five broad habitat types have been established on the island and these are as follows:

a) planted woodland
b) tall shrub
c) low shrub
d) grassland
e) coastal vegetation

a) planted woodland

Parts of the island close to the abandoned village and up to around the 50 metre contour are planted with the exotic tree *Acacia confusa*. It is thought that after the last war forestry licences were issued to local villagers to encourage the establishment of plantations on Crown Land. It is likely that the *Acacia* planting on Siu A Chau was carried out this way.

These plantations have a high closed tree canopy which precludes understorey vegetation. A thick cover of sterile leaf litter has developed and there is little evidence of natural regeneration.

b) tall scrub

This habitat type is characterised by a variety of tree and shrub species growing to approximately 2 meters in height. It is representative of the progressive changes in species composition, resulting from competition and modification of the environment. Because of exposure and the nature of the soils on Siu A Chau, tall scrub is of limited distribution on the island.

c) low shrub

These areas represent the initial stages of plant colonisation. This vegetation type is characterised by low shrub species growing to a maximum of 1.0 meters in height. The natural successional stages have been severely retarded by the thin soils and salt winds.

This vegetation type is extensive and mainly occurs on the higher exposed slopes with poorer soils and greater climatic variation.

d) *grassland*

This vegetation type predominates on the most exposed areas spreading gradually among bare rock areas. It also occurs intermixed with scrubland. Limited areas of erosion caused by instability could result in potentially unstable slopes.

e) *coastal vegetation*

This vegetation type is characterised predominantly by Screw Pine (*Pandanus remotus*) and Spiny Date Palm (*Phoenix hanceana*) colonising between rocks on the beaches and rocky shores and extending up the hillsides as pioneer vegetation. In places, the Screw Pine forms a protective screen against prevailing winds on the coast.

The terrestrial habitats present on the proposed site for the low-level radioactive waste storage facility on Siu A Chau are the coastal vegetation at the back of a rocky shore, grassland and low scrub. The area could be described as open grassland with patches of low scrub and scattered rock outcrops/boulders.

During a site visit in September 1994, species recorded from this grassland and low shrub on the proposed site included *Lantana camara, Pandanus tectorius, Phoenix hanceana, Arundinella spp., Wickstoemia indica, Breynia indica, Ischaemum spp., Eremochloa ciliaris, Eurya chinensis, Aster ageratoides, Solidago virgo-aurea* and *Chrysanthemum linearum*. The low scrub and grassland present is typically low in species diversity.

The back of the rocky shore supports a few species including the common *Suaeda australis, Ipomea brasiliensis* and *Canavalia maritima.*

The habitats represented are widely distributed within the Territory and are typical of Jurassic Granitoid slopes (Sung Kong Granite) which tend to have a very thin soil cover. The vegetation types recorded on this site are widespread all over the island of Siu A Chau and are typical offshore island habitats. No rare plant species were recorded. However, the habitats represented are natural, undisturbed, comprise generally of native species and are typical examples of their type.

As the island is so remote from the urban area and is not easily accessible, very little data exist from local ecologists and amateur naturalists (see list of organisations and individuals consulted).

The low diversity of habitats, plant species and the lack of cover available on the site, means that it is not considered likely to be of importance for mammals or insects (Gary Ades and Mike Bascombe pers. comm).

The Hong Kong Birdwatching Society have "no useful data yet for the Soko Islands" (Mike Chalmers, pers. comm.) and only common and widespread sea bird species were recorded on the site visit in September 1994 including Cormorant (*Phalacrocorax carbo*), Reef Egret (*Egretta sacra*), Black-eared Kite (*Milvus lineatus*) and Crested Mynah (*Acridotheres cristellus*).

The proposed site itself is not thought to be suitable as a breeding site for the White Bellied Sea Eagle (*Haliaeetus albicilla*). This bird of prey is essentially maritime and favours rocky coastlines on island shores. It likes to nest on remote undisturbed rocky cliff ledges which do not exist within or in close proximity to the site. However, it is highly likely that the White Bellied Sea Eagle would be seen on Siu A Chau and it is known to breed on the nearby island of Shek Kwu Chau.

It is understood that in the late 1980's, a detailed amphibian and reptile survey was carried out on Siu A Chau under the direction of Skip Lazell, an American herpetologist (Michael Lau, pers.comm.). These data have been requested from Skip Lazell in the United States; however, it has been confirmed by Michael Lau that nothing of particular interest or note was found on the island at that time.

2.4.2 Marine Ecology and Fisheries

The marine ecology of Siu A Chau, and in particular the site area in Sum Wan, have been reviewed. The Agriculture and Fisheries Department advise that the south-west Lantau area is earmarked as a potential Marine Park. There is no plan yet to proceed with this park and further investigation would be required prior to definitions of the boundary.

Consultation with various organisations and individuals including the Hong Kong Marine Conservation Society, the Swire Institute of Marine Science of Hong Kong University and the World Wide Fund for Nature, has revealed some existing marine data for the area.

A subtidal survey in Sum Wan adjacent to the site was conducted by divers from Swire Institute of Marine Science. One of the four transects was along the line of the proposed jetty. Although the intertidal areas are all rock and boulders, some subtidal areas also contain sand. More rock and boulders occurred at the south and west sides of the bay and sand with small boulders was present at depth towards the north and east sides of the bay. The plant and animal communities on rock and boulders in the bay are typical of the location. A species list is provided at Appendix F. Two species of coral were found, which occurred as isolated groups of small coral heads (a maximum of 10 cm in diameter); these corals are not of particular conservation importance.

The rare Chinese White Dolphins (*Sousa chinensis*) have regularly been sighted off the south coast of Lantau and in the vicinity of the Soko Islands (Lindsay Porter and Chris Parsons pers. comm.). It should be noted, however, that these sightings have been part of a Territory wide project and no specific surveys have been undertaken around the Soko Islands.

Black Finless porpoises (*Neophocaena phocaenoides*), also known in Chinese as Hai-chu, have been recorded from the western most waters of the Territory in the general vicinity of the Soko Islands.

Little information exists regarding the distribution and movements of porpoises and dolphins within the Territory, but it is understood that pods are regularly sighted off the south of Lantau Island as well as in eastern waters off Cape D'Aguilar and the Po Toi and Waglan Island groups.

The Black Finless porpoise is an inshore species, and is recorded from regular and frequent strandings on beaches, inadvertent catches in fishing nets and sightings at sea

and from land [Ref. 4]. Their conservation status in Hong Kong is unclear at present.

There has been some indication that the Green Sea Turtle (*Chelonia mydas*) may utilise the sandy beach on Siu A Chau to lay eggs but it has proved impossible to substantiate this suggestion and the source of the information is not known. (Consultants were originally informed by copy of memo from Planning Department to EPD, dated 15 September 1994). In any event, the proposed site is situated away from the sandy beach at Siu A Chau Wan. The Green Sea Turtle is protected under the Bonn Convention and CITES and is a Red Data Book Species.

According to the Agriculture and Fisheries Department there is a limited small-scale capture fishery in the area of Siu A Chau. The inshore area in the vicinity is likely to constitute some of the remaining fish nursery area that is in relatively pristine condition.

According to the Agriculture and Fisheries Department, the area is potentially an excellent one for marine fish culture, having been used for this in the past.

2.5 Water Quality

There is no permanent surface fresh water at the site.

The site is adjacent to a small bay (Sum Wan) on the south-eastern side of the island. The island's waters are gazetted within the Southern Water Control Zone (WCZ). The relevant guideline standards for discharge of effluent to coastal waters [Ref. 5] are presented in Table 2.1.

A review of EPD data [Ref. 6] for monitoring stations in the Southern WCZ indicates that the water body away from main centres of population which are sources of pollution, is generally very good and is typical of marine water. The Pearl River outflow can reduce salinity slightly in the wetter summer months, and can transport suspended solids into the vicinity. Indicators of organic and sewage pollution (Biochemical Oxygen Demand, plant growth nutrients and the bacterium *E. coli*) remained very low, whereas dissolved oxygen content was always fairly well saturated. The summary of data for 1992 (the most recent available) are presented in Table 2.2.

There are no existing data for Sum Wan bay in the vicinity of the proposed LRWF, although it can be expected that seawater quality in the bay is good as there are no pollution sources nearby. During a site visit, some debris was observed along the strand line which is derived from floating refuse from a variety of sources.

As expected, EPD data [Ref. 6] for marine sediment south of Lantau (although not in the vicinity of Siu A Chau) indicate sediment of a slightly coarser composition with less evidence of organic pollution (shown by a reduced redox potential) and absence of contamination by heavy metals. It can be inferred that other potential pollutants are similarly absent or only occur in low concentrations. The general quality of sediment near the proposed LRWF site can be expected to be at least as good.

Table 2.1 Standards for Effluents Discharged into the inshore waters of Southern Water Control Zone
(All units in mg/L unless otherwise stated; all figures are upper limits unless otherwise indicated)

Flow rate (m^3/day) / Determinand	≤10	>10 and ≤200	>200 and ≤400	>400 and ≤600	>600 and ≤800	>800 and ≤1000	>1000 and ≤1500	>1500 and ≤2000	>2000 and ≤3000	>3000 and ≤4000	>4000 and ≤5000	>5000 and ≤6000
pH (pH units)	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9
Temperature (°C)	40	40	40	40	40	40	40	40	40	40	40	40
Colour (lovibond units) (25mm cell length)	1	1	1	1	1	1	1	1	1	1	1	1
Suspended solids	50	30	30	30	30	30	30	30	30	30	30	30
BOD	50	20	20	20	20	20	20	20	20	20	20	20
COD	100	80	80	80	80	80	80	80	80	80	80	80
Oil & Grease	30	20	20	20	20	20	20	20	20	20	20	10
Iron	15	10	10	7	5	4	3	2	1	1	0.8	0.6
Boron	5	4	3	2	2	1.5	1.1	0.8	0.5	0.4	0.3	0.2
Barium	5	4	3	2	2	1.5	1.1	0.8	0.5	0.4	0.3	0.2
Mercury	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cadmium	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Other toxic metals individually	1	1	0.8	0.7	0.5	0.4	0.3	0.2	0.15	0.1	0.1	0.1
Total toxic metals	2	2	1.6	1.4	1	0.8	0.6	0.4	0.3	0.2	0.1	0.1
Cyanide	0.2	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.03	0.02	0.02	0.01
Phenols	0.5	0.5	0.5	0.3	0.25	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Sulphide	5	5	5	5	5	5	2.5	2.5	1.5	1	1	0.5
Total residual chlorine	1	1	1	1	1	1	1	1	1	1	1	1
Total nitrogen	100	100	80	80	80	80	50	50	50	50	50	30
Total phosphorus	10	10	8	8	8	8	5	5	5	5	5	5
Surfactants (total)	20	15	15	15	15	15	10	10	10	10	10	10
E. coli (count/100 ml)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Source : EPD Technical Memorandum on Effluent Standards, [Ref. 5] Table 10a

Table 2.2 Summary of data for 1992 for station SM17, south of Lantau

Determinand	Mean[1]	Minimum	Maximum
Temperature (°C) - surface	21.7	15.4	29.4
Temperature (°C) - bottom	21.5	15.3	28.4
Salinity (ppt) - surface	31.9	30.3	33.3
Salinity (ppt) - bottom	32.6	31.6	33.2
D.O. (% saturation), surface	87	80	92
D.O. (% saturation), bottom	81	67	90
pH value	8.0	8.0	8.2
Secchi disc depth (m)	1.8	1.0	2.8
Turbidity (NTU)	5.2	2.4	9.3
Suspended solids (mg l^{-1})	7.7	2.5	11.0
B.O.D. (mg l^{-1})	0.7	0.2	1.0
Inorganic Nitrogen (mg l^{-1})	0.12	0.03	0.19
Total Nitrogen (mg l^{-1})	0.50	0.29	0.68
Phosphate-Phosphorus (mg l^{-1})	0.02	<0.01	0.04
Total Phosphorus (mg l^{-1})	0.09	0.02	0.14
Chlorophyll-a (µg l^{-1})	0.55	0.43	0.77
E. coli (number per 100 ml)	2	1	5

Note 1: arithmetic mean of 5 samples taken during 1992 (except *E. coli*; geometric mean of 5 samples)

2.6 Air Quality

There are no existing data on air quality for the island of Siu A Chau. As the island is uninhabited and because it is very remote from any sources of atmospheric pollution, the air quality is likely to be typical of rural background conditions and thus would be very good. Under certain conditions, sea spray would probably be carried inland.

2.7 Noise

As with air quality, background noise conditions are likely to be very low because the island is uninhabited and is remote from any sources of noise. Background conditions, because of the relatively exposed location, are likely to be dominated by the sound of wind and waves.

2.8 Transport

Siu A Chau has long been uninhabited and appears to have never had any formal transportation network. Some concreted footpaths exist for short distances. There is an existing stone jetty in poor condition, at the southeastern end of the main sand beach. The bay of Sum Wan has no existing facilities.

2.9 Historical and Cultural Heritage

The Antiquities and Monuments Office of the Recreation and Culture Branch note that Siu A Chau is of great archaeological significance and has been designated a 'Special Site of Archaeological Interest (SSAI/NT2)'. A plan supplied by the Antiquities and Monuments Office indicates that the SSAI covers the entire central portion of the island, including the village site at Siu A Chau Tsuen, but appears to exclude the proposed LRWF site at Sum Wan.

Relics of prehistoric material and Tang dynasty kiln debris have been found in previous surveys on the island although the precise location of the finds and the survey areas is not known.

2.10 Visual Amenity

2.10.1 General Location

Siu A Chau is part of the Soko Islands group, and is located approximately three kilometres to the south of the Shek Mun Shan/Luk Keng Shan peninsula of Lantau Island. Siu A Chau has an hour-glass plan form consisting of two rocky outcrops joined by a low-lying sand spit; a form which is prevalent in Hong Kong islands. The island has a maximum dimension of 1.5 kilometres across. The island is of rugged terrain with minimal vegetation, and rises to a maximum height of more than 120 metres in the western part and 77 metres in the eastern part. A busy shipping lane, including many passenger vessels en route to Macau and Chinese cities, passes to the north of the island.

The island is unspoiled, with minimal previous human occupation and is now uninhabited. The abandoned village (Siu A Chau Tsuen) now is ruined and overgrown. The island is of high visual quality, and the unspoiled nature of the island makes it extremely sensitive to human impact. The general situation is shown in Figure 2.1.

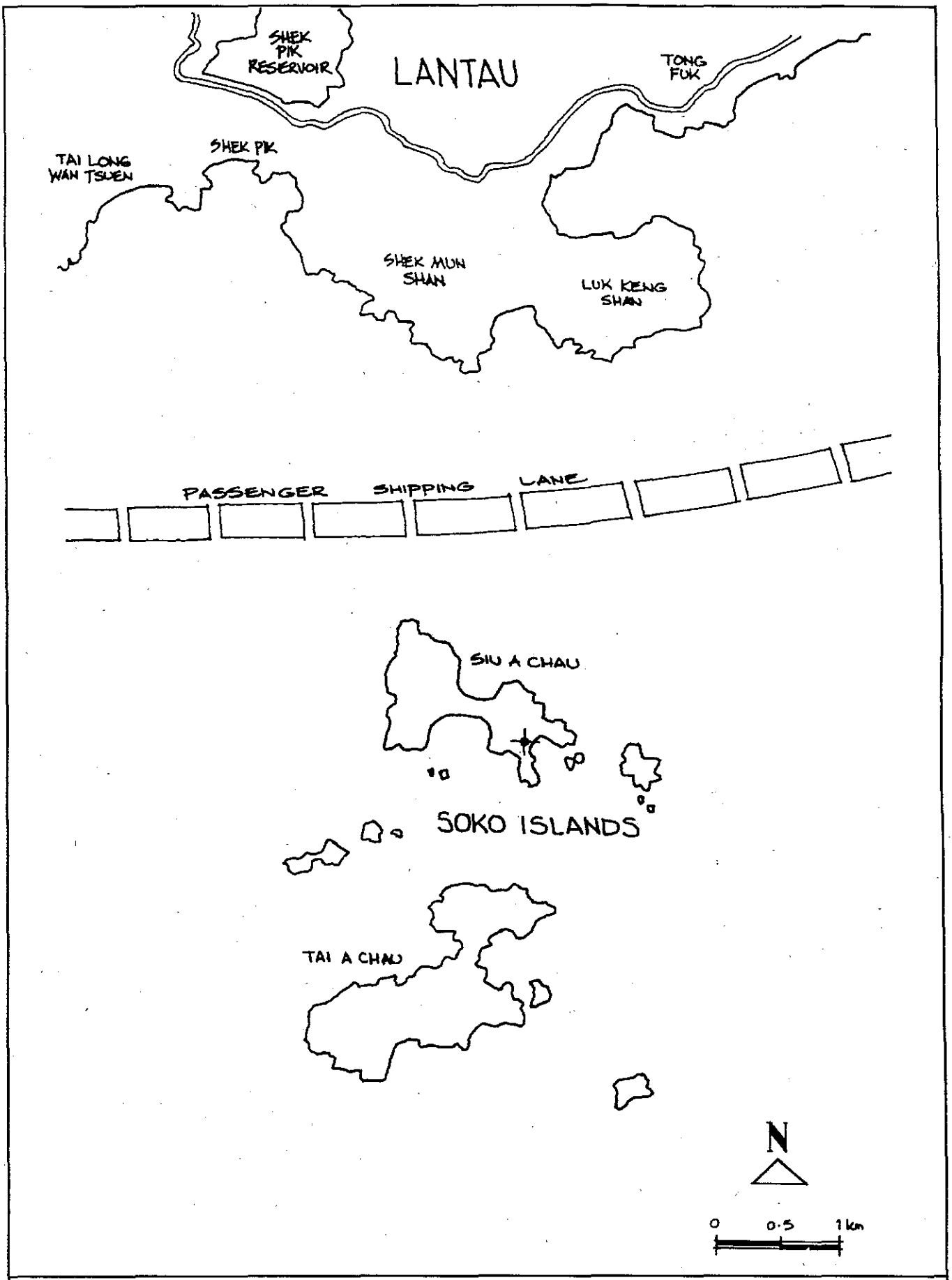

Figure 2.1 Soko Islands: General Situation

2.10.2 Specific Situation and Localised Viewsheds

The eastern half of the island's hour-glass plan form splits to embrace the bay of Sum Wan, which is the location of the site. The topography of the island divides the island into distinct localised viewsheds, and thereby ensures that visual intrusion into certain areas need not impact on the whole island. Specifically, the topography ensures that the site is screened from views from Lantau and the busy shipping lane to the north, and is also screened from the majority of the island itself. This will ensure that the visual impact of the facility can be limited to the Sum Wan area. The site is exposed to views from the south-east, from the sea, although this area is not frequented by vessels as much as the northern body of water. The viewsheds and site location are indicated in Figure 2.2.

2.10.3 Visual Characteristics of the Site and Environs

The site is exposed to inward views within the Sum Wan visual envelope. The land in the vicinity of the site rises gently from the coast, ensuring that any visual intrusion will be fully apparent and offering limited potential for natural screening. The landform rises to a saddle located to the west of the site, which dips to 14.03 mPD at its lowest point, and to 15.24 mPD in the vicinity of the site. There is very little vegetation in the vicinity, the area features short grasses and very small areas of short shrubs. There is no possibility of using the natural vegetation for screening, and the lack of existing vegetation means that the addition of dedicated planting would be difficult to integrate visually, and would itself have a visual impact. The area's visual characteristics can be seen in the attached photographs (Figure 2.3).

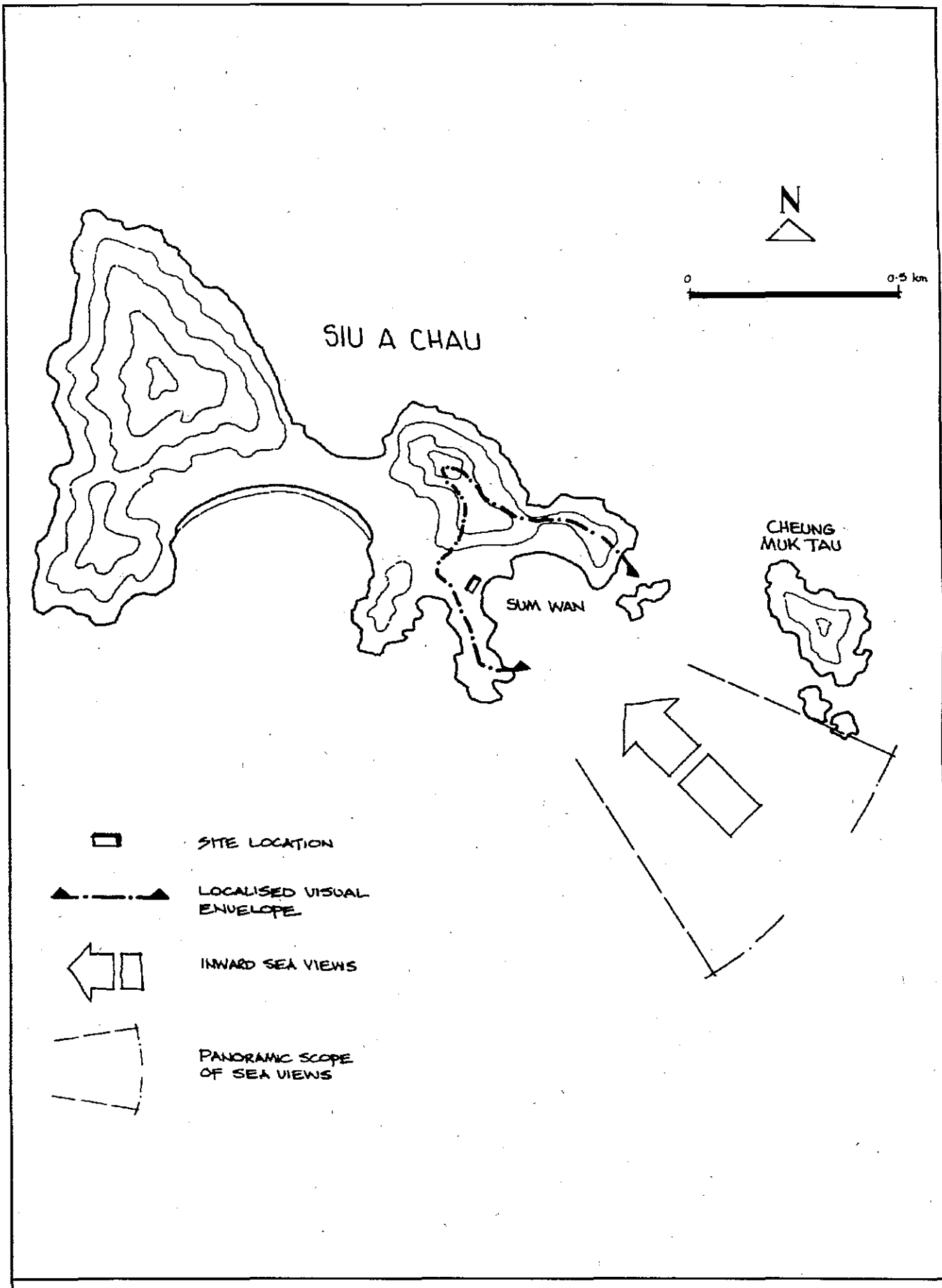

Figure 2.2 Proposed Site on Siu A Chau: Site Location & Local Viewsheds

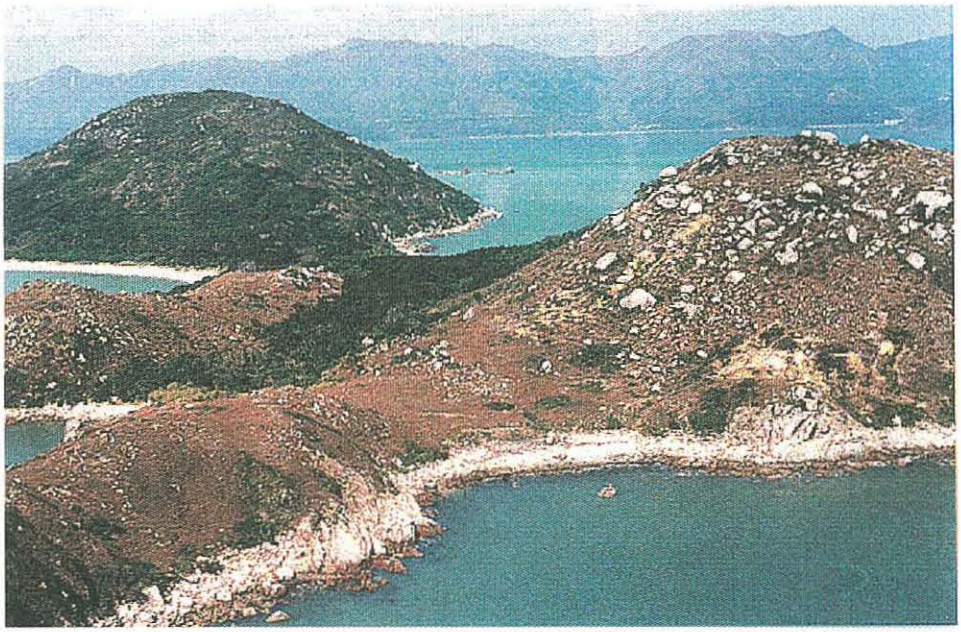

Figure 2.3 Proposed Site: Site Photographs

3 DESCRIPTION OF THE PROPOSED STORAGE FACILITY

3 DESCRIPTION OF THE PROPOSED STORAGE FACILITY

3.1 Outline Design

The design criteria for the LRWF are outlined in Working Paper number 1 and the detailed requirements for design are covered in Working Paper number 2.

Preliminary evaluation of the waste arisings suggests a building of approximately 1000 m^2 with an elevation of about 6.5m would be required to store circa 260, 340-litre drums if unstacked and moved by overhead travelling crane (o.t.c.) or forklift (see plan in Figure 3.1). A helicopter landing pad and marine access jetty, together with landscaping and security requirements, bring the total site area to approximately 0.61 ha.

The envisaged storage requirements led to an initial design concept of a simple building with a reinforced concrete or structural steel frame. The composition and finish of external walls and roof would be determined by the requirements for weatherproofing and other considerations such as visual impact. The building would be raised on a 200mm dais to prevent water ingress and all internal areas would drain to a sump. The building would contain a main storage area with aisles for manoeuvring a stacking vehicle, a processing/repackaging/assaying area, and an administration area with washroom facilities.

3.2 General Characteristics of the Proposal

The general requirement is for a secure storage facility, which is resistant to weather, groundwater, and physical intrusion, and has appropriate access arrangements from the sea. The facility will take the form of a single building, with the larger part dedicated to a drum storage area and the remainder used for ancillary functions. The building will be served by a main entrance door for pedestrian access, a heavy duty steel door which is of sufficient size to allow for a drum handling vehicle, and emergency exits, also with heavy duty steel doors.

3.2.1 Building Dimensions

The building size is governed by the number of drums to be stored, the adopted stacking arrangements, and the access/retrieval requirements. The building will be designed for a potential 260 drums to be stored, unstacked, and that the overall plan dimensions including internal ancillary areas, will be approximately 44 x 24 metres. The clear internal height of the facility will allow for future double-stacking of drums, and will also allow for the use of an overhead travelling crane. The minimum ceiling height will therefore need to be about 5 metres.

3.2.2 Visual Aspects

Due to the location of the building, the potential exists for quite a large visual intrusion, especially considering the generally small scale of the island and natural features in the area. The physical requirements of the facility's operation, however, will not have notable visual impact implications. The facility should be of relatively discrete design, allowing the incorporation of visual mitigation measures.

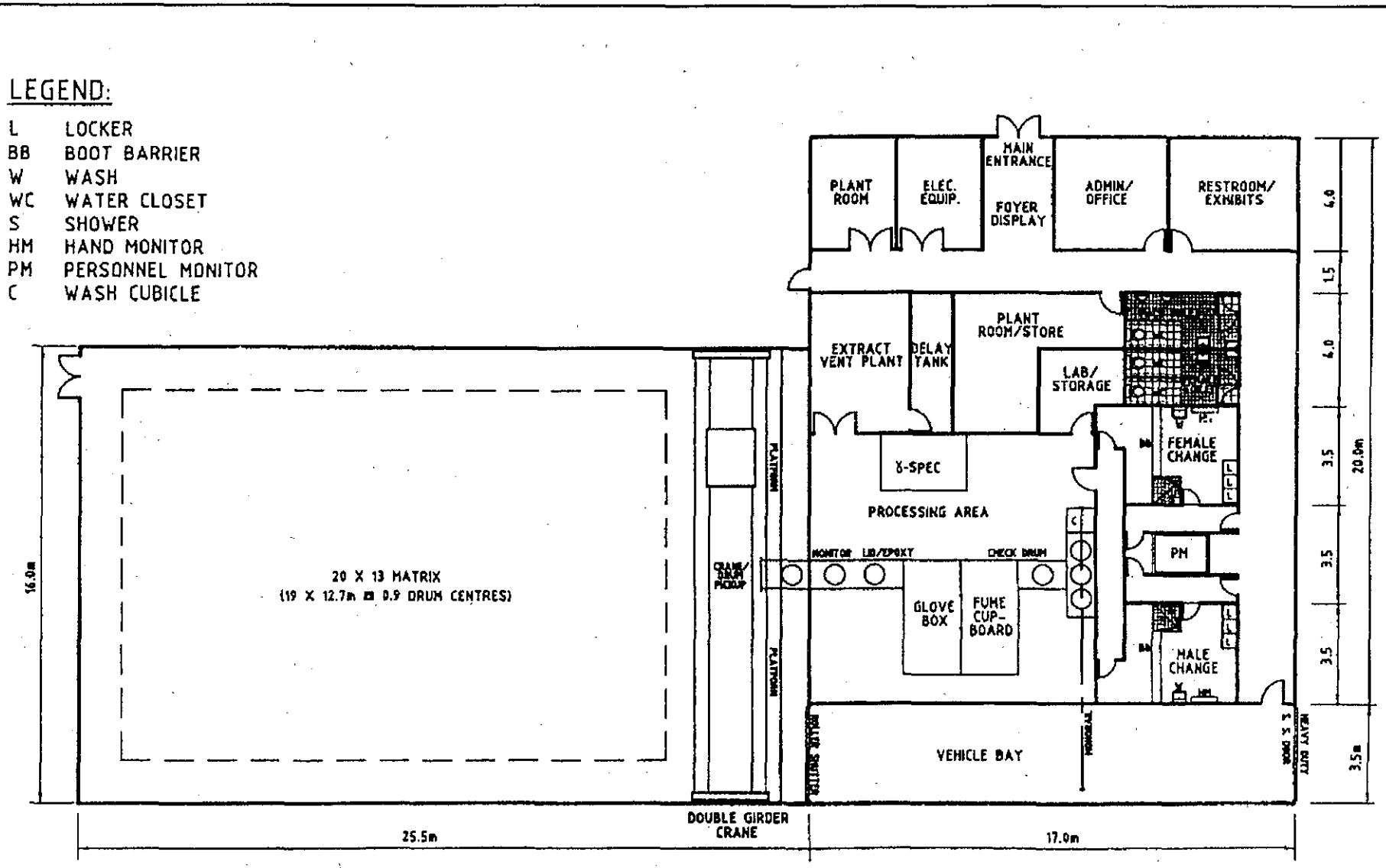

Figure 3.1 Diagram Illustrating Proposed Layout of LRWF

Architectural drawings which illustrates the type of building envisaged, are shown in Figures 3.2 and 3.3. A brief description of such a building is contained below. The final layout, form and structure of the building will be finalised at the detailed design stage after award of contract and therefore the following description should not necessarily be adopted as the final design specification. The building design will be one of the parameters to be considered when assessing tenders.

"To keep the building as low as possible, a sloping flat tiled roof is used to minimise the impact of the front elevation from the water. Weatherproofing over the concrete structure will be used because of the close proximity of the sea. Natural stone cladding will wrap the columns and walls to help integrate the structure into the natural setting (landscape) in which rock outcrops of many sizes are already on site. A stone canopy (trellis) will be used in the front elevation to minimise the scale of the building. Glass block windows will be used in the administration and restroom area for natural illumination and for security reasons. Steel reinforced exit doors are provided also for security. Using the natural rock outcrops existing on site and stone cladding material as the exterior finish, will substantially reduce the impact of the building on the site."

3.2.3 Access Requirements

The facility will be accessed from the sea by means of a fixed jetty. The jetty will be constructed partly on piles in the bay and partly on a rock filled causeway across the intertidal zone. The proximity of the facility to the coast means that an access road is not required; the pier will lead directly to a hard standing located adjacent to the building. The performance requirements document will require the DBO Contractor to provide details of the jetty design and confirm the construction programme.

3.3 Construction Schedule and Methods

The construction work in the LRWF project includes a jetty, an access road and a one-storey building. The construction works would take an estimated twelve months to complete, which can be divided into the following stages:

- construction of jetty (4.5 months)
- site formation (4 months)
- construction of main building and access road (4 months)
- installation of E & M equipment and interior fittings and furniture (2 months)

In view of the remoteness of Siu A Chau, it is recommended that the jetty be constructed first so that the construction materials and labour required for the building and access road can be easily transported to the site. The site formation can proceed at the same time as the jetty construction. The excavation material can be stored temporarily at the site prior to use in the site landscaping or export for dumping after the jetty construction has been completed. On-site mixing of concrete for the construction of the works is likely to be adopted. The installation of electricity supply cabling and equipment will be concurrent with other construction works.

3.4 Operating Regime and Waste Transport Arrangements

The LRWF will receive low level radioactive waste generated as a result of medicinal, educational and industrial operations in Hong Kong.

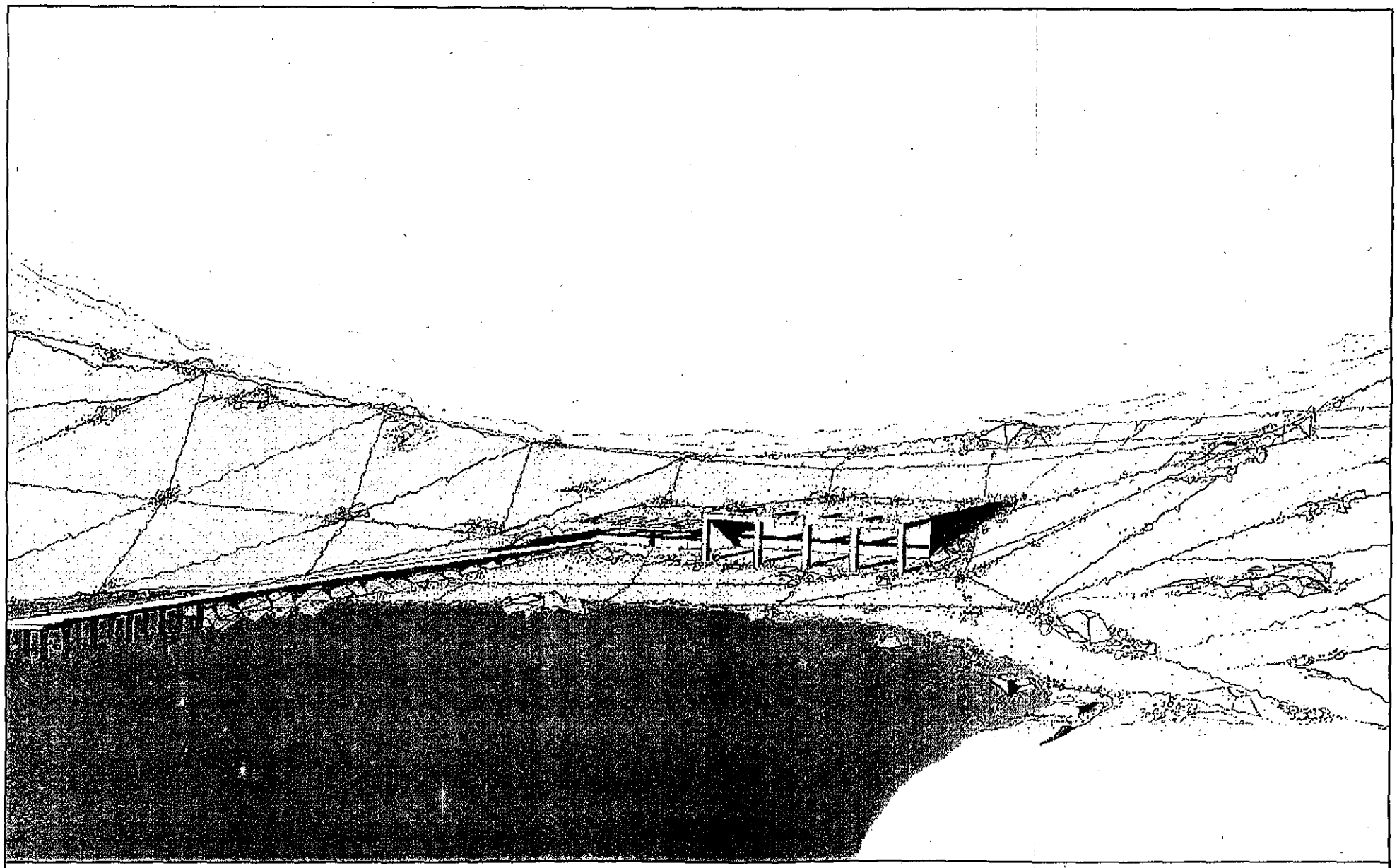

Figure 3.2 Illustration of Possible Form of theProposed LRWF

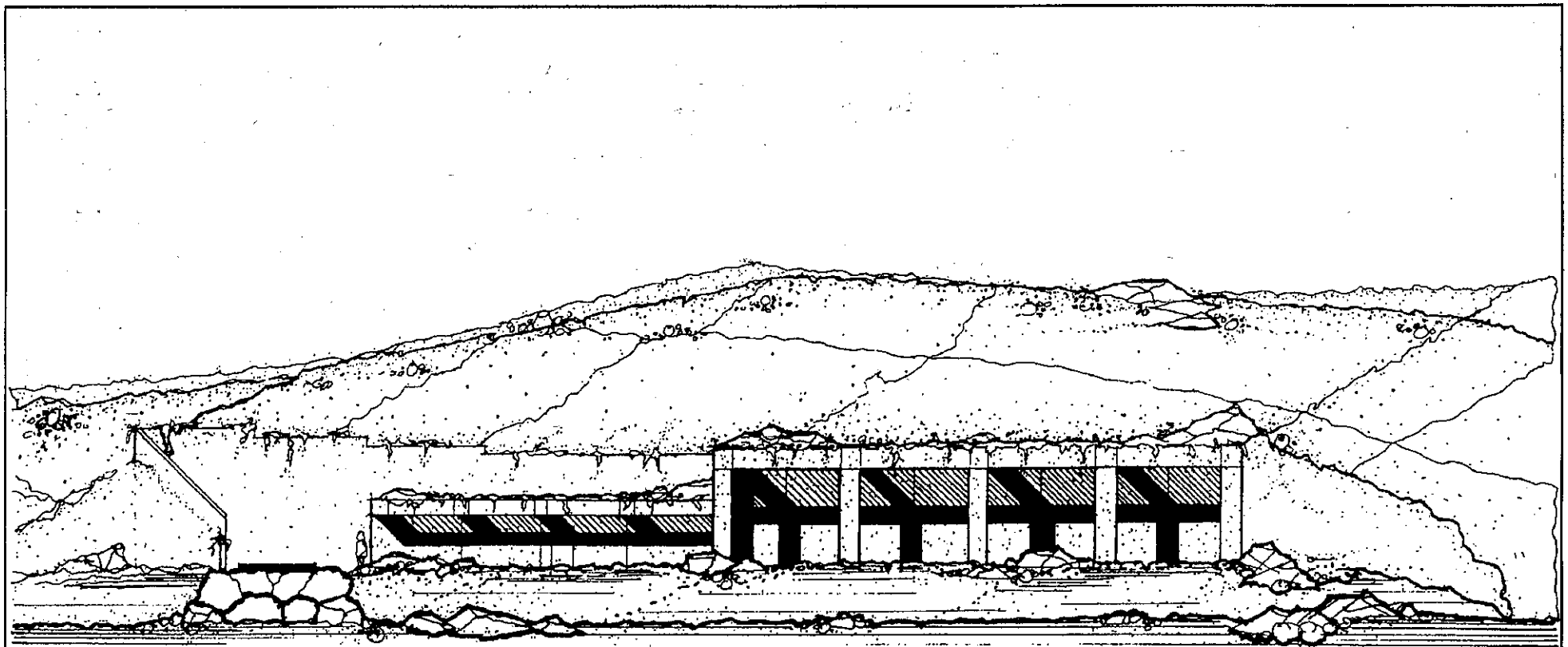

Figure 3.3 Illustrative Elevation of Proposed LRWF

The waste the LRWF will store will include both historic arisings from the current Store located at Queens Road East (QRE), Wan Chai and ongoing current and future arisings.

3.4.1 Historical Wastes from Queens Road East (QRE)

Historical wastes from QRE will be assayed and repackaged into storage drums at QRE prior to commissioning of the LRWF. The storage drums will be 'Type A' designation under the IAEA Regulations.

Before dispatch from QRE the storage drums will be monitored for external contamination and radiation to confirm the drums meet the IAEA Regulations. If external contamination is detected, the drums will need to be decontaminated before despatch from QRE. If excess radiation levels are detected, appropriate action, to be determined at the time, will be taken. It is not expected that storage drum radiation levels will exceed IAEA Transport Regulations. It is recommended that appropriate procedures are adopted during repackaging operations to ensure that storage drum radiation levels are acceptable.

Once cleared for dispatch from QRE, the storage drums will be loaded onto a road transport vehicle for transport to a suitable jetty/dock. Each storage drum will be accompanied by a consignment certificate. On arrival at the jetty/dock storage drums will be transferred to a sea-going vessel for the journey to Siu A Chau. On arrival at Siu A Chau storage drums will be off-loaded from the vessel onto a dedicated transport vehicle on the jetty in Sum Wan Bay. This will be used to transfer the storage drum into the road bay of the LRWF.

All the transport arrangements described in the preceding paragraphs will be in accordance with the IAEA Transport Regulations [Ref. 9].

On arrival at the LRWF the storage drums will be subjected to a further external radiation and contamination check to confirm acceptability before being placed directly into the storage vault. (Any drums showing signs of contamination would be routed through the processing area.) The drum will be then transferred into the storage vault such that it is under the operating area of the crane. (It is envisaged that either through procedural or interlock arrangements that doors at both ends of the road bay will not be permitted to be open at the same time). The crane will then be used to lift the storage drum into its storage location. The location of the drum, together with other appropriate information will be logged in an Inventory System.

3.4.2 Future Arisings (and historical arisings from locations other than QRE)

For ease of description throughout this sub-section all wastes are described as 'future arisings' (including historical arisings from locations other than QRE).

Future arisings of waste will be packaged at waste consignors into a variety of packages. However, it is envisaged all packaging will meet the requirements of the IAEA Transport Regulations.

The transportation arrangements for future arisings will be essentially the same as that described in Section 3.4.1.

The following description relates to waste that requires repackaging. Handling of 'higher activity' sealed source wastes is described in Section 3.4.2.1.

On arrival at the LRWF packages will be subject to confirmatory radiation and contamination checks before being lifted into the waste processing area. If necessary a small number of packages may be stored in this area for operational reasons. Waste from packages (or the complete package) will then be repackaged into the storage drum using suitable equipment. The storage drum will be 'quality checked' before being loaded with waste. Once full, the storage drum will be lidded, capped and monitored for external radiation and contamination. If necessary the drum will be decontaminated. The drum will then be passed into the storage vault and placed in its storage location using the crane. The location of the drum, together with the other appropriate information will be logged in an inventory system.

3.4.2.1 Certain Sealed Source Arisings

It is not considered feasible or economic to repackage certain sealed source arisings of waste which are known to have higher radioactive content. Such wastes will be placed directly into the storage vault within their 'original' packaging as described for storage drums in Section 3.4.1.

3.4.3 Operating Arrangements

3.4.3.1 Storage Vault

Accurate knowledge of radiation levels from the storage drums and packages to be held in the LRWF is difficult at present because:

- wastes at QRE which comprise a significant proportion of the wastes have not yet been completely repackaged and assayed.
- uncertainty over future wastes.

However, it is known that radiation levels will vary.

Two aspects to the storage regime within the vault will therefore be considered:

- storing 'higher activity' wastes at the centre of the vault to benefit from distance.
- the use of portable shielding blocks around the periphery of the storage locations to cater for local 'higher' areas of radiation. The shielding blocks will be designed to be handled by the crane.

In order to minimise radiation dose uptake it is envisaged the crane will be automatic and capable of remote operation. Manual operation should also be provided. However, radiation levels are not considered to warrant remote recovery following failure of the crane. Manual recovery is considered acceptable.

The crane will require maintenance and testing periodically and this will be performed with the storage vault at the crane parking position. It is therefore preferable that 'high

activity' storage drums/packages are stored away from this location to minimise dose uptake.

Stocks of empty drums will also be stored within the storage vault.

3.4.3.2 Waste Processing Area

The waste processing area has only been developed in concept at this stage. However, it is envisaged this area will be operated by classified workers assisted by suitable installed and portable plant and equipment. Subject to development of the design for this area the following equipment is envisaged:

- Monorail or similar for lifting waste from the road bay into the waste processing area.
- Small Shielded area for temporary storage of drums/packages.
- Suitable equipment for repackaging waste, for instance fume cupboards/hoods, gloveboxes, tongs.
- Equipment to assay waste.
- Equipment to decontaminate drums/packages preferably generating a minimum of liquid effluent.
- Handling equipment (eg. trolleys) for handling packages/drums.

3.4.3.3 Manning

It is envisaged that the facility will not be permanently manned. Visits to the LRWF will be made to:

- undertake operation (eg waste handling)
- carry out preventive or breakdown maintenance
- carry out inspection activities

3.4.3.4 Wet/Dry Facility Option

The Contractor will be required to design the facility to operate as a 'dry facility', that is, producing no radioactive liquid effluent. If the Contractor can provide at the detailed design stage, recommendations on discharge limits to the satisfaction of the Environmental Protection Department (EPD), then the facility may operate as a 'wet facility', that is producing loading in compliance with the agreed discharge limits. The source of the effluent would be limited to that produced as a by product of decontamination activities such as washing down of drums, floor etc. On that basis this EISA has included an assessment of the facility operating as a 'wet facility'.

3.5 Contract Options

The LRWF project will comprise a number of discrete but interdependent phases, including Design, Construction and Commissioning, and Operation and Maintenance. Each phase could be carried out under a number of different contract arrangements, whereby Government or a private contractor could be responsible for any one, or all of the separate phases. It is currently envisaged (see Working Paper number 3 - Contract Options) that the most favourable option in terms of simplicity, assignment of responsibility and contingent liabilities, would be a design-build and operate contract (DBO). The period of operation has yet to be determined, but should allow training of locally based staff, before transfer of the facility to the Department of Health for management. A relatively long period, say ten years, may be favoured by Government although a one-year period was recommended in WP3.

Suitable contractual clauses will need to be drawn up to specify the responsibility of the selected contractor to install and maintain, for the duration of the contract, suitable pollution control equipment and to undertake recommended environmental and radiological monitoring. Following implementation of a spill contingency plan and emergency procedures as required by Hong Kong Government, the contractor will be obliged to respond to potential emergency situations and to contain and rectify any resulting contamination so that damage to the environment and the public is minimised. Such recommended measures are discussed in more detail in other sections of this report.

4 POTENTIAL NON-RADIOLOGICAL IMPACTS

4 POTENTIAL NON-RADIOLOGICAL IMPACTS

4.1 Ecology and Fisheries

4.1.1 Terrestrial Ecology

Whilst the proposed site does not support any particularly important or rare plant species, it is considered to be situated in a typical, natural habitat representative of its type.

The proposed site does not contain any habitats that are favoured by amphibians, reptiles, insects or mammals and is not likely to be of significant interest for these species.

Approximately one hectare of grassland and low scrub would need to be removed during the construction of the waste storage facility and to provide the associated helipad. In addition, the access road would impact on a very small area of the rocky shore.

In summary, the impacts of the proposed low-level radioactive waste storage facility on the terrestrial ecology of the island are likely to be low and of local significance. They do, however, serve to introduce an expressly operational facility into an area which, in Hong Kong, has hitherto been a fairly natural and unaffected ecological environment. In the context of the Territory's reducing inventory of such sites, this is unfortunate.

In addition, the provision of a jetty may encourage public use of the island if it improves access. This would undoubtedly increase the potential for impact on the island's ecology, and in particular would increase the potential risk from hill fires.

4.1.2 Marine Ecology and Fisheries

It is known that the rare Chinese White Dolphin and Black Finless Porpoise utilise the waters around Siu A Chau, south Lantau and Tai A Chau. However, given the restricted nature and small scale of the proposals and the low level of usage envisaged, any impacts are likely to be extremely localised. With regard to potential impacts on marine mammals, piling work for construction of the jetty is the most critical aspect, however, with careful planning potential impacts could be reduced to low levels. This would include the use of the least disturbing construction methods and programming of the 6 month jetty construction period with attention to duration of work and phasing to occur outside critical seasons (eg. from October to December) for these mammals.

The possible use of the island by Green Sea Turtles has not been confirmed, but the most sensitive area is likely to be the main sand beach as a nesting site. This beach is not affected by the proposal. The rocky shore in Sum Wan is not the type of habitat that is conducive to egg laying by turtles. There is no existing information to indicate that turtles graze in Sum Wan.

Approximately 55m of the jetty will extend above the waters over the sandy seabottom of the subtidal zone. With a width of 3 to 5 m, construction of the jetty would cause disturbance to less than 0.03 ha of sandy bottom fauna. The jetty would be supported on about 18 piles in the subtidal area and it is likely that these piles will be bored through about 2 to 5 metres of decomposed granite and into 1 metre of bedrock. As the bored piles will be small diameter (400mm to 500mm), there will be minimal generation of suspended solids. Debris is likely to be large grained and to settle close to the site of

the boring.

In view of the small area affected, the ubiquitous nature of benthos inhabiting sandy substrates in the marine environment and the short duration of jetty construction (4.5 months), the impact on sandy bottom benthos is negligible and short term. The communities on rock and boulder in the bay are typical of the location. As the species list (Appendix F) is not extensive, loss of marine species due to construction of jetty piles would be minimal. Two species of coral were found during the survey, which occurred as isolated groups of small coral heads; these corals are not of particular conservation importance. Measures which have been specified to limit the amount of suspended sediment entering the water at the site and during jetty construction will protect these species.

Upon completion of jetty construction, only the areas occupied by the piles will be permanently removed. Surficial substrata underneath the jetty will be reworked by tidal and wave action and should be indistinguishable from substrata outside the jetty area (there may be scouring around the piles but such an effect is small and localised). It has been widely reported in literature that recolonisation of benthos occurs rapidly (usually within one month). There should be no long term impact on sandy or rock bottom benthos. The presence of the jetty construction would provide opportunities to create new underwater surfaces of value to marine life.

The Siu A Chau area has potential importance for capture fisheries and as a nursery ground, however, the small scale and very localised nature of the proposed development should not cause unacceptable impact on the resources. Assuming the scenario that radioactive liquid effluent is discharged, the low level of radioactivity (see section 5.4.3) coupled with the instantaneous dilution and dispersion of Sum Wan waters, is likely to result in levels that approach background radioactivity in seawater. Fish fry generally move into inshore shallow waters to feed. When they reach a certain size, they would move into deeper waters or offshore to reach maturity. They are temporarily residents of inshore waters and their residence time is generally short. Hence their exposure time to infrequent radioactive discharges is very short. Based on the above, the potential for fish fry being adversely affected by radioactive effluent discharge from the LRWF can be deemed to be minimal. Potential for bio-accumulation and trophic transfer up the food chain is also regarded as minimal.

4.2 Water Quality

4.2.1 Construction

As the site is located at low level adjacent to the coast, construction activities have the potential to impact on coastal water (there are no surface water streams to be affected). Methods should therefore be employed to minimise the risk of polluting the inshore water. Such mitigating measures are specified in a separate section of this report.

It is likely that construction will involve ground preparation, concrete mixing and laying, fabrication and fitting-out of the structure. Pollution could arise primarily from run-off across exposed areas of bare ground and across other active site areas. Such areas should generally be minimised and potentially polluting areas such as concrete plants and fuel storage areas will be bunded. With such precautions, and given the small area affected by construction works, it is anticipated that the potential impacts will be minimal.

Water quality impacts could also arise from the waste water arisings from toilets and canteens on site. The guidelines in the Technical Memorandum on discharges of effluent to coastal waters [Ref. 5] indicate quite low levels of BOD and suspended solids permitted in a discharge (both 50 mg l^{-1} for less than 10 m^3 d^{-1} of effluent), which suggests that direct discharge without treatment would not be possible. As the bay is partially sheltered and is at present unimpacted, every effort should be made to avoid effluent discharges to the bay. It would therefore be preferable to contain all liquid waste. A septic tank with soakaway would probably be the most cost-effective solution, due to the small size of the workforce. Infrequent de-sludging would be required, with disposal to land nearby or transferred elsewhere.

A small local effluent treatment and disposal system may satisfy the Water Quality Objectives for the Southern Water Control Zone (although discharge into Sum Wan is not recommended) although operational difficulties and expense may preclude this option. Alternatively, but at greater expense, effluent could be disposed of through the existing sewerage system or waste treatment facilities in Hong Kong. Clauses to ensure proper and adequate disposal of waste should be incorporated into the conditions of the contract.

4.2.2 Operation

Liquid effluent from the LRWF will be separated into discharges from active and from non-active areas. As the rationale for the operation of the LRWF is to isolate active waste material from the environment, there should be minimal discharge of contaminated material. In addition, it is planned that the LRWF will operate as a 'dry' facility to minimise active liquid arisings. In spite of this, this assessment assumes a conservative approach and pessimistic scenario that active liquid arisings may be discharged.

All active area effluent will be contained in a monitoring tank and will be subject to radiological monitoring before it can be released. Discharges of radioactive substances to coastal waters are generally prohibited [Ref. 5]. The Radiation Ordinance regulates the discharge of radioactive substance with respect to public health. The Water Pollution Control Ordinance regulates the discharge of radioactive substance with respect to the protection of water quality and the marine environment. Under the Radiation Ordinance, a licence for discharge of liquid waste containing radioactive substances should therefore be obtained from the Radiation Board with discharge limits set on a site-specific basis with regard to the available dilution, nuclides present in the effluent, pathways for transfer of activity along the food chain to man, accepted transfer factors for these pathways, and the annual limit of intake (ALI) for each nuclide.

It should be noted that transfer factors used internationally and published, for instance, in IAEA publications, may relate mostly to temperate species which could have lower transfer factors. A precautionary approach to the use of such data, perhaps with an additional safety margin (such as a factor of ten increase in the relevant transfer factors) should be applied. It is presumed that protection of the environment would be assured by protection of man.

Conventionally accepted practice as currently applied in Hong Kong is that monthly discharges should be less than ten times the sum, for each nuclide, of the ratio of activity (A) to the ALI, as shown in the equation below.

$$\sum_i (A_i / ALI_i) \leq 10 \text{ per month}$$

Effluent within the limits determined for safe discharge will be pumped out to the outfall. It is likely that, due to the low volume of liquid arisings from potentially contaminated areas, the infrequent and controlled nature of such discharges, that such effluent would be not much higher in radioactivity than the natural radioactivity content of the seawater into which it would be discharged. Some isotopes, however, which could theoretically be present in such a discharge (including isotopes of promethium) are not naturally occurring and such discharges should be subject to a detailed assessment and justification. Further discussion is provided in Section 5 of this report.

Any effluent that has the potential to contain contamination will be routed to the active liquid effluent system. As such all drains from contaminated controlled areas at the facility will be routed to the active effluent system as will arisings from the change-rooms associated with contamination controlled areas. Arisings from the former are expected to be low in volume and would typically arise from cleaning or decontamination operations. Arisings from the latter would not normally be expected to contain contamination but are routed to this system as a matter of procedure. The low level of occupancy and frequency of operation suggests very low volume of active effluent.

Effluent from non-active sources is expected to comprise foul effluent from toilets and sinks/washbasins in other areas of the facility. These will probably be directed to a septic tank with soakaway for land disposal. Alternatively, toilets could be of the ventilated dry latrine type for minimal impact. Again for the reasons stated above, the arisings are expected to be very low.

There may be a need to store small quantities of diesel or petrol at the site for powering the delivery vehicles. Any such fuel will need to be stored in a sealed area with a suitable bund. Alternatively, electric powered vehicles may be used. In addition, storage and use of other chemicals would be required at the LRWF. Such chemicals would include epoxy resin monomers and fixing agents used to seal the waste drums after filling. With Safety and Health precautions on the use and disposal of such materials, there should be no impacts.

The potential causes and consequences of an accidental release of waste are discussed in Section 5. It is considered that the risk of an accident that would result in a significant release of waste is very low. Firstly, the waste comprises a very small volume (about 50 m^3 for the existing waste and less than 1 m^3 per year arising thereafter) and so the potential for release is small, because deliveries are very infrequent and amount moved each trip are small. If a package was dropped during transfer (the most likely scenario) then it is unlikely that the package would rupture sufficiently for all the waste to be spilled. Most of the waste materials are encapsulated (such as sealed check sources which are designed to have a very low leachability) or are in solid form (most liquid arisings already having been disposed of to sewer). Therefore the loss of waste material is less likely to occur following an accident, recovery of the material may be possible, and the amount of material released to the environment is likely to be very small.

The most toxic of the waste materials to be stored is a single source of plutonium-238, which is present in only trace amounts. Larger amounts of chemicals such as thorium and promethium are present in the waste, but relative to the enormous volume of water

available for dilution of any chemical release that became dissolved or mixed with the water body, would ensure that resulting concentrations were very low. It is recommended that a scoping exercise is carried out to identify if any chemical is present in the waste in a form and concentration which could present an environmental hazard.

4.3 Air Quality

4.3.1 Introduction

Air quality impacts arising from construction and operation of this facility are not considered to be a key issue because of the remote location. During construction there may be generation of dust (total suspended particulates (TSP) and respirable suspended particulates (RSP)) but the facility is small and the construction period short. It is proposed that air quality during construction is subject to standard pollution control clauses which should form part of the construction contract. This should prevent poor working practices.

During the operational phase, there will be no emissions that are subject to the terms of the Air Pollution Control Ordinance. Gaseous or particulate emissions from the facility during operation are considered to be negligible. All emissions will be filtered through High Efficiency Particulate Air (HEPA) filters.

In view of the remoteness of the facility, and small scale, quantitative assessment of emissions impacts on receivers is not considered necessary.

4.3.2 Legislation and Guidelines

The Air Pollution Control Ordinance (APCO) (Cap. 311, 1983) provides authority for controlling air pollutants from a variety of stationary and mobile sources, including fugitive dust emissions from construction sites, and encompasses a number of Air Quality Objectives (AQO). Currently AQOs stipulate concentrations for sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and total and respirable suspended particulates (TSP/RSP) in ambient air over the Territory. These are listed in Table 4.1.

Table 4.1 Hong Kong Air Quality Objectives (AQOs)

Parameter	Maximum Average Concentration μgm^{-3}			
	1-Hour*	8-Hour	24-Hour**	Annual
SO_2	800	-----	350	80
CO	30000	10000	-----	-----
NO_2	300	-----	150	80
TSP	500***	-----	260	80
RSP	-----	-----	180	55

* Not to be exceeded more than three times per year.
** Not to be exceeded more than once per year.

*** In addition to the above established legislative controls, it is generally accepted that an hourly average TSP concentration of 500 μgm^{-3} should not be exceeded. Such a control limit is particularly relevant to construction work and has been imposed on a number of construction projects in Hong Kong in the form of contract clauses.

The TSP and RSP AQOs are of relevance to construction activity.

4.3.3 Construction Phase Impacts

The facility is small and will be constructed within about a twelve month period. In view of the distance to the receivers (1.7 km to Ha Tsuen and 5.5 km to Shek Pik Prison), it is considered that there will be no impact on receivers during the construction phase.

In order to minimise general dust formation, standard control clauses should be adopted, see Appendix B. Monitoring for dust during construction is not considered necessary in view of the small scale.

4.3.4 Operational Phase Impacts

Emissions from the facility during operation are considered to be minimal. The ventilation system will be fitted with a high efficiency particulate (HEPA) filter. Small amounts of radon may be produced from the decay of thorium 232 (from old gas mantles). However, the waste will be contained in epoxy lined steel drums which will minimise leakage. Radon is present naturally in the environment and is considered to be an insignificant issue with regard to ambient air quality. Radon build up is normally considered to be an indoor air quality issue because of emissions from granite used in concrete. In view of the distance of the facility from the receivers and the amount of radon expected to be released, it is considered that there will not be any adverse impact on ambient air quality.

Some of the radiological health monitoring equipment requires the use of small amounts of bottled argon/methane mixtures. The use of such materials should present no potential for significant impact on air quality.

4.4 Noise

4.4.1 Introduction

Noise may be generated during the construction phase of the facility. During the operational phase there will be minimal noise generated.

4.4.2 Legislation and Guidelines

The Noise Control Ordinance (NCO) provides the statutory framework for noise control. This defines statutory limits applicable to construction and operation. In addition, EPD has stated that for better planning and in order not to contravene the NCO, considerations should be taken of the Hong Kong Planning Standards and Guidelines which recommends levels 5 dB(A) below the statutory criteria.

The NCO invokes three Technical Memoranda (TM) which define the technical means for noise assessment. Together, the NCO and the TM provide a mechanism for assessing noise levels and the statutory power to control noise.

Operational Noise

The TM for the Assessment of Noise from Places Other Than Domestic Premises or Construction Sites provides the statutory control and mechanism for assessing noise from plant items. It provides a method for determining the Area Sensitivity Rating (ASR) of a Noise Sensitive Receiver (NSR), and the Acceptable Noise Level (ANL). Table 4.2 shows the criteria for determining the ASR and Table 4.3 shows the ANLs with respect to the time of the day.

Table 4.2 Area Sensitivity Rating (ASR)

Type of Area	Degree to which NSR is affected by Influencing Factors		
	Not Affected	Indirectly Affected	Directly Affected
1) Rural area, including country parks or village type developments	A	B	B
2) Low density residential area consisting of low-rise or isolated high-rise developments	A	B	C
3) Urban area	B	C	C
4) Area other than those above	B	B	C

Table 4.3 Acceptable Noise Levels (ANL)

Time Period		ANL dB(A)		
		A	B	C
Day	(0700 to 1900)	60	65	70
Evening	(1900 to 2300)			
Night	(2300 to 0700)	50	55	60

Construction Noise

The NCO divides construction noise into activities involving powered mechanical equipment excluding percussive piling, and percussive piling activity. The criteria for the assessment of noise from construction are therefore similarly divided.

Under the Technical Memorandum on 'Noise from Construction Work other than Percussive Piling,' noise from activity excluding piling is not restricted during the period 0700-1900 hours (except all day Sunday and Public Holidays). EPD has suggested a

daytime general construction noise limit of 75 dB(A) (Table 4.4). This should be assumed to apply to those activities which are defined as construction, although this has no statutory basis.

Between 1900 and 0700 hours and all day on Sundays and public holidays, activity is prohibited unless a permit is obtained. A permit will be granted provided that the Acceptable Noise Level (ANL) for the noise sensitive receiver can be complied with. ANLs are assigned depending upon the Area Sensitivity Rating (ASR). For the receivers at Tai A Chau and Lantau, NSRs are likely to be assigned an ASR of A and the corresponding Basic Noise Levels (BNLs) for evening and night-time periods are given in Table 4.4

Table 4.4 Construction Noise Criteria for Activity Other Than Percussive Piling

Basic Noise Level dB(A)		
$L_{Aeq\ (30\ min)}$ *	$L_{Aeq\ (5\ min)}$	
Daytime (all ASRs)	Evening ASR `A'	Night ASR `A'
75	60	45

* Recommended by EPD, but not statutory

4.4.3 Construction Phase Impacts

The receivers on Tai A Chau will be completely shielded by the topography from the facility, and are located at a distance of 1.7 km. The noise attenuation afforded by these factors (approximately 10 dB(A) for the shielding effect and 73 dB(A) for distance attenuation) should reduce noise levels to unnoticeable levels.

4.4.4 Operational Phase Impacts

During the operation of the facility, loading may take place approximately every three months, and will last 1-2 days. During loading, noise may arise from delivery vehicles, ventilation plant, cranes and other equipment within the building. In view of the limited activity, it is not anticipated that noise nuisance would occur.

Ventilation plant may be left running continuously. This should be designed to meet the HKPSG noise criteria at the nearest sensitive receivers. It is likely that the need to preserve the comfort of the facility operators would be a more stringent requirement.

4.5 Transport

4.5.1 Construction

Construction of the LRWF would involve the use of sea-going vessels for the transport of construction equipment and materials and the use of land-based plant for the site preparation, cable laying, building fabrication and ancillary works. There will be no need

to construct any haul roads or other access save for the jetty and LRWF access.

There will be no traffic impacts on Siu A Chau and the number of sea-going vessel trips required to transport plant and materials would probably cause no difficulty for other maritime traffic, particularly as the main shipping lane passes to the north of the island. There may be localised impact on other uses of the area, such as fishing in the bay and approaches. This is not considered a significant impact on such uses in the wider area of the Soko Islands and south Lantau.

The origin of construction plant and equipment has not been identified, but it would appear unlikely that any noticeable adverse impact on land-based or marine traffic will result from sourcing and delivery of such small quantities of materials. It is possible that, due to the remote location, a helicopter may be used to deliver some items or personnel. The very limited potential use of such means is not considered to present any significant impacts.

4.5.2 Operation

Existing waste delivery arrangements to the LRWF will be made by the DBO contractor. Future waste arisings will be transported to an assigned collection point by the waste producers, and then collected and transported to the LRWF by the DBO contractor. The potential impacts are considered briefly in the following paragraphs. The need for further assessment will be addressed at the detailed design stage.

It is envisaged that delivery of waste will be required from Queen's Road East (for the initial waste delivery loads) during the first phase of operation. Approximately 200 drums of waste will be delivered in a suitable vessel. The number of trips required is not known, but is not envisaged to be substantial. The best estimate is that perhaps 5 drums will be delivered daily, possibly as one load requiring a single trip. On this basis some 40 days would be required to transport all existing waste to the LRWF. Assuming the worst case, a single drum would be transported, requiring some 200 trips; at a maximum frequency of 4 trips per day, this would entail some 50 days. Waste loading from the QRE tunnels onto a vehicle will take place during this period. Arrangements at QRE during this period will be the responsibility of the DBO contractor. However, it is likely that traffic management will be required whilst the collection vehicle is being loaded, although it may be possible to use the bus stop located nearby.

On-going waste arisings will be delivered (under permit issued by the DH), probably in smaller packages on an ad-hoc basis as required. Maintenance and delivery visits should not be necessary more than once per month. As the number of deliveries and visits will be low, the potential land and marine traffic impacts are likely to be insignificant. The proposed site is situated within a sheltered bay, but the location of Siu A Chau in southern Hong Kong waters means that sea conditions can become generally rough. Sum Wan is exposed to winds from the south-east, which although not the predominant wind direction, would probably render mooring and off-loading impracticable. It is envisaged, however, that deliveries can be scheduled for fine weather only, as the small volumes of waste and the infrequent delivery requirements permit a degree of flexibility.

It is understood that a permit is required from the 'Port Formalities and Dangerous Goods Unit' of the Marine Department. It is possible that certain restrictions could be placed on this permit, including times and routing of deliveries.

Special attention will need to be paid to the mechanisms for delivery, in particular the methods of loading/unloading (especially at jetties), the means of transport and the locations of collection and loading points. Such items are as yet undecided, but could affect the safety and smooth operation of the transport process. It is unlikely that the maximum lifting height would exceed 3 metres, the height to which the drums have been drop tested, and the consequences (discussed in greater detail in Section 5) are not great. However, this would need to be evaluated in greater detail when transport routes and equipment/vessels are known. Similarly, transport of future waste arisings may be in alternative packages and the transport arrangements will have to be reviewed for suitability at the appropriate time.

A contingency plan will be required in case of an accidental drop of the waste containers during transport. This would include arrangements for maintaining a safety clearance zone during retrieval of the package, means to retrieve the package and any remedial measures to be implemented, including post-event monitoring. Such plans are described in a later section. It is apparent, however, that non-radiological impacts of such an event, including disruption along transport routes, is likely to be minimal because of the infrequent requirement for waste transportation.

4.6 Historical and Cultural Heritage

4.6.1 Construction

There are no listed sites of archaeological importance at the site and it is therefore unlikely that any impacts will arise from construction of the LRWF. It will not be necessary to survey the site prior to, or during the construction phase (a 'rescue dig'). Similarly, there are no known grave sites or Fung Shui interest in the area and no known sites of cultural or historical importance that could be affected by construction.

4.6.2 Operation

No impacts on historical and cultural heritage arising from operation of the facility can be envisaged.

4.7 Potential Visual Impact

4.7.1 Introduction

The facility will inevitably have a significant localised visual impact, arising from the required size and the high visual quality of the area.

4.7.2 Impact Within the Sum Wan Viewshed

The facility will be fully exposed to views within the Sum Wan area, and minimisation of the visual impact will therefore depend upon mitigation measures. The topography will help to minimise the visual intrusion, as the facility will often be viewed against the landform of the saddle mentioned in Section 2.10, the high ground to the north (which rises to 77 mPD), and the high ground to the south (which rises to 24 mPD). The jetty will generally be of minimal intrusion, as it will most likely be of minimal cross-section and will usually be seen in profile. It will have the greatest impact on views looking down to the sea, such as views from the areas of high ground to the north and south

mentioned above, in which case the plan form will also be apparent. It should be stressed that the number of visitors who will actually experience the impacted views will be minimal. Access is only possible by private boat, such as a junk trip, and the island is located in the far south-western corner of the Territory, beyond the geographical scope of most such trips.

4.7.3 Impact on the Remainder of Siu A Chau

The facility need not have any visual impact on the remainder of the island. The topography will confine the impact to the Sum Wan area. To an observer visiting the island, however, the presence of the facility may lead to the impression that the island is no longer unspoiled, even though the direct visual impact is limited. The critical relationship is the height of the building compared to the height of the saddle mentioned in Section 2.10, as this is the lowest part of the natural topographical screening. The highest part of the facility should not project beyond the height of the lowest part of the saddle, and should preferably be comfortably below that height. This results in a maximum building height of 14 mPD.

4.7.4 Impact on Views from the Sea

The facility will be exposed to views from the south-east only. The building will be seen against the backdrop of the landform surrounding Sum Wan, specifically against the saddle mentioned above. It is important to avoid breaking the ridgeline as seen in inward views. The proximity of the facility and saddle is of benefit, as the ridgeline will be intact on views from points quite close to the facility. The criteria of keeping the building height below the height of the saddle for island views and safety aspects will therefore aid in minimising the impact on sea views.

4.8 Solid Waste

Potential liquid and aerial discharges have been dealt with under Sections 4.2 and 4.3. This section therefore deals only with solid waste arisings (other than radioactive materials).

4.8.1 Construction

During the construction period, the following activities will generate some solid waste material:

- excess rock and soil cover cut from the hillside to form the site platform
- excess materials generated on the construction site, including timber shuttering, metal reinforcing, excess or wasted cement and concrete
- discarded packaging material, particularly from equipment and furniture deployed during fitting out of the LRWF
- general refuse from construction workers, site offices, etc.

Contract clauses should be written to generally preclude the accumulation of waste materials on site, especially in areas or in a manner which would permit the dispersion of wind-blown debris. Open incineration of waste matter should be prohibited, as should dumping of refuse on the island or at sea. Providing that suitable precautionary measures are employed on site including regular removal of debris to licensed disposal areas off the island, there will be minimal impact from solid waste arisings.

4.8.2 Operation

Solid waste arisings during the operational phase of the LRWF include the following:

- waste matter from office use
- waste from visitors and staff using rest rooms (such as discarded food wrapping)
- occasional waste arising from facility maintenance
- occasional non-contaminated solid waste from processing areas (after monitoring), which includes damaged overalls and gloves

With each visit to the island (for instance, for maintenance or waste delivery), all non-contaminated waste arisings should be removed from the island on departure and disposed of at a suitably licensed facility. As most such materials, however, will comprise low volumes of normal refuse, this would simply entail entering such waste into the normal refuse disposal system at the point of return. Other waste, which may include discarded oils from machinery maintenance, should be disposed of in accordance with regulations.

The LRWF is designed to separate the active from non-active areas and careful attention is paid to monitoring of personnel exiting active areas of the facility. As protective clothing such as disposable overalls will be worn in active areas, any surface contamination can then be kept in the active area by discarding the overalls before exiting. It will also be policy to minimise the import of materials to active areas, by for example discarding of packaging materials in clean areas before transfer of equipment into an active area. All active waste generated in the LRWF will be monitored at the site and directed to normal disposal routes or to controlled storage within the facility.

5 PRELIMINARY RADIOLOGICAL SAFETY ASSESSMENT

5 PRELIMINARY RADIOLOGICAL SAFETY ASSESSMENT

This section of the report makes a preliminary evaluation of the radiological safety of the LRWF. The level of detail reflects the current stage of the project. It is recommended that a full safety assessment is prepared by the successful Design, Build and Operate (DBO) Contractor based on the detail design developed by that Contractor. The DBO Contractor's safety assessment should be subject to independent assessment.

This preliminary safety report covers the LRWF facility that is to be built on Siu A Chau. The LRWF will be a new plant and will cater partly for wastes currently stored elsewhere in Hong Kong, principally within tunnels at Queens Road East (QRE) Wanchai, and will also cater for future arising of waste from medical, educational and industrial facilities.

The assessment considers both normal operations and unplanned events.

5.1 Outline Process Description

Most historical wastes will be assayed and repackaged into storage drums at QRE. The waste will be repackaged directly into the drum that is to be used for most waste storage at the LRWF. The drums will be transferred to the LRWF by road and sea transport. On arrival at the LRWF waste from the QRE tunnels will therefore need to undergo only minimal handling before being placed in the storage vault for long term storage. Drums will enter an enclosed road bay within the building, be subject to confirmatory external radiation and contamination checks, and be placed directly from the road bay into the storage vault using suitable handling equipment.

Certain future arisings, and small quantities of historic arisings, may require repackaging into the storage drum for long term storage. These wastes will arrive at the LRWF, again by road and sea, packed in a variety of packages and will also enter the facility via the enclosed road bay. From the road bay the packages will enter a dedicated waste processing/packaging area. Waste will either be unpacked from its transport package and be placed in a storage drum or the complete waste package will be placed within a storage drum. Waste will also be assayed and the external surfaces of the storage drum monitored for external radiation and contamination before the drum is placed in the storage vault for long term storage. Storage drums will be decontaminated if necessary before being placed in the storage vault, although this is not expected to be a routine event. Emphasis will be placed on maintaining the external surfaces of the drum clean during repackaging operations.

Certain sealed sources may also be transferred to the LRWF, some of which have significant radiation levels that would make repackaging not feasible. These wastes will be placed directly in the storage vault within their original packaging (without repackaging) after external contamination and confirmatory radiation checks.

Details of all waste stored at the LRWF and its storage location, will be entered into an inventory data base.

5.2 Justification of Plant and Process

The waste storage arrangements at QRE are not purpose designed for the storage of radioactive wastes and have been assessed as unsuitable. A survey of waste packages currently held at QRE has also revealed them generally to be in a poor condition.

The Government intends to encourage return of waste to originating countries or manufacturers where feasible. However, this is not possible for historic wastes or all future arisings and no disposal route is available for this waste in Hong Kong. The waste must therefore be stored. A new facility is favoured as the existing facility is unsuitable for continued storage. Similarly conversion or upgrading of the existing facility into an acceptable condition is regarded as impractical.

The site on Siu A Chau has been selected after an extensive search [Ref. 2].

Repackaging of existing wastes at QRE is favoured as this ensures that wastes are in a safe condition for transport. It also allows repackaging to commence prior to the LRWF being available.

Repackaging of future wastes at the LRWF is favoured, where feasible, as this allows a standard drum type to be used, thus simplifying long term storage. It is also considered impractical for some of the current waste consignors to pack their waste directly into the storage drum to be used at the LRWF because of size and handling constraints.

In certain cases wastes may be stored at the LRWF in alternative suitable packages either because unjustified dose uptake, or cost, would be incurred in repackaging. Wastes stored in this fashion are expected to be sealed sources.

The Basis of Design and Functional Specification of the facility is outlined in Working Papers WP1 and WP2.

5.3 Radiological Standards and Safety Principles

The LRWF will be assessed against the following safety standards and principles.

5.3.1 General Safety Principles

The LRWF will be subject to the following general safety principles:

a) The LRWF shall be designed to reduce to an acceptable level the possibility of accidental radioactive release during the whole period of operation.

b) The LRWF shall be adequately designed to cater for, and be protected against internal and external hazards.

c) Radiological doses to persons both on and off site as a result of normal operation of the LRWF shall meet the dose limits prescribed in the Radiation Ordinance [Ref 7].

d) The LRWF shall be designed to essentially be "intrinsically passive safe", such that interruption of any service connection(s), at any time, for a period of a few

days, would not lead to any significant danger to persons or have a significant long term adverse affect on the condition of the stored waste or its container.

e) The LRWF will be designed to meet applicable Hong Kong Statutory Regulations.

5.3.2 Radiological Protection Requirements

The LRWF shall comply with the following standards:

a) All exposures shall be kept As Low As Reasonably Practicable (ALARP).

b) The radiation dose for both radiation workers and members of the public shall meet the limits prescribed by the Radiation Ordinance. In summary the main limits are:

- The maximum individual effective dose for any occupational radiation worker should be 20 mSv per year.
- A maximum equivalent dose for any occupational radiation worker of 500 mSv/y to skin, averaged over any $1cm^2$.
- A maximum equivalent dose for any occupational radiation worker of 500 mSv/y to the hands, forearm, feet and ankles.
- A maximum equivalent dose for any occupational radiation worker of 150 mSv/y to the lens of the eye.
- The maximum individual effective dose for members of the public should be 1.0 mSv per year.

[Note - The above radiological dose limits are a summary and full details of the requirements are given in Reference 7].

As guidelines to achieving the above dose limits the target maximum whole body dose in continually occupied areas should be:

- 10 µSv/h for occupational radiation workers and,
- 1 µSv/h for members of the public.

If the above limits cannot be achieved, for whatever reason, justification of alternative values will be necessary.

5.3.3 Liquid and Airborne Effluent Discharge

Routine liquid and aerial discharges from the LRWF shall be limited to ensure that the most exposed member of the public does not exceed the limits set out by the Radiation Ordinance.

In addition liquid and aerial discharges shall be assessed against the following requirements:

Liquid

The total monthly radioactive discharge of each radionuclide should be less than ten times the sum, for each nuclide of the ratio of activity (A) to the ALI, as shown in the equation in section 4.2.2, where ALI is the Annual Limit of Intake set out in ICRP 61 [Ref. 8].

Aerial

The total monthly radioactive discharge of each radionuclide should be less than ten times the sum, for each nuclide of the ratio of activity (A) to the ALI, as shown in the equation in section 4.2.2, where ALI is the Annual Limit of Intake set out in ICRP 61 [Ref. 8].

5.3.4 Accident Risk Criteria

It is recognised that a distinction can be made between exposure to radiation as a result of planned operations and discharges, and potential exposure as a consequence of unplanned events, for example, accidents. The level of risk that is tolerable due to unplanned events is inevitably a qualitative assessment. However the UK Health and Safety Executive (HSE) has published guidance on the safety assessment of nuclear plants that sets Basic Safety Objectives (BSO) and Basic Safety Limits (BSL) and utilises the As Low As Reasonable Practicable (ALARP) principle. In summary the tolerable frequencies of accidents, which would give rise to doses to a person outside the plant (ie. public) are:

Maximum	Total predicted frequency, per year	
effective dose		
mSv	BSL	BSO
0.1-1	1	10^{-2}
1-10	10^{-1}	10^{-3}
10-100	10^{-2}	10^{-4}
100-1000	10^{-3}	10^{-5}
>1000	10^{-4}	10^{-6}

For workers the individual risk of death either from accidents are:

BSL 10^{-4}

BSO 10^{-6}

The LRWF must achieve the BSL's, with further risk reduction being considered using the ALARP principle. BSO's are used by UK HSE to determine when independent assessors need not seek further safety improvements by the operator. The operator should utilise the ALARP principal to determine the level to which further risk reduction below BSL's is justified. Full explanation of this is given in a recent UK HSE document [Ref. 11].

5.4 Normal Plant Operations

The following design principles and features will as a minimum be incorporated into the LRWF. These are expected to contribute to the provision of a safe facility:

- All waste will be transported to the LRWF in accordance with the IAEA Regulations which "experience has shown ensures a high degree of safety" [Ref. 9].
- The facility will store waste in storage drums or packages, which will themselves be stored within a storage vault providing a "double containment" concept.
- The facility will be designed to be "intrinsically passive safe" such that interruption of any service connection(s), at any time, for a period of a few days, would not lead to any significant danger to persons or have a significant long term adverse affect on the condition of the stored waste or its container. The LRWF will not therefore be reliant on service connections to maintain a safe environment.
- All radioactive liquid discharges will be prohibited until after agreement is reached with EPD on discharge limits.
- All aerial discharges will, as necessary, be filtered and monitored on discharge.
- The facility will be designed to withstand extreme weather conditions.
- The facility will incorporate fire detection and suppression facilities.
- A security system will be installed in the facility.
- Radiological monitoring equipment will be installed inside and outside the LRWF.
- Operating personnel will be subject to monitoring for radiological dose uptake.

In order to assess the acceptability of the LRWF concept under normal plant operations, a preliminary dose uptake assessment has been undertaken and assessments made of projected solid, liquid and aerial discharges.

5.4.1 Preliminary Dose Uptake Assessment

The dose uptake assessment has, at this stage, only considered external dose uptake, as knowledge of the detail design and layout is required to assess potential internal doses. Similarly extremity doses have not been assessed at this stage. It is recommended that these factors are assessed by the DBO Contractor.

As it is planned that there will be significantly more operations during the first year of operation of the LRWF, due to the transfer of drums from QRE, a separate assessment has been made for the first year of operation.

A summary of the preliminary dose uptake assessment is given in Table 5.1 with supporting data in Appendix D.

In order to prepare the assessment a number of assumptions have been made and these are discussed briefly below:

5.4.1.1 Year 1 Operation

It has been assumed that the waste from QRE will comprise 60 drums Th-232, 75 drums Pm-147, and 65 drums miscellaneous wastes.

As there is little activity content data available the following assumptions have been made:

- The Th-232 waste has a specific activity of 3500 Bq/g. Qualitatively comparing the predicted radiation level from this calculation, with radiation levels measured at QRE, suggests this to be a pessimistic assumption (ie assumed radiation levels are greater than the actual).

- The Pm-147 waste has a specific activity of 3.5E13 Bq/g (pure material). Comparing this with radiation levels measured in QRE suggests this to be a slightly optimistic assumption although not significantly so (ie. assumed radiation levels are lower than the actual).

- Miscellaneous wastes have been treated as Th-232. Comparing this against doses measured at QRE suggests that overall this is a pessimistic assumption.

Ongoing arisings in Year 1 have been assumed the same as future arisings as outlined in Section 5.4.1.2.

5.4.1.2 Future Arisings

The majority of future arisings are expected to be Pm-147 with some miscellaneous waste. For Pm-147 it has been assumed 4 packages of Pm-147 are delivered to the LRWF and repackaged into 2 drums. For miscellaneous waste it is assumed that 10 packages are repackaged into 2 drums. Each package containing miscellaneous material has been assumed to have a dose rate of 5 µSv/h based on an assessment of data from QRE.

Table 5.1 Summary of Dose Uptake Assessment

Activity	Total dose (μSv) Operator 1	Operator 2
YEAR 1 SUMMARY		
QRE Waste Transfer		
Transfer of Th-232 wastes (60 drums)	7325	6390
Transfer of Pm-147 wastes (75 drums)	969	969
Transfer of Miscellaneous wastes (65 drums)	7935	6923
Loading Empty drums into Vault		
Loading 60 empty drums into Vault	774	774
Current Waste		
Pm-147 packages delivery to LRWF and repackaging (4 packages)	50	50
Pm-147 drums containing repackaged waste (2 drums)	57	57
Misc. waste packages delivery to LRWF and repackaging (10 packages)	219	219
Misc. waste drums containing repackaged waste (2 drums)	365	191
ANNUAL TOTAL YEAR 1 OPERATIONS	17694	15571
YEAR 2 Onwards		
Pm-147 packages delivery to LRWF and repackaging (4 packages)	50	50
Pm-147 drums containing repackaged waste (2 drums)	57	57
Misc. waste packages delivery to LRWF and repackaging (10 packages)	219	219
Misc. waste drums containing repackaged waste (2 drums)	365	191
ANNUAL TOTAL YEAR 2 ONWARDS	691	516

5.4.1.3 Results

The results of the preliminary dose uptake assessment indicate occupational dose limits specified by the Radiation Ordinance will be achieved.

In year 2 onwards annual doses are less than 5% of the limits set out in 5.3.

In Year 1 doses approach the annual limit, principally because of handling the backlog of Th-232 wastes. Notably however the predicted dose uptake exceeds the investigation level specified by the Radiation Ordinance. Whereas it is noted that the dose uptake is considered to be overall pessimistic as the transfers of all miscellaneous wastes from QRE are assumed to result in the same dose uptake (on a pro rata drum basis) as transfers of Th-232 wastes, and calculated radiation levels appear higher than actual for Th-232 wastes, this assessment does indicate the need to ensure Year 1 doses are consistent with ALARP and suggests the DBO Contractor should pay particular attention to Year 1 doses during the design development.

Maintenance and unplanned operations have not been assessed at this time but it is considered that such activities can be carried out within overall annual limits from Year 2 onwards.

It should be noted that although annual limits are not expected to be exceeded, the guideline instantaneous dose of 10 μSv/h [Ref. 7] is likely to be exceeded within certain areas on a temporary basis when certain waste types are handled. Additionally certain areas of the storage vault are also likely to exceed this limit. However this is not regarded as significant as these areas are either not normally occupied, are occupied infrequently for relatively short periods, or the increase in dose is temporary.

As noted earlier internal dose to workers has not been considered at this stage but it is recommended this is reviewed when the design is further progressed. However with appropriate design of equipment and, if necessary use of suitable protective equipment, maintaining dose limits is unlikely to be a problem. It should be noted that the 'first choice' method of protecting operators from internal dose should be appropriate design and engineering measures rather than reliance on procedures or personal protective equipment.

Direct dose to the public has not been assessed at this time. It is recommended that this forms part of subsequent safety assessments. Shielding should be provided as necessary to achieve dose targets.

5.4.2 Active Solid Waste

It is expected that the LRWF will generate only small quantities of active solid waste because of the low 'throughput' of waste.

Around 66% of the waste will arrive from QRE already packed into storage drums and this should give rise to negligible additional quantities of solid waste as the waste does not require processing. Future waste arisings to be handled and processed at the LRWF are in total expected to be less than $1m^3/yr$ necessitating only occasional waste processing

operations. Waste generated as a by-product of these operations is expected to be small and will typically comprise:

- used disposable clothing and personal protective equipment.
- PVC sheeting used to protect plant and equipment.

Routine storage of waste is also expected to generate minimal solid waste which will typically include:

- ventilation filters

Some waste may also be generated as a result of maintenance operations, typically:

- scrap plant items
- used disposable clothing and personal protection equipment
- PVC sheeting
- cleaning materials

The total volume of active solid waste generated as a result of the operation of the LRWF has not been assessed at this time, but is considered minimal.

The wastes generated will either themselves be stored at the LRWF as waste within a storage drum or where feasible will be disposed of by 'Dustbin' disposal after monitoring.

A principal of operation will be to minimise consumables or other materials taken into areas where potential contamination exists to minimise generation of contaminated waste.

As the only solid radioactive discharges from the LRWF will be waste suitable for 'Dustbin' disposal and this limit is already accepted in Hong Kong and other countries, assessment of dose to the public from this waste is not considered necessary.

5.4.3 Active Liquid Discharges

The LRWF will operate as a dry facility. Discharge of active effluent is prohibited before any agreement is reached with EPD and the Radiation Board on discharge limits. This section assesses potential water quality impacts if and when active arisings are discharged. The routine arisings that have been identified as 'suspect' active are:

- effluents from changerooms
- cleaning waste from potentially contaminated areas (eg. from cleaning floors).

Other arisings that could be described as normal and that may occur (depending on detail design) are:

- liquor from decontamination of drums or equipment (although dry methods will be the chosen preference where feasible and the use of suitable absorbents will be considered for small quantities of liquor).

As waste from QRE will be delivered in sealed drums this is considered to give rise to negligible risk of contamination to equipment or personnel and therefore negligible quantities of activity in liquid arisings.

It is considered that handling of 'unsealed' sources of waste gives rise to the greatest potential for spread of contamination and therefore greatest risk of contamination in effluents.

Future arisings of waste are estimated to be less than 1 m^3/yr. The most significant volume of waste that may require repackaging, and is in an unsealed form, is Pm-147 wastes from Wongs Nemoto. This waste accounts for approximately 0.5 m^3/yr of future arisings. This waste will therefore be used as a basis for an initial assessment of liquid arisings. The Radioactive Waste Management Study [Ref. 1] indicates this waste will be watch dials and contaminated utensils. It is possible therefore that some contamination may become dislodged from the waste, in particular utensils, and result in contamination of equipment in the repackaging area and possibly personal protective equipment. It is then possible that any wet clean up operations used or contamination of personnel could result in this material entering the liquid discharge system. It is thought unlikely that material will easily become dislodged from the watch dials, but it is considered that a pessimistic assumption is that 1% the Pm-147 activity becomes dislodged during repackaging operations. For this assessment it is assumed that this 1% of activity dislodged is divided equally between solid, liquid and gaseous discharges. It is also assumed that all contamination entering the LRWF liquid collection system will eventually be discharged to sea.

A calculation [Ref. 12] shows that total annual discharges would be 280 MBq compared to a monthly limit (set in the Radiation Ordinance for the protection of human health) of 500 MBq. It can be seen therefore that even if all annual contamination was discharged in a single month Hong Kong Government guidelines would not be exceeded. Attention is drawn to the assumptions made [Ref. 12].

It is difficult to assess potential dose uptake to members of the public from liquid discharges as no data are available on pathways and critical groups that are likely to receive the greatest dose from the LRWF. However, an attempt has been made at a quasi assessment.

It is assumed that a member of the public must not exceed 0.1 mSv/yr from liquid discharges. This is 1/10 of the limit identified in Section 5.3.2 to allow for potential dose to the public from other pathways (eg direct radiation, aerial discharges etc). An assessment has then been made of the activity intake that would be 'tolerable' for members of the public based on a pro-rata assessment of workers' Annual Limit of Intake (ALI). Full details of the calculation and assumptions are given [Ref. 12]. In summary results suggest that a swimmer, fisherman or other individual would need to ingest 75 litres of sea water annually to reach this limit assuming that in any one year the arisings

disperse into 100 m^3 of sea water.

It is considered that:

(a) ingesting 75 litres of sea water is not credible
(b) that dispersion into only 100m^3 of water is conservative

Based on the above assessment and that the nearest occupied area is 1.7km distant, it is considered that the dose to members of the public will be within dose limits and is likely to be insignificant.

5.4.4 Aerial Discharges

As waste is to be stored in sealed drums or as sealed sources within packages it is considered that activity in air in the storage vault should be negligible under normal operating conditions

Within the waste processing area, waste is to be repackaged and if necessary drums will be decontaminated. As waste handled in this area will include unsealed sources, operations in the waste processing area are considered to be the most likely to generate airborne activity. For the reasons outlined in Section 5.4.3 it is assumed, for this assessment, that 0.33% of the annual activity of Pm-147 becomes entrained in the ventilation system.

It should be noted that although detailed arrangements for repackaging the waste have yet to be determined suitable facilities (such as fume hoods/cupboards) will be provided for the protection of workers.

It is planned that ventilation extract from these areas will be HEPA filtered before discharge. Typically such filters are required to have an efficiency of at least 99.99%. A calculation [Ref. 13] demonstrates that under these conditions 28 kBq of activity per year would be discharged which is an order of magnitude below the monthly limit set out in Section 5.3.

As discussed in Section 5.4.3 it is similarly difficult to assess dose to members of the public for aerial discharges. However assessing the activity intake that would be 'tolerable' for members of the public based on a pro-rata assessment of workers' ALI, suggests that members of the public would need to inhale an excess of 3kBq/yr. The calculation [Ref. 13] suggests this would involve inhaling over 10% of the total annual discharges from the LRWF. It is suggested this is not credible, and therefore that doses to the public will be within limits.

It should however be noted that the above assessments of liquid and aerial discharges do not attempt to identify the pathway to the critical group, as no data are believed to be available. For example it is known fish can preferentially absorb the activity. To provide reassurance an environmental sampling programme could be initiated, and more detailed modelling of dispersion etc., attempted when the design has further progressed.

5.5 Fault and Hazard Identification

A preliminary hazard identification review was carried out (Appendix E) on the proposed design shown in Figure 3.1. The aim was to identify the main hazards and key operability issues at an early stage of the project. A full HAZOP assessment including quantitative assessment of hazards will be carried out by the DBO contractor during the design stage of the project, to ensure the design has the capability to achieve its operating objectives and the safety standards identified in Section 5.3.

5.5.1 Hazards Identified

The hazards identified have been classified under the following headings for initial assessment and discussion:

(i) Loss of Storage Drum Containment
(ii) Loss of Package Containment
(iii) Building Service Failures
(iv) Fire
(v) External Hazards
(vi) Wrong Waste Delivered
(vii) Over-Filling of Drum

An assessment of the hazards identified above is given in Section 5.6.

It should be appreciated that at this stage of design and with the data available a full quantitative assessment is not feasible.

A brief summary is given below of the approach used to assess each hazard.

(i) Loss of Storage Drum Containment

The most predominant wastes are considered (ie Pm-147 and Th-232) and incidents both inside and outside the LRWF considered. As little definitive data are available on the activity content of the waste or dispersion data following an incident, the volume of material that would be required to be inhaled/ingested for workers to exceed one ALI has been estimated. It has then been considered whether this is credible. Where appropriate the risk from the event has then been compared with accident risk criteria for the LRWF. A similar approach has been used for members of the public, with the worker ALI limit being linearly adjusted to take account of the lower dose levels applicable to the public.

The loss of storage drum containment assessment has been used as a reference assessment, where appropriate, for other assessments.

(ii) Loss of Package Containment

A similar approach to 'Loss of Drum Containment' has been used.

(iii) Building Services Failure

The consequences of building services failure have been identified as far as practicable. Where relevant, suggestions for features that should be incorporated in the design have

been identified. Without the design of these services being available a quantitative assessment is not practicable nor justified.

(iv) Fire

A similar approach to Building Services Failure has been used.

(v) External Hazards

It is noted that the building should be designed to ensure the building withstands extreme weather conditions to meet the accident risk criteria. A preliminary qualitative assessment of the consequences of flooding is also considered.

(vi) Wrong Waste Delivered

A qualitative assessment of the consequences of the delivery of wrong waste to the LRWF has been made and suggestions for mitigating design features are also highlighted.

(vii) Overfill Drum

A similar approach to 'Wrong Waste Delivered' has been used.

In general in preparing the safety assessment pessimistic assumptions have been made.

5.6 Assessment of Hazards

5.6.1 Loss of Storage Drum Containment

A number of scenarios have been identified that could potentially lead to loss of the storage drum containment. For assessment purposes these can be conveniently classified as incidents that could occur external to the LRWF (ie when the drum is in transit to the facility) and incidents that could occur when the drum is within the facility.

5.6.1.1 Incidents External to the LRWF Building

It should be noted that this category of incident can only occur for waste that is repackaged into the storage drum at Queens Road East as it is currently expected that other types of package will be used to transfer the remaining historic, and future, arisings of waste to the LRWF. This hazard is therefore limited to Year 1 of operation. It should also be noted that the limit of consideration of this assessment is the loading of the drum onto the road transport vehicle at Queens Road East (that is, repackaging and handling within the QRE facility is not considered).

In outline the transport process involves loading the drums onto road vehicles at QRE, road transport to a suitable jetty for transfer to sea vessel (at location currently not identified), sea transfer to Siu A Chau, off-loading at Siu A Chau to transfer shuttle, and short road transfer from the jetty into the LRWF road bay.

The potential scenarios identified are:

- a dropped load incident during transfer onto and between transportation
- a transportation accident (either on road or at sea).

Dropped Load Incident

Each drum will need to be:

- lifted onto road transport at QRE
- lifted from road transport at Mainland/Hong Kong Island jetty either directly onto sea transport by a single lift, or indirectly by being lifted from road transport onto the dockside/jetty and subsequently onto sea transport
- lifted from sea transport at Siu A Chau onto a transport shuttle again either directly or indirectly

Pessimistically therefore each drum is likely to undergo 5 no. lifts, and as there is expected to be approximately 200 drums in total, a total of 1000 drum lifts can be expected.

The drum is to be designed and tested to IAEA Regulations [Ref. 9] and be classified as a Type A package. These regulations require a 1.2m free drop test "onto a target so as to suffer maximum damage in respect of the safety features to be tested...". Additionally the Government has imposed more stringent requirements for the drums by requiring a 3m drop test. The IAEA Regulations also require that following the drop test the package prevents "loss or dispersal of the radioactive contents" and damage to shielding integrity should not result in more than a 20% increase in radiation level at any external surface of the package.

It is considered that lifting the drum onto and off road transport is not going to necessitate lifting above 3m and therefore the radiological risks associated with such a dropped load incident during these lifts are negligible as the containment is unlikely to be breached. This view is reinforced by the construction of the drum which contains the waste within an inner drum, which is enclosed within a 1" epoxy matrix, which itself is contained within an outer drum.

Arrangements for lifting the drum onto and off sea transport are not, at present, determined. It is not therefore possible to determine whether this will necessitate lifting the drum above 3m. However, it is considered unlikely that this height will be significantly exceeded, thus reducing the probability of a significant breach of containment. It is also noted that it would be good practice to limit the lift height to 3m if feasible although this may not be possible due to tidal effects.

There will be approximately 400 lifts of this nature to transfer waste from QRE to Siu A Chau. (200 at the Mainland/Hong Kong Island and 200 at Siu A Chau). Without details of the lifting device it is not possible to assess the probability of this incident occurring. It is, in any case, considered that data are likely to be unavailable and will also be influenced by human error (eg. error attaching lifting device to drum). However it is not considered unreasonable that 400 lifting operations occur without incident. In addition

for it to be likely that a breach of containment to occur, any failure must occur during the portion of the lift above 3m further reducing the possibility of this event.

The consequences of such a dropped incident will depend on where the drum lands after being dropped. If the drum lands on the jetty, and a breach of containment does occur, the waste could potentially spill out. However since these drums will only contain solid waste, significant dispersion is unlikely to occur and recovery from the incident would be a relatively straightforward operation. Since the drums are not designed to provide significant gamma shielding, additional external dose to workers will effectively be related to the time required to recover from the incident and can be minimised by the methods used if necessary. On the basis of the dose rates currently observed at QRE it is considered likely that this can be achieved within recommended dose limits. The potential also exists for airborne dispersion although this will depend on the type of waste in the drum and the prevailing weather conditions.

A review of the waste arisings shows Pm-147 and Th-232 to be the two most common radionuclides accounting for over 60% of the waste at QRE. As the greater, albeit low, risk therefore exists for an incident involving these radionuclides this assessment considers the consequence of such an incident.

A review of Pm-147 wastes suggest it comprises mainly watch dials although there is also a small amount of dismantled incinerator parts and incinerator ash. It is considered that contaminated ash presents the greatest potential for dispersion although the quantities of this are small (approx. 0.5 m^3), say equivalent to only about 2 drums out of 200. However even if such an incident did occur, a calculation [Ref. 14] suggests that workers should not exceed ALI (Inhalation) and the risk to the public would be below the BSO for the lowest dose uptake band for the public (see Section 5.3.4).

A review of Th-232 waste arisings indicates the majority to be gas mantles with a small amount of thorium nitrate crystals. Making some assumptions it is estimated that, in order not to exceed occupational worker ALI (Inhalation) less than 0.02g of Th-232 should be inhaled in the incident under consideration. It is difficult to assess whether this is likely because the dispersion is unknown and will depend amongst other things on the nature of the accident and weather conditions. However at this stage it has been assumed that there is a 10^{-1} risk a worker would inhale this amount and 10^{-2} risk a member of the public would inhale this amount. (Note - these risk levels are only the risk of inhaling greater than 0.02g and do not include the risk of the accident occurring). A calculation [Ref. 15] suggests that based on these assumptions that the incident is likely to meet the BSL.

If a drum landed on the boat a similar scenario exists to that described for a jetty above except that damage to the boat may also occur. Depending on the boat design the impact of the drum could cause damage to the boat resulting in ingress of water, thereby resulting in release of material to the marine environment. The consequences of the release of material to the marine environment are considered in the following paragraphs.

It is also possible to identify a scenario where a dropped drum falls into the sea, although it is considered that this is only likely to occur in a minority of accidents as it is probably that when the drum is being transferred onto the boat it will normally be either over the jetty or the boat.

If a drum was to be dropped or to fall into the sea it can be argued that it may be less likely to suffer a breach of containment because of the greater cushioning effect of landing on water. However, the consequences of a drum being dropped in the sea are realistically at this time unknown in terms of whether the drum will break containment, and whether it will float or sink. For this assessment a worst case scenario is initially considered involving breach of the drum containment and the contents of the drum being released to the marine environment. Calculations [Refs. 14, 15] suggest release of Th-232 to result in the 'worst' consequences due to the low ALI for this material.

It can be seen [Ref. 16], that under the assumptions made, that release of a drum's contents to sea would exceed the Hong Kong Government guideline of a monthly limit of 10 x ALI for normal discharges. However since this limit applies to normal rather than unplanned releases, and because it does not directly consider the consequences of the event, this in itself is not considered unacceptable. However it does suggest further evaluation is justified.

For workers therefore a comparison has been made with the circumstances that could lead to activity being ingested equivalent to 1 ALI and a comparison has also been made against the BSL and BSO outlined in Section 5.3.4. For members of the public comparison has been made against BSL and BSO standards.

Routes of dose uptake from this incident to workers or members of the public as a result of this incident are not easy to identify as the waste is assumed to become dispersed in sea water. (If dispersion does not occur, ie waste stays in the drum, or near the drum, recovery can be considered).

For workers it is assumed that the incident also involves a worker falling into the sea and accidentally ingesting sea water. Calculation [Ref. 16] shows that if it is assumed that a worker ingests 10 cm^3 of water and all the activity was released from a drum of Th-232, and if dispersion into 70 m^3 of water occurred a worker would not ingest more than 1 ALI.

It is suggested that dispersion into approximately the equivalent of a 4m x 4m x 4m cube of water is not unreasonable. The risk of death eventually resulting to the worker (from radiological consequences) is about 10^{-6} [Ref. 16] which is consistent with BSO.

For members of the public, the pathways for activity to reach members of the public is unknown. However, calculation [Ref. 16] shows that assuming by the time the activity reaches a member of the public it has dispersed into 10^6 m^3 of water (a cube of water 100m x 100m x 100m), the dose uptake to the public is < 0.002 mSv and is therefore regarded as insignificant.

Calculations [Ref. 21] indicate the consequences of this incident due to Pm-147 to be less than that from Th-232.

Road/Sea Transportation Incident

Storage drums will be transported by road from QRE to a suitable jetty/dock on Hong Kong Island or the Hong Kong Mainland for transfer onto a sea-going vessel. The drums will then be transported by sea to Siu A Chau, and subsequently a short distance from a jetty on Siu A Chau to the LRWF. It is not known at this time how many storage

drums will be transported together in a single consignment.

As noted earlier in Section 5.6.1.1 the storage drums are to be designed and tested as an IAEA Type A package in order to ensure their suitability for normal transport conditions. However, this would not necessarily mean that a drum would maintain containment in a transport accident, particularly a severe one. However it should be noted that the drums will also be transported in accordance with the IAEA Regulations, which experience has shown ensures a high degree of safety [Ref. 9]. A review of Pm-147 and Th-232 waste to be transported [Ref. 17] confirms the activity of these wastes will be within the limits required for transportation in a Type A package. Both road and sea accidents are however briefly assessed below.

Road Accident

A total of 200 drums are to be transported. Although the location of transfer to sea-going vessel at Hong Kong Island/Hong Kong Mainland is unknown, it is considered unlikely that it will be necessary to transport the drums more than 20 miles by road. The distance of transport on Siu A Chau is estimated to be less than 200m and in addition it is worth noting that on Siu A Chau there will be no other road traffic.

Pessimistically (in terms of the risk of a road accident occurring) if it is assumed each drum is transported singly then a total of 200 journeys would be made giving a total of approximately 4000 miles of road transport. It is considered not unreasonable that this distance be covered without accident, particularly so when it is considered that the accident must be of such severity as to damage the containment of a drum.

If containment of the drum was compromised, the potential exists for waste to spill out, but as noted earlier in Section 5.6.1.1, since the waste is solid significant dispersion is not expected and recovery would be relatively straightforward. The potential would also exist for some airborne dispersion and the consequences of this are considered in outline below.

It is difficult to assess accurately the risk of a road accident that will result in damage to the containment of the drum. However, as a benchmark the risk of dying in a road accident (in the UK) is approximately 1×10^{-4}/yr, and assuming an annual mileage of 10,000 miles/yr, this gives a risk of death of approximately 1×10^{-8}/mile. It is assumed that the risk of accident occurring of such severity to breach the containment of a drum is, say, 10 times greater than the risk of death. Again Pm-147 and Th-232 wastes have been considered as they are the most common.

For Pm-147, a quasi-assessment has been made of the consequences from inhaling the equivalent of 1 ALI (Inhalation), even though this does not appear credible and is therefore pessimistic. For both workers and members of the public the risk appears to be approximately near the BSO [Ref. 18] and this is considered acceptable especially considering the pessimistic assumptions made.

For Th-232, the risk and consequences of inhaling the equivalent of 1 ALI (Inhalation) have been assessed [Ref. 19]. This suggests the risks to both workers and public around or below BSO levels, which at this stage of assessment this is regarded as acceptable.

Sea Accident

Assuming pessimistically (in terms of risk of an accident occurring) that each drum is transported separately a total of 4000 miles would also need to be travelled by sea (assuming 20 miles per journey). Again it is considered not unreasonable that this distance be covered without accident. Data on the probability of a sea accident in Hong Kong waters is not known to be available.

The consequences of a sea accident are somewhat different from a road accident. It is possible under "worst case", albeit unlikely, scenario that the drum and/or waste may enter the sea, the consequences of which would be similar to those described for a dropped load into sea incident described earlier.

The risk from Pm-147 and Th-232 is near the BSO [Refs. 22, 23] and it is suggested therefore this is acceptable.

5.6.1.2 Incidents Inside the LRWF

Once a storage drum is received at the LRWF it will be off-loaded from the road vehicle within the road bay of the facility, monitored for external radiation and contamination, and placed into a specified location for long term storage. Appropriate data will then be logged into the LRWF inventory system.

The potential hazardous scenarios identified are:

- a dropped load incident
- excess external radiation/contamination detected on the drum

Dropped Load Incident

Each drum will need to be:

- lifted off road transport within the road bay
- lifted into its storage position

As stacking the drum more than two high is not being considered, it will not be necessary to lift the drum above 3m anywhere within the facility. Given the drum height of approximately 1m, and allowing a clearance of 0.2m suggests that the maximum drum handling height of 2.2m within the storage vault. It is considered this height will also be sufficient for off-loading the storage drums from the transport vehicle. As noted in Section 5.6.1.1, the drum will have been drop tested to 3m. It is therefore considered unlikely that the drum containment would be breached in the event of a dropped load incident. It is also noted that the completed storage drum comprises inner drum, epoxy lining, and outer drum all of which would need to fail in order for waste to be released. Furthermore, even if the drum containment was breached it is considered that the impact to workers would be no more significant than the dropped load incident identified in Section 5.6.1.1, and that since the waste is solid, recovery would be a relatively straight-forward matter.

It is also possible that the storage drum will be transported over other drums when being manoeuvred into its storage location within the vault and therefore the possibility exists for damage to drums already in situ as a result of a drum falling onto them. It is planned that drums will be lifted over other drums at a minimum height commensurate with safe

handling. The drum is therefore only likely to drop a short distance, estimated to be 0.2m, which because drums are designed to withstand a 3m drop test, and furthermore are subject to a penetration test under IAEA regulations, is considered unlikely to result in breach of containment. Since breach of containment is unlikely and consequences will be similar to those identified in Section 5.6.1.1, this event is not considered further.

It is also noted that dose uptake to the public is likely to be less than that from a dropped load incident external to the LRWF, and that the majority of any contamination released will be retained within the building.

Excess External Radiation/Contamination

Radiation

Drums will be monitored for external radiation before dispatch from waste consignors and monitored on receipt at the LRWF. Two possible causes have been identified that could result in highe than expected radiation levels:

(a) Procedural Failure (radiation levels not correctly measured at waste consigning plant)

As the storage drum will be monitored on arrival at the LRWF this is likely to be identified at this time. However higher than anticipated radiation levels would have been experienced by workers and possibly public during transit. This is not considered significant because the radiation levels of waste at present in QRE [Ref. 24], are considered not to be at such a level that IAEA Regulations would be exceeded.

(b) Damage to drum (the drum is damaged during transit and as a result radiation levels increase)

As the drum does not provide significant gamma shielding it is considered that damage that is sufficient to result in any significant increase in radiation levels will be identified at this time of the incident. Minor damage to the drum is considered to result in insignificant increases in radiation levels.

Contamination

Drums will be monitored for external contamination before despatch from waste consignors and again monitored on receipt at the LRWF. The possible causes of high contamination are:

(a) Procedural Failure (contamination levels were high leaving the consigning plant)

As the storage drum will be monitored on arrival at the LRWF this failure should be detected before handling within the LRWF. However, equipment and personnel in contact with the storage drum would, potentially have become contaminated, and therefore a programme of monitoring and decontamination (if necessary) would be required.

(b) Damage to/leak from drum (the drum is damaged or leaks during transit)

Serious damage is likely to be spotted by operators at the time of the incident. Unnoticed damage or an unknown leak would lead to the same consequence and mitigating actions as described immediately above under 'Procedural Failure'.

5.6.2 Loss of Package Containment

As well as receiving storage drums, the LRWF will receive packages containing future arisings of waste. The design of the packages has not, at this time, been determined. However, it is planned that all packages will meet the requirements of the IAEA Transport Regulations. As far as can be identified at this stage therefore the transportation process and hazards identified are the same as those identified for a storage drum described in Section 5.6.

The majority (in volume terms) of the waste to be transported is predicted to be Pm-147, in the form of sealed sources. Waste packages will generally be smaller (in volume terms) than drums. Some sealed sources may contain significantly higher radioactive content, but it is noted that the 'sealed' source will limit dispersion of radioactivity.

5.6.2.1 Accidents External to the LRWF

For this assessment it is assumed that approximately 20 packages per year containing radioactive material could require transportation to the LRWF. Assuming the distance covered as outlined in Section 5.6.1, this will involve road transport of some 400 miles/yr and sea transport also of some 400 miles/year. Assuming the same risk rate as identified in Section 5.6.1.1, this gives the risk of an accident on a road of 4×10^{-5}/yr [Ref. 20]. The same rate is assumed for sea transport.

The most common routine arising is Pm-147. Since it is envisaged that this waste will be transported in smaller packages than storage drums (and therefore will contain less activity), and there are significantly fewer journeys per year the overall risks and hazards are considered less than that identified in Section 5.6.1 and have therefore not been considered further. It is not appropriate to consider Th-232 wastes as these are not expected to arise routinely to the LRWF.

Other waste transported will be miscellaneous items and the arrival of 'one-off' arisings. An assessment of miscellaneous items has not been carried out at this stage as they occur with a low frequency. The 'one-off' arisings identified have a greater range of activity content. Due to the current uncertainty regarding wastes that are likely to arise and the nature of the package, the diverse range of materials under consideration, and the arrangements that will cover such transfer it is considered that a meaningful assessment cannot be performed at this time. However, it is noted that it is possible to conceive of hazards and consequences that may be different from routine wastes, for example damage to shielded packaging could result in significant direct radiation dose. It is also noted that if the activity content of certain 'one-off' arisings is significantly higher than 'routine' arisings, this could potentially have more serious consequences. In mitigation it is noted that 'one-off' items are sealed sources and will be less liable to dispersion under accident scenarios, particularly if they meet the requirements of 'special form' material as defined by the IAEA Regulations.

For these reasons it is recommended that transport of these wastes is addressed by the DBO Contractor during the design phase. If necessary, to limit the assessment to

reasonable bounds, a number of 'model' sources can be considered for assessment purposes.

5.6.2.2 Incidents Within the LRWF

Once a package is received at the LRWF it will normally be unloaded from the road vehicle within the road bay, and lifted into the processing area for the waste to be repackaged into storage drums. Operations in the waste processing area other than loss of containment of the package are considered in Sections 5.6.7 and 5.6.8. Certain packages containing "high activity" sealed sources may be placed directly into the storage vault without repackaging (that is, in the original shielded package).

The main hazard identified relates to dropping a package or release of material such as through spillage. As noted in Section 5.6.2.1, all packages are expected to meet the requirements of the IAEA Transport Regulations and therefore should have been proven to retain containment and suffer only limited loss of shielding integrity under normal handling conditions.

Routine arisings of waste are for this assessment assumed to be typified by Pm-147 for the reasons outlined in Section 5.6.2.1. For the same reasons as outlined in Section 5.6.1.2, accidental release of material due to dropping a closed package is not considered to result in an unacceptable hazard.

It is noted that packages will be opened within the waste processing area, arguably increasing the risk of an unplanned release. The arrangements for opening and repackaging waste are not yet fully defined and it is not therefore practicable to conduct a meaningful hazard analysis. However it is noted that the waste is likely to be repacked under controlled conditions, such as in a fume cupboard, to provide protection to the operators. It is also considered that the spillage of waste, for whatever reason (currently undefined), is unlikely to result in more significant consequences (in terms of dose and inhalation to a worker) than a dropped load incident described earlier in Section 5.6.1.2 Therefore it is considered that if sufficient engineering and procedural controls are provided to ensure the risk of the event occurring is sufficiently low, the consequences are likely to be considered to be acceptable.

Any spillage of waste within the LRWF is considered unlikely to significantly affect members of the public since waste will still be contained within the building, and the consequences are therefore considered likely to be less than similar incidents occurring outside the LRWF.

It is currently envisaged that 'high activity' wastes will not be repackaged.

The consequences of dropping a completed storage drum containing repackaged waste are also as considered in earlier sections.

5.6.3 Building Services Failure

As noted in Section 5.3, a design principle of the LRWF is that the facility should be "intrinsically passive safe" such that interruption of any service connection(s) at any time, for a period of a few days, will not lead to any significant danger to persons or have a significant long term adverse effect on the condition of the stored waste or its container.

A preliminary evaluation of the design parameters needed to meet this requirement are discussed below.

It is expected that the LRWF will be provided with the following building services/utilities:

- Electrical Supply
- Potable Water
- Environmental Monitoring (Radiological)
- Drainage (active liquids)
- Ventilation
- Communications
- Fire Detection & Suppression
- Security

Failure of each of these services is considered below.

5.6.3.1 Electrical Supply

Failure of electrical supply will affect all powered items/equipment. The consequence of resultant failures of other building services as a result of power failure or other reasons are generically discussed in the Sections 5.6.3.3, 5.6.3.4, 5.6.3.6, 5.6.3.7 and 5.6.3.8. 'Direct' consequences of power failure are considered below.

Lighting

Following failure of lighting, it will be necessary, to ensure operators/visitors can safely find their way to a suitable area. Provision of emergency lighting to enable escape is therefore recommended. No radiological consequences have been identified as the result of failure of lighting.

Powered Process Equipment

Any process equipment operating at the time of power failure will cease operation. Typically equipment affected will be the crane, powered trolleys, powered grabs, powered doors etc. This equipment has not at this stage been designed but it is recommended that the design of such equipment takes into account power failure (and restart) such that safe conditions prevail, eg. cranes retain their loads securely. In general this is likely to mean that equipment stops and retains its current position, although a detailed assessment will be required.

5.6.3.2 Potable Water

No significant hazardous conditions have been identified as a result of failure of potable water systems. Plant safety does not depend on such supplies.

5.6.3.3 Environmental Monitoring (Radiological)

Failure of radiological monitoring equipment will not in itself create a hazard. However, since the main function of this equipment is to warn operators of hazardous situations or record radiological releases, it is suggested that a plant wide failure would necessitate

ceasing operations.

5.6.3.4 Drainage (active liquid)

It is envisaged that discharge of 'active' liquid arisings to sea will be by pumped system to prevent accidental release of contaminated effluent. On failure the pump will stop, resulting in the discharge also stopping. No hazards have been identified with this event although it is suggested the potential for a syphon effect is considered. It is suggested however that during power restart, following a power failure, that it should be necessary to positively restart the release.

Consideration will be required in the design phase to minimise the potential for overfilling the monitoring tank. It is noted however that it is expected the monitoring tank will be contained within a bund to prevent accidental release of materials in this event.

5.6.3.5 Ventilation

During power failure, the ventilation system will stop. It is noted that a design principal of the LRWF will be that it should be 'intrinsically passive safe' and therefore the ventilation plant design should ensure this event does not cause a significant hazard.

It is known that certain wastes can give rise to gaseous daughter products, and during failure of the ventilation system, the potential exists for there to be a build up of these gases. It is considered that the build up likely over a period of a few days will be insignificant as the primary wastes generating gaseous daughters will be within sealed drums. It is recommended this is reviewed during the final safety assessment.

5.6.3.6 Communications

It is expected that key plant data will be relayed to a Remote Monitoring Centre [Ref. 10]. It is expected this will include alarm data on security, fire detection, and if necessary radiological monitoring. As the communication centre provides monitoring rather than control capabilities, failure of this link alone will not cause any significant hazard

5.6.3.7 Fire Detection & Suppressions

Fire Hazards, Detection and Suppression are specifically addressed in Section 5.6.4.

5.6.3.8 Security

Failure of the security system will not cause any significant hazard. The significance of the failure of the security system, to detect, or prevent entry, of intruders will depend on the actions of the intruders once inside the LRWF. Since, during unmanned periods, all waste is expected to be within storage drums or packages, it is noted that release of material would require deliberate malicious action.

5.6.4 Fire

Two sources of fire need to be considered:

- a fire starting within the building
- a fire starting external to the building

In both cases, because of the remote location of Siu A Chau, it must be considered that there is likely to be some considerable time lapse before the arrival of any support fire fighting services. Prompt assistance from emergency fire crews cannot therefore be assumed.

5.6.4.1 Fire Within the Building

In considering fire requirements there are a number of aspects that should be considered including; fire loading of the building and contents, ignition sources, risk and consequences of a fire.

The wastes stored within the building will comprise both non-combustible and combustible wastes. A schedule of projected waste arisings is given in [Ref. 10]. Waste will be stored either within sealed storage drums or in dedicated packages except when being repackaged when loose waste, in small quantities, will be present in the waste processing area.

The building materials have not, at this stage been selected. However, it is recommended that as far as practicable building construction materials with a low fire risk should be selected.

Consideration will also need to be given to the storage of pressurised gas cylinders within the LRWF.

The operations management of the LRWF will also be required to ensure good housekeeping measures to minimise risk from loose waste and flammable materials held at the facility (such as oil or greases).

The aim will be to reduce sources of ignition which have been identified as:

- human
- electrical
- mechanical

Human

Smoking will be prohibited throughout the LRWF for both workers and visitors.

Maintenance activities may occasionally necessitate hot work processes such as welding. It is planned that suitable systems of work be employed to control such processes and that suitable precautions be taken, including provision of portable fire suppression devices.

Electrical

To reduce the potential for ignition sources to develop as a result of electrical distribution systems, all cabling should be conservatively sized for the maximum envisaged load to help ensure that overloading and subsequent heating is unlikely. Power cables should be overload and fire protected as necessary.

Mechanical Heating

There will be some equipment that has the potential to provide ignition sources through for example friction induced sparking (for instance, fan drives). However, in general, good mechanical design and maintenance coupled with limited combustible material local to the equipment should limit potential ignition sources.

At the current stage of development a meaningful assessment of the risk of fire cannot be achieved as neither the fire detection nor suppression system design is known. It is recommended that an assessment of the risk and consequences of fire should form part of the main safety assessment. This assessment should analyse the potential for fire initiation and growth, determine the need for any necessary segregation and boundaries to limit the spread of fire and review the capability of fire detection and suppression systems. It is noted that a fire, if allowed to develop unchecked, could result in a significant release of activity, and given the remote location of the LRWF it is recommended this subject should be given close attention.

It is noted that the majority of waste at any one time will be contained within storage drums or packages and these may delay ignition or growth of fire. However, it is also noted that storage drums are sealed and contain epoxy (which according to the manufacturer's data sheet is flammable material). The consequences of fire on drums and packages clearly therefore needs to be considered.

Fire Detection

A suitable fire detection system will be required within the LRWF.

Ventilation System Response

The ventilation system should be designed to limit the spread of fire, fumes and smoke in the LRWF, and minimise the spread of contamination. The ventilation system will therefore be deemed to respond appropriately in the case of fire to meet the above aims. As such it is expected that the ventilation system will be linked to the fire detection system.

Fire Suppression

Suitable fire suppression will be provided taking into account the potential for, and significance of, a fire. The fact that prompt assistance from emergency services is unlikely shall also be taken into account. The consequence of the initiation and release of fire suppressant (such as water or gas) shall be considered. The source of fire fighting water will also need consideration.

Fire Escape

Suitable fire escape routes for personnel will be provided.

Fire Panel

It is envisaged that a fire panel will be provided at the main entrance to the building.

5.6.4.2 Fires External to the LRWF

It is known that hill fires can, and do, occur within Hong Kong, although it is noted that these seem less prevalent on Siu A Chau, see Section 2.4.1. The potential for a fire external to the LRWF affecting the facility should be considered during the design of the LRWF. Traditionally fire detection and suppressions systems cover only the internal area of buildings, and under this arrangement an external fire may have the potential to 'get hold' of the building before internal detection suppression systems activate. It is noted that the LRWF is surrounded by grassland rather than significant shrub or tree growth, and that this may limit the severity of any fire occurring near the facility. It is also noted that the use of fire resistant, or low fire risk materials on the external face of the facility can limit the risk. However, it is recommended external fires are considered during the main safety assessment and consideration be given to mitigating features, including a fire break.

5.6.5 External Hazards (except seismic)

The external hazards identified are:

- extreme weather
- external impacts

5.6.5.1 Extreme Weather

The frequency and expected consequences of extreme weather conditions, including extreme high and low temperatures, extreme rainfall, and extreme winds will be assessed and the design of the LRWF should ensure that the accident risk criteria set out in Section 5.3.4, are not exceeded. This assessment shall include the risk of flooding and high tidal conditions.

Combinations of extreme conditions should be considered where these reasonably may be expected to occur.

Temperature

The risk to the LRWF from high and low temperature, subject to suitable design of the facility, is considered to be very low.

Rainfall/Flooding

Extreme rainfall, could conceivably result in flooding of the facility. It is being considered that the main floor level of the LRWF may be raised to prevent ingress of flood water. It is also noted that the catchment area above the site is relatively small and run-off from

above the LRWF and the site would naturally discharge to sea (considering the current undisturbed lay of the land). Furthermore the consequences of an unplanned release of activity due to flooding, while not desirable, is considered to be limited. Most waste will be in sealed storage drums which include a one inch layer of epoxy. This should limit the potential for ingress of water except under the most severe conditions. Waste contained within packages are expected to be sealed sources. The highest risk therefore of accidental release during flooding would seem to be from contaminated surfaces, any unpacked waste, HEPA filters (depending on their location) and monitoring tank (which may be the lowest point in the building).

Sea Level

The building is to be constructed above +5m PD which is above wave attack levels.

Wind

The building should be designed to withstand extreme wind conditions that as determined by an assessment of the frequency and consequences of potential damage to the building.

5.6.5.2 External Impacts

The external hazards identified are:

- impact from vehicle (road)
- impact from air
- deliberate damage (vandalism)

Impact from Road Vehicle

There are no roads on Siu A Chau and the only potential for vehicular impact to the facility exists from the dedicated vehicle(s) handling waste drums/packages between the jetty and LRWF. The vehicle is expected to be low speed and operated by trained operators. Because of this and the infrequent use of the vehicle the risk of significant damage to the LRWF that could cause a radiological release is insignificant.

Impact from Air

The facility is not believed to be under the flight path for the current or future airport. However, planes may overfly the facility. It is considered the greatest risk, however, may be posed by a helicopter using the helipad adjacent to the LRWF. This should be assessed during the detail design stage.

Deliberate Damage

As the LRWF will not be manned the potential for vandalism/forced entry exists, with associated malicious damage and/or arson. It is planned that a security fence will surround the facility as a "first line of defence" and that the LRWF building itself will be secure, with intruder detection facilities relayed to a 24 hour manned point. It is difficult to assess the likely frequency of such events but it is considered that these measures should discourage unauthorised entry. It is noted however that due to the isolated

location of the facility, assistance could be some considerable time arriving. As most waste is contained in sealed drums or packages malicious damage would have to be quite deliberate to cause a release from this source and the greatest risk, particularly for higher activity material is likely to be to the perpetrators of the crime. Arson is likely to activate the fire suppression system.

5.6.6 Wrong Waste Delivered

The potential is considered below for waste delivered to the LRWF to be of a type that is not acceptable to the facility or to be different from that stated on the consignment certificate. The main hazards identified are:

- high radioactivity
- liquid waste
- different characteristics

Each of these is considered below:

5.6.6.1 High Radioactivity

The significance of receiving waste in storage drums of higher activity than expected is discussed in Section 5.6.1.2.

It is considered the greatest consequences of receiving waste of higher activity than expected exists with shielded packages. If an operator erroneously attempted to repack waste that had radiation levels in excess of those suitable for 'hands-on' handling, significant dose uptake could occur depending on the activity of the waste. This event should be considered during the full safety assessment and engineering controls should be incorporated into the design of the facility if justified. As a minimum it is considered a 'high radiation level alarm(s)' should be incorporated at the waste unloading station(s) within the waste processing area to give the operator immediate warning of high radiation levels.

It is noted that certain 'one-off' sealed source wastes have very high radiation levels that could lead to serious consequences if the operator was to handle them unshielded.

It is recommended gas canisters are de-pressurised before storage at the LRWF.

The design of the waste unloading station needs to cater for release of any gases accumulating during transit. It is envisaged these will be negligible.

It is understood that the contractors who are responsible for repackaging existing waste at QRE have stated that gaseous releases within a storage drum will not be hazardous.

5.6.6.2 Liquid Waste

Wastes arriving at the LRWF should all be in a solid form. However, it is possible that liquid is received due to procedural failures at the waste consignor.

It is important that liquid waste is not accidentally transported to the LRWF as:

- depending on the transport container, leakage may occur if the container is only designed for solid waste
- the LRWF is not being designed to handle liquid wastes.

It is therefore suggested that emphasis is placed on ensuring the event does not occur.

For liquid to be accidentally sent to the LRWF it is considered that the liquid itself would need to be within a container otherwise it would be evident to the waste consignor that he was sending an unacceptable waste to the LRWF. The risk of leakage during transit is therefore reduced but not eliminated. It is difficult to assess the consequences of a leak occurring but clearly the potential exists for transport vehicles, equipment and personnel to become contaminated if a leak was undetected. The significance of this would depend on the activity of the material concerned.

If a leak does not occur during transit, the liquid, or package containing liquid, is likely to be subject to repackaging activities. If the liquid phase present is not obvious it may be repackaged into a storage drum. It is suggested that the consequences of this are assessed. If it becomes apparent, the option is available (if safe) to return the waste to the waste consignor or solidify the waste by 'ad-hoc' temporary arrangements at the LRWF. This can be determined at the time of the incident.

The detail design may also need to consider the potential consequences to the operator as liquid may spill, particularly if the operator is not expecting to handle liquid waste. It is considered that this should be reviewed when the design of repackaging equipment is known.

5.6.6.3 Different Characteristics

Waste could be delivered to the LRWF either with its physical description not coinciding with the statement on the consignor certificate, or with a different isotopic/activity content.

If waste of different physical characteristics is received this will be identified during repackaging operations assuming the waste is visible to the operator. A potential hazard is that inappropriate methods are used to unload waste from its incoming packages. Assuming however the waste is of a type acceptable to the LRWF, a significant problem is unlikely to exist although a review of the potential hazards can be undertaken when detailed arrangements of waste repackaging are available. In particular the danger to operators from sharp objects should be considered.

It is envisaged that all waste entering the facility will be subject, as far as practicable, to checking to determine its isotopic content, using a gamma spectrometer. Within the capabilities of the instrument employed therefore, inaccurate manifests of waste should be identified. Significant hazardous consequences of waste being stored with its isotopic content being wrongly recorded have not been identified, provided the wastes are not fissile. (Negligible quantities of fissile material have been identified in Hong Kong). The main risks would seem to relate to any handling or disposal of the waste after storage at the LRWF.

5.6.7 Overfilling of Drum

Since waste is to be repackaged into a storage drum the potential exists for loading excess waste in a drum such that:

(a) the lid cannot be replaced
(b) the payload of the drum is exceeded

Currently no significant consequences have been identified as a result of occurrence (a). Recovery is expected to be relatively straightforward by removing excess waste.

The maximum payload of the drum is 227 kg in an available volume of 267 litres, giving an equivalent bulk density of waste of 859 kg/m^3. It is therefore conceivable that the drum could accidentally be loaded with waste in excess of its permissible payload. The consequences of this are difficult to determine at this stage but it is possible that:

- a failure could occur on the drum (for instance, the lifting lugs break off)
- a failure could occur to equipment handling or lifting the drum

Since the maximum payload is specified at 227 kg it must be assumed that the potential exists to overload the drum by weight and therefore it is considered prudent that methods should be incorporated to prevent overfilling the drum by weight. This could be achieved, for example, through use of load cells at the filling point.

The consequences of a drum failure during handling are considered in Section 5.6.1.1.

The drum-handling equipment has not yet been specified and it is therefore not possible to identify at this stage whether overfilling a drum by weight would exceed the Safe Working Load (SWL) of the handling equipment.

6 RECOMMENDED MITIGATION MEASURES (NON-RADIOLOGICAL)

6 RECOMMENDED MITIGATION MEASURES (NON-RADIOLOGICAL)

6.1 Ecology

The part of the island affected by the proposal is virtually devoid of any large trees and shrubs with the exception of *Pandanus remota* and *Phoenix hancaeana* which both seem to thrive in these exposed, thin-soil, coastal situations. The large scale planting of native (or exotic) trees is therefore not considered appropriate in this location. Rather, mitigation against the loss of the grassland and low shrub habitats should concentrate on the possible storage and reuse of the soil and turf on the site by careful stripping and on the use of native, local grass and low shrub species for the purpose of restoring the vegetation on the site. Any planting should involve the use of local, native species.

Careful consideration should be given to the engineering and design of the cut slope that would need to be formed behind the building and for the drainage facilities required. These should be sympathetic to the local environment, ecologically sensitive and the use of "shotcrete" or equivalent should be avoided. This point is of particular relevance due to the current "unspoiled" nature of the island in this area.

For the protection of marine plants and animals (including corals) in Sum Wan, the mitigating measures recommended for safeguarding water quality (see Section 6.2) will also be sufficient. Also, drilling methods resulting in the least disturbance to the seabed are recommended. The suggested method is bored piling with a small diameter of 400 to 500 mm. In addition, for mitigating potential impacts on the Chinese White Dolphin, it is recommended that the tender document specifies that construction of the jetty be curtailed from October to December.

6.2 Water Quality

Potential water quality impacts during construction will be mitigated by adoption of good site practice consistent with the EPD ProPECC Paper on Construction Site Drainage [Ref. 25], including minimisation and/or covering of exposed working areas and bunding of areas subject to run-off containing potentially polluting material (such as cement and fuel storage areas). Bunds on fuel or chemical storage areas should contain a volume of 110% of the capacity of the materials stored and should only be capable of drainage through interceptors. Drainage of site areas should not allow transport of suspended solids to inshore waters such that suspended solids increase by more than 30% above a measured baseline.

All waste water generated on site will either be treated before discharge or will be contained and removed from site for authorised disposal to sewer. EPD will need to be satisfied of the quality of any effluent before licensing any discharge.

Waste water generated during operations will either be an active stream or an in-active stream. A monitoring tank will be provided at the facility to intercept all active waste and low and high level alarms will be provided on the tank. The contents of the tank will be monitored for radioactivity prior to being pumped out or otherwise treated prior to disposal, assuming that agreement on discharge limits has been reached with EPD. Segregation of active and non-active areas will reduce the volume of potentially contaminated waste water as well as the potential for contamination.

No special mitigation measures will be required for other waste water arisings because of the very low volumes and infrequent production.

6.3 Air Quality

Apart from the obvious requirement to meet the statutory quality objectives, the measures already discussed and those presented as recommended contract clauses in Appendix B, should be sufficient to ensure maintenance of good air quality. There will therefore be no further need for mitigation measures.

6.4 Noise

The LRWF is designed to meet applicable statutory noise emission objectives, and the measures already discussed and those presented as recommended contract clauses in Appendix B, should therefore be sufficient to ensure that noise nuisance does not occur. There will be no further need for mitigation measures.

6.5 Transport

No special mitigatory measures are envisaged to be necessary because of the small volume of land and marine traffic and the infrequent nature of trips. A temporary traffic management scheme is recommended whilst the existing drummed waste is removed from the QRE tunnels and loaded onto a vehicle.

6.6 Historical and Cultural Heritage

There will be no requirement for mitigation measures to protect sites of historical or cultural importance.

6.7 Visual Amenity

6.7.1 General Criteria

The island is uninhabited and unspoiled, and mitigation measures should concentrate on ensuring a discrete approach to the design and mitigation measures. The mitigation proposals should aim to minimise the impact by drawing on natural forms and materials. An approach which sought to disguise the facility as another building form, which may be valid elsewhere would be less appropriate in this case.

6.7.2 Precise Siting: Ensuring a Smooth Fit With the Landscape

The visual impact of the proposal can be minimised by ensuring the best possible relationship between the facility and the natural landform, to achieve a "smooth fit" with the natural context. The gently sloping landform should be used to advantage. The facility will be accessed from the seaward side, at low level, and by cutting into the hillside at the lowest possible level, with respect to access and flooding requirements, it would be possible to mask the facility by it being set into the landform. At the same time, the visual impact implications of cut faces and permanent intrusions on the landscape should be minimised. Wherever possible, the landform should be re-instated around the facility, to keep visual intrusion to an absolute minimum, particularly with respect to the junction between the facility and the landform at the landward side and

flanking sides. The optimum arrangement in terms of visual impact would be to set the facility into the hillside, with the natural landform extended over and around the building, as indicated by Figure 6.1(a). This could, however, lead to condensation and ventilation problems which may be operationally difficult to overcome. If this design concept progresses further then these potential problems will be investigated at the detailed design stage.

6.7.3 Surface Finishes

The facility should be finished in materials which are consistent with the natural context. Surfaces should be non-reflective, and should be of recessive colour. One possible finish would be a green colour which is consistent with the general and mean seasonal colour of the surrounding vegetation, and which is of matt finish. However, due to seasonal changes in the background vegetation colour, the optimal finish would be natural grasses based on the species in the vicinity of the proposal. An alternative would be natural stone cladding to blend with the many exposed rock outcrops at the site.

6.7.4 Minimisation/Elimination of Secure Enclosure

The facility will need to be of secure design. Consideration should be given to the need for, and design of, a secure enclosure. Even the best of mitigation strategies would be ruined by the addition of an unsympathetic wall or fence structure. The optimal design approach would be one in which the building is secure in itself, and has no need of additional security measures.

6.7.5 Access Arrangements

The visual impact arising from the hardstanding area and jetty should be minimised wherever possible. This has implications for the design and materials specification of these elements. The hardstanding area will need to be at a relatively low level, as access will be from the sea via the jetty. It would therefore be appropriate to locate the hardstanding at the coastal side of the facility, in order to avoid any need to cut into the rising landform to create a low-level platform. The hardstanding area should be of the minimum required operating area, and of a surface finish material and colour which minimises visual impact. The best approach for the jetty would be to ensure that it is of the minimum required length, width, and structural depth, and is of elegant structural design.

6.7.6 Potential Screening Measures

There may be scope to minimise the impact of the facility by adopting screening measures. These could include soft landscaping or earth bunding. The specific site situation is such that there is minimal existing vegetation suitable for screening purposes, and subsequently the integration of dedicated soft landscaping screening would be difficult. Similarly, the general landform in the area rises gently and consistently from the coast to the saddle, making it difficult to convincingly integrate dedicated earth bund screening.

If used, then soft landscaping would be appropriate between the facility and the coastline, and also to a lesser extent at the perimeter of the facility, to soften the views from the rear and the sides. The chosen species should be based on the shrubs which already

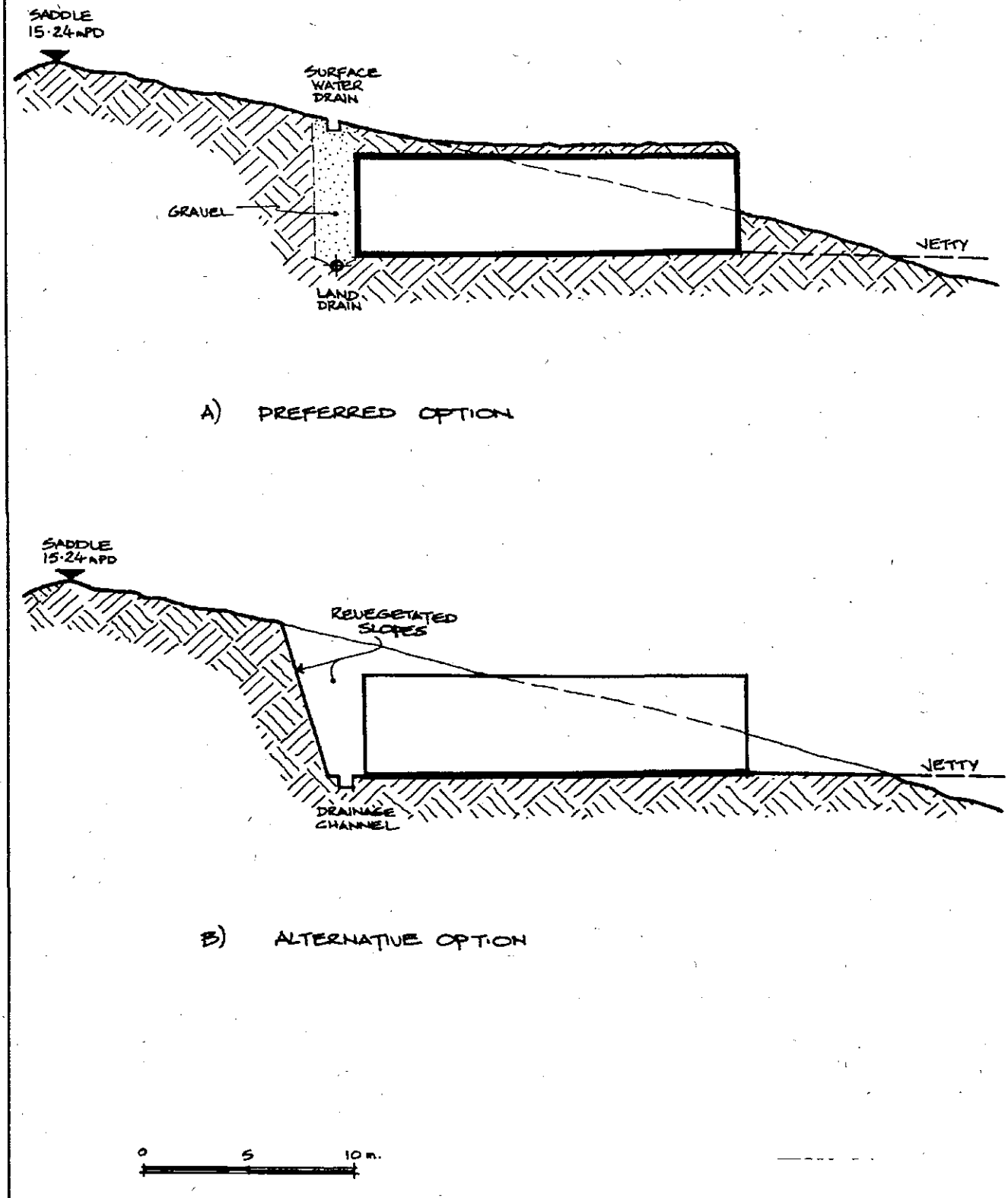

Figure 6.1 Visual Mitigation Measures: Possible Cut Slope Option

exist in the area. Earth bunding would be best located between the facility and the coastline. It should be of as natural a form as possible, including minor undulations and plan variances. The bunding could be planted with the local grass species, and could also include small areas of local shrub species and a few boulders.

It should be emphasised that the above measures could themselves be out of context and could give rise to visual intrusion. While the scope for screening may remain, the best mitigation strategy would appear initially to be based on measures to minimise the visual intrusion of the facility itself.

6.7.7 Outline Tender Approach

It would seem appropriate that the visual mitigation measures are taken forward to the tender stage by means of a "Performance Specification" rather than detailed requirements. The criteria would be based on the above recommendations, as follows;

(i) the proposal should, wherever possible, achieve a smooth fit with the natural landform,

(ii) the proposal should be finished in surface materials which are consistent with the natural environment, and should be of non-reflective finish and of appropriate colour,

(iii) the proposal should be designed in a manner which minimises or eliminates the need for a secure enclosure,

(iv) the access arrangements (hardstanding and jetty), should be designed in a manner, and should include surface materials which will minimise visual intrusion,

(v) the potential for visual screening measures should be considered, although it should be assumed that mitigation measures will depend largely on the design treatment of the facility itself, and

(vi) any innovative ideas regarding visual impact mitigation should be suggested, with a brief assessment of the benefits arising and any operational or cost implications.

6.8 Solid Waste

It will be necessary for all contaminated waste arising in the active areas of the LRWF to be monitored and assigned to either normal disposal routes or to controlled storage at the facility. The volumes of material entering the active areas will be kept to a minimum by removal of packaging prior to transfer into the active areas and only allowing essential items into such areas.

It is recommended that all solid waste that is uncontaminated be transported back to the point of embarkation for disposal via the normal refuse collection system or to licensed waste collection and disposal facilities. As this material will be removed in small quantities with each visit, there will not be any need for mitigation measures to be employed on site for storage or treatment of waste, other than provision of appropriate covered receptacles and a sufficient temporary storage area.

7 RECOMMENDED RADIOLOGICAL PROTECTION & MITIGATION MEASURES

7 RECOMMENDED RADIOLOGICAL PROTECTION & MITIGATION MEASURES

7.1 Safety & Operations Management

The purpose of this section is to describe how safety in the design, construction and operation of the LRWF will be managed and to identify the measures and procedures to be utilised by the management of the DBO Contractor and the Government to assure themselves that a diligent standard of safety is being maintained.

The aim of the safety systems will be to ensure safety of both workers and members of the public, and protection of the LRWF against damage.

The project will be carried out by a DBO Contractor who will be required to operate a Quality Programme typically in accordance with ISO9000 or equivalent.

7.1.1 Design

The main design phase of the project will be carried out by the DBO Contractor, in accordance with the Quality Programme. The Quality Programme shall include procedures relevant to the activities of the Contractor and work will be controlled in accordance with these procedures.

Where design is carried out by others (such as sub-contractors) the work shall be carried out by procedures equivalent to, and compatible with, the DBO Contractor's procedures. The design quality assurance programme shall include procedures for independent checking of safety assessment (see Section 7.1.8).

7.1.2 Supply and Construction Phase

Supply of equipment and construction will be carried out in accordance with the appropriate procedures and as detailed in the Quality Programme. For each contractor, sub-contractor or supplier an appropriate level of the quality assurance system should be identified. This classification will be based on an assessment of the importance and integrity required of the various plant items. Surveillance of sub-contractors and suppliers work will be carried out by the DBO Contractor.

On completion of the Construction Phase, and before active commissioning, the DBO Contractor will be required to provide comprehensive Operating and Maintenance Manuals. The DBO Contractor will also be required to provide 'As-Built' drawings.

7.1.3 Commissioning Phase

The DBO Contractor will be required to produce a Commissioning Plan, Commissioning Schedules and Worksheets. Commissioning will be divided into two phases:

- inactive commissioning
- active commissioning

A key aim of the inactive phase will be to prove the integrity and operability of the plant before the introduction of radioactive materials. As such, progression from inactive to active commissioning will be a 'hold point' in the project, requiring Government approval

before active materials are handled by the LRWF, and a licence from the Radiation Board to possess, transport and store radioactive materials.

7.1.4 Training

Before operating the plant, the plant operators will be required to receive supervised, on plant, instruction covering the tasks they will be required to undertake. The DBO Contractor will be required to develop a training plan outlining his training proposals.

The DBO Contractor will also be required to train Government Staff.

7.1.5 Staffing

The DBO Contractor will determine and provide staffing of the facility. The level of staffing is expected to vary with the nature of operations being carried out. However it will be a requirement that a minimum of two people be present at the LRWF when it is manned, and that sufficient staff with appropriate levels of training and skills are available to ensure that safe systems of work are adopted.

Key data that require 24-hour monitoring (such as security, alarms) will be relayed to a suitable location. This location is to be agreed upon at the detailed design stage, but it is likely that the location will be manned by a private security contractor. In the event of an incident the receiver of the monitoring information will be required to initiate suitable procedures which will include informing the DBO Contractor, who will be required to provide a 24-hour contact point, and relevant Government Officials (for instance, DH). This is described in the outline contingency plan in Section 7.2.

7.1.6 Operations

The DBO Contractor will be required to operate a Safety Management System which will cover both routine and maintenance operations. This will include provision of written instructions to operators typically including Operating Instructions, Operating Procedures, Operating Rules and Emergency Instructions. The Operating Procedures will define the level of supervision required.

Procedures will also be implemented for the reporting, investigation, and recording of accidents and incidents. These procedures will also allow the implementation and auditing of operational (and hardware) changes as a result of incidents.

A contingency plan (see Section 7.2) will be prepared that will outline actions to be taken following an unplanned incident at the LRWF resulting in the release, or potential for release, of radioactive materials.

7.1.7 Maintenance

The DBO Contractor will be required to develop a planned maintenance programme and written maintenance instructions to ensure that the plant is maintained in a safe condition.

The DBO Contractor will be required to ensure that safe systems of work are adopted during maintenance operations, and it is expected that 'Permit to Work' systems will be adopted as appropriate.

The DBO Contractor will also be required to ensure all operating, maintenance and record documentation is maintained up to date.

7.1.8 Safety Documentation Programme

The DBO Contractor will be required to prepare a detailed environmental impact and safety assessment report based on the design he develops. This will cover design, construction, commissioning and operation of the LRWF and include, as a minimum (as far as safety aspects are concerned):

- a description of the project
- process and plant description
- statements on the safety standards to be achieved
- justification of the plant from a safety viewpoint
- identification of hazards (HAZOP)
- assessment of hazards (including both planned and unplanned events)
- demonstration that the proposed design meets the required safety standards
- assessment of routine discharges
- a dose uptake assessment
- an identification of any outstanding issues
- supporting analyses and justification

Advice on the preparation of Safety Cases for Nuclear Plants is given in Reference 11.

Where identified as necessary by the safety case, mitigating features will be incorporated into the design and as such it is expected the safety case will be completed before construction commences.

The safety case will be assessed independently of the DBO Contractor by the Hong Kong Government or an independent assessor.

7.1.9 Quality Audits

During the DBO Contract, audits will be carried out by the Hong Kong Government or an independent assessor to ensure that all activities are being carried out in accordance with the appropriate procedures.

7.1.10 Records

The DBO Contractor will be required to maintain appropriate records from the design and construction phase of the project, and keep records of the operating and maintenance history of the LRWF.

An inventory database will also be maintained of all waste held in the LRWF.

7.2 Outline Contingency Plan

This section describes an outline contingency plan for actions to be taken following an accident at the LRWF that potentially involves the release of radioactive material. The plan is necessarily in outline at this stage. It is recommended that the DBO Contractor be required to prepare a comprehensive contingency plan, in conjunction with the Hong Kong Government.

Remote security monitoring of the LRWF will be undertaken on a 24-hour basis, the monitoring information being relayed to a suitable location to be agreed upon at the detailed design stage. The centre will be manned by a private security contractor or similar proposed by the DBO Contractor. The person manning the 24 hour monitoring centre is to be known as the DBO Contractor Emergency Representative (DBOER). If a modem facility is required then this will be provided, though there will clearly be a cost involved. At present there are no telephone links on Siu A Chau. The security monitoring will allow emergency action to taken in the event of fire, security breach, or detection of activity by the radiological and/or stack monitors. Three 'design base' incidents have therefore been considered:

- fire detection
- security alarm
- radiological alarm

In developing the contingency plan below it is assumed the LRWF is unmanned at the time of incident. Transport arrangements for emergencies will form part of the contingency plans to be prepared by the DBO Contractor.

7.2.1 Fire

The initiating event is assumed to be receipt of a fire alarm at the 24 hour monitoring centre. A fire could also be reported at or near the LRWF (in the latter case assuming the report is received first by the Fire Service, the Fire Service will be required to notify Marine Police). It is also assumed the extent of the fire is largely unknown and that it is not known whether the LRWF's fire suppression systems have successfully controlled and extinguished the fire.

(a) On receiving alarm/information the DBOER will notify:

- Fire Services
- Royal Hong Kong Police Force
- DH Physicist on Duty (DHPD)

(b) The Fire Services will immediately leave for the scene. The Fire Service will be equipped with suitable monitoring and protective equipment and will have been trained in the action to be taken.

(c) The DBOER and DHPD will meet the Police at a pre-arranged location and be equipped with suitable monitoring and protective equipment. Radiological monitoring and protective equipment used during the event of an incident should be provided to the relevant government departments by the DBO Contractor.

(d) Communications between all parties will be via emergency services, that is, Fire and Police.

(e) If the DBOER and DHPD team arrive at the vicinity of the LRWF first they shall await the arrival of the fire services, away from, and if possible upwind, of the LRWF. The DBOER and DHPD will make an initial assessment of the incident based on a distant viewing.

(f) If the fire services arrive first they shall approach the LRWF (on approach to the LRWF will evaluate the radiological hazards and don suitable protective clothing as determined by the Superintending Fire Officer at the scene of the incident).

(g) On approaching the scene of the incident the Superintending Fire Officer (SFO), will determine and then initiate immediate countermeasures needed to control the fire, taking into account the radiological hazards. The SFO will also report the nature and extent of the incident to the DBOER and DHPD. The DBOER and DHPD shall provide any additional advice necessary to the SFO.

(h) If the incident is serious and casualties may occur, the nearest Hospital with suitable facilities shall be warned of the event.

(i) If the incident is serious the DHPD will warn the DH Senior Officer (DHSO).

(j) Any public nearby on Siu A Chau shall be instructed to clear the area by Police. The area of evacuation being determined by the DBOER and DHPD.

(k) The Marine Police will clear the immediate area of boats/fishing vessels.

(l) Once immediate countermeasures have been undertaken, and the situation is under control the DBOER and DHPD will determine action to be taken to prevent further spread of contamination. These actions will be initiated.

(m) The DBO will then be required to develop a plan and initiate actions to make the facility safe following the incident.

7.2.1.1 Security

It is noted that a security breach will in itself not cause a release of active material.

The initiating event is assumed to be receipt of a security alarm at the DBO Contractor's 24 hour monitoring centre.

(a) On receipt of the alarm the DBOER will contact the Police.

(b) The DBOER will meet with the Police at a predetermined location. The DBOER will bring suitable monitoring equipment.

(c) The Police accompanied by the DBOER will investigate the incident. The DBOER will provide advice to the Police as necessary.

(d) Any personnel arrested as a result of the incident will be checked for contamination.

(e) The LRWF plant and equipment will be checked by the DBOER to ensure radioactive material has not been tampered with.

(f) If a release of radioactive material is suspected the DHPD shall be advised.

(g) The DBOER shall determine what mitigating actions need to be taken in case of damage to the plant. The police will provide immediate assistance.

7.2.1.2 Radiological Alarm

(a) The initiating event is assumed to be receipt of an alarm at the DBO Contractor's 24 hour monitoring centre.

(b) After confirming that the alarm is genuine, DBOER will notify the Police and DHPD.

(c) The DBOER/DHPD will enter the LRWF and determine the cause of the incident and effect mitigating actions as appropriate.

8 PROPOSED ENVIRONMENTAL MONITORING AND AUDIT

8 PROPOSED ENVIRONMENTAL MONITORING AND AUDIT

8.1 Internal Organisation of the Project Team

Figure 8.1 illustrates the proposed structure of the project management team. It is proposed that the Environmental Team (ET) reports direct to the Government to ensure complete independence from the contractor.

8.2 Internal Organisation of the Environmental Team

The ET leader should be experienced in monitoring and audit of construction work and will be supported by specialists in each area of environmental concern as well as a field monitoring team. The ET leader will report to Government on all environmental issues.

8.3 Contractual Issues

It has become increasingly clear that to exert effective control over contractors in respect of environmental issues a financial incentive to comply with the prescribed limits must be integrated into the contract. This incentive may take the form of a fixed percentage of the total contract sum, which is allocated to environmental compliance. If all the ET readings show the contractor to be in compliance with the specified TAT levels, then the contractor will receive all of the monies allocated. If partial compliance is achieved, only partial payment will be made.

How to achieve this and the exact system for allocation, however, has not yet been determined and would require substantial resources to set up. If the principle is accepted, suitable contract clauses could be devised. These clauses would define the amount of financial penalty commensurate with an amount of environmental damage by defining an appropriate relationship between number and extent of failures at each TAT level and financial penalty equivalent to loss of resource or equivalent to costs of rectifying any damage. If such a system is not implemented, then standard alternative approaches such as implementation of action plans or cessation of works will need to be invoked.

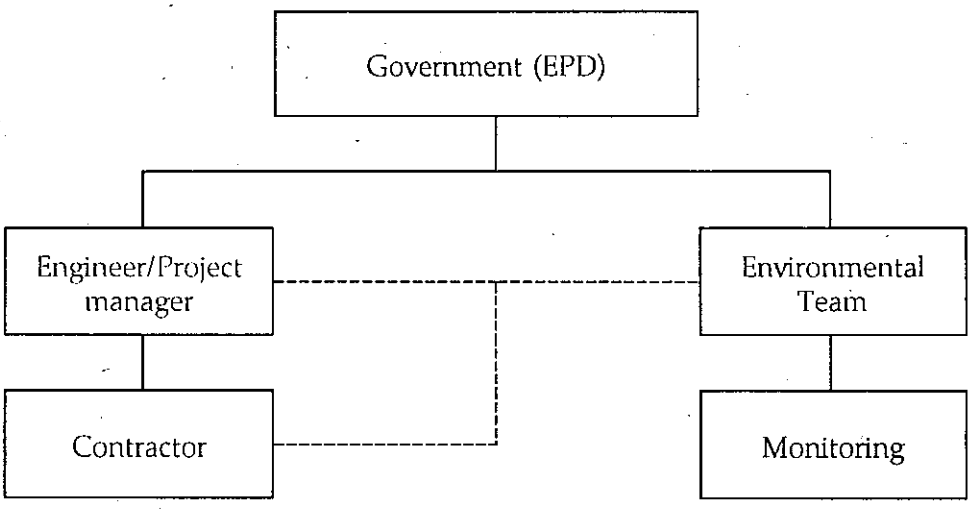

Figure 8.1 Proposed Environmental Team Organisation Chart

8.4 Proposed Environmental Monitoring and Audit (non-radiological)

The proposed methods, equipment, programme and location of monitoring are outlined in Appendix C. Also presented are the control methods and statistical comparisons which could be applied to assess the degree of compliance with the proposed standards and action plans to minimise environmental impact and prevent recurrence of exceedance of defined standards.

9 PROPOSED RADIOLOGICAL MONITORING

9 PROPOSED RADIOLOGICAL MONITORING

9.1 Monitoring within the LRWF

A description of the proposed monitoring equipment for each area/room within the LRWF is given below. This includes monitors both for personnel protection and process operations. Permanently installed and portable monitors are considered separately. Figure 9.1 provides an indicative layout showing positioning of installed monitors.

9.1.1 Installed Monitors

9.1.1.1 Road Bay

(a) Installed alarming alpha and beta-in-air particulate sampling instruments in order to provide early identification of drums or packages delivered to the LRWF that are leaking.

9.1.1.2 Storage Vault

(a) Installed area gamma monitor between road bay/vault and waste processing area/vault doors to provide operators with indication of radiation levels in the crane parking area of storage vault.

(b) Installed, alarming alpha and beta-in-air particulate monitoring to detect airborne activity in the vault area.

9.1.1.3 Waste Processing Area

(a) Installed, alarming and beta-in-air particulate sampling instrument(s) to detect high activity in air in waste processing area. Location(s) to be determined following detail design of this area.

(b) Installed beta/gamma alarm(s), located immediately at the waste unloading station(s), location to provide the operator with an immediate warning of high activity.

(c) Gamma spectrometry instrument for monitoring of both incoming packages and unpacked waste in drums.

(d) Installed alarming area gamma monitor(s) suitably located to detect high dose rates in the waste processing area.

9.1.1.4 Extract Vent Plant Room

(a) Alpha and beta stack monitor to monitor ventilation discharges.

(b) Installed, alarming alpha and beta-in-air particulate sampling instrument to detect any airborne contamination within the extract plant room.

9.1.1.5 Change Rooms

(a) Single hand monitor, wall mounted, location on 'contaminated' side of barrier to detect contamination on hands following work in waste processing area (provided in both male and female changing rooms).

(b) Installed hand monitor, together with frisking probe to check for personal contamination on clean side of changeroom (provided in both male and female changing room).

(c) Installed personnel monitor for final checking/confirmation of personnel before leaving active plant area. To be provided with entry/exit control. Common instrument on exit from for both male and female changerooms.

9.1.1.6 Portable Equipment

(a) Portable dual (alpha and beta/gamma) contamination probe(s) and ratemeter(s) for use to monitor packages/drums/vehicles in road bay and for use on clean side of changeroom.

(b) Portable doserate meter(s) to monitor packages/drums in road bay.

(c) Portable dual (alpha and beta/gamma) contamination probe(s) and ratemeter(s) for use within waste processing area, extract plant room and monitoring tank room.

(d) Portable doserate meter(s) for use in waste processing area, extract plant room and monitoring tank room.

(e) Personal alarming dose rate meters to be used by personnel working in waste processing and storage vault areas.

(f) TLD's for use by operators.

(g) Personal air samplers (PAS's), for work involving potential air contamination hazards.

(h) Floor monitor.

9.1.1.7 Other Instruments

In addition to the above instruments the following will be required to support the LRWF operation. For certain of this equipment it may be possible for the LRWF to utilise equipment at other locations in Hong Kong.

(a) TLD Reader.

(b) Filter paper counter and scanner for filter papers from PAS.

(c) Alpha and beta spectrometer system to analyse samples of liquid effluent, PAS filter papers with high counts and environmental samples.

(d) Charger for PAS's and personal dose meters.

9.1.1.8 Environmental Monitoring System

All alpha and beta/gamma-in-air monitors will be linked to a centralised environmental monitoring system (EMS) that will record and display data on the status of these monitors.

9.2 Monitoring External to the LRWF

It is envisaged that an environmental monitoring programme will be established to monitor the area local to the LRWF. This will include taking airborne, liquid and solid samples. A suggested scheme is outlined below:

9.2.1 Airborne

Passive air sampling using dry cloth samplers with collected material periodically analysed and monitored.

9.2.2 Liquids

Sea water to be sampled and analysed periodically within beach and bay area. Sea water to be sampled at various levels. This analysis also to include suspended particulates.

9.2.3 Solids

(a) Periodic vegetation sampling and analysis from around the LRWF.

(b) Periodic sampling and analysis of sea fish and other beach fauna.

(c) Periodic sampling and analysis of sediment within Sum Wan Bay. Typically samples would be obtained at low water.

The above proposals could be incorporated within the existing sampling programme in operation within Hong Kong.

It should also be noted that the above monitoring programme may require specialist equipment to perform the analyses (such as a drying furnace and liquid scintillation counter).

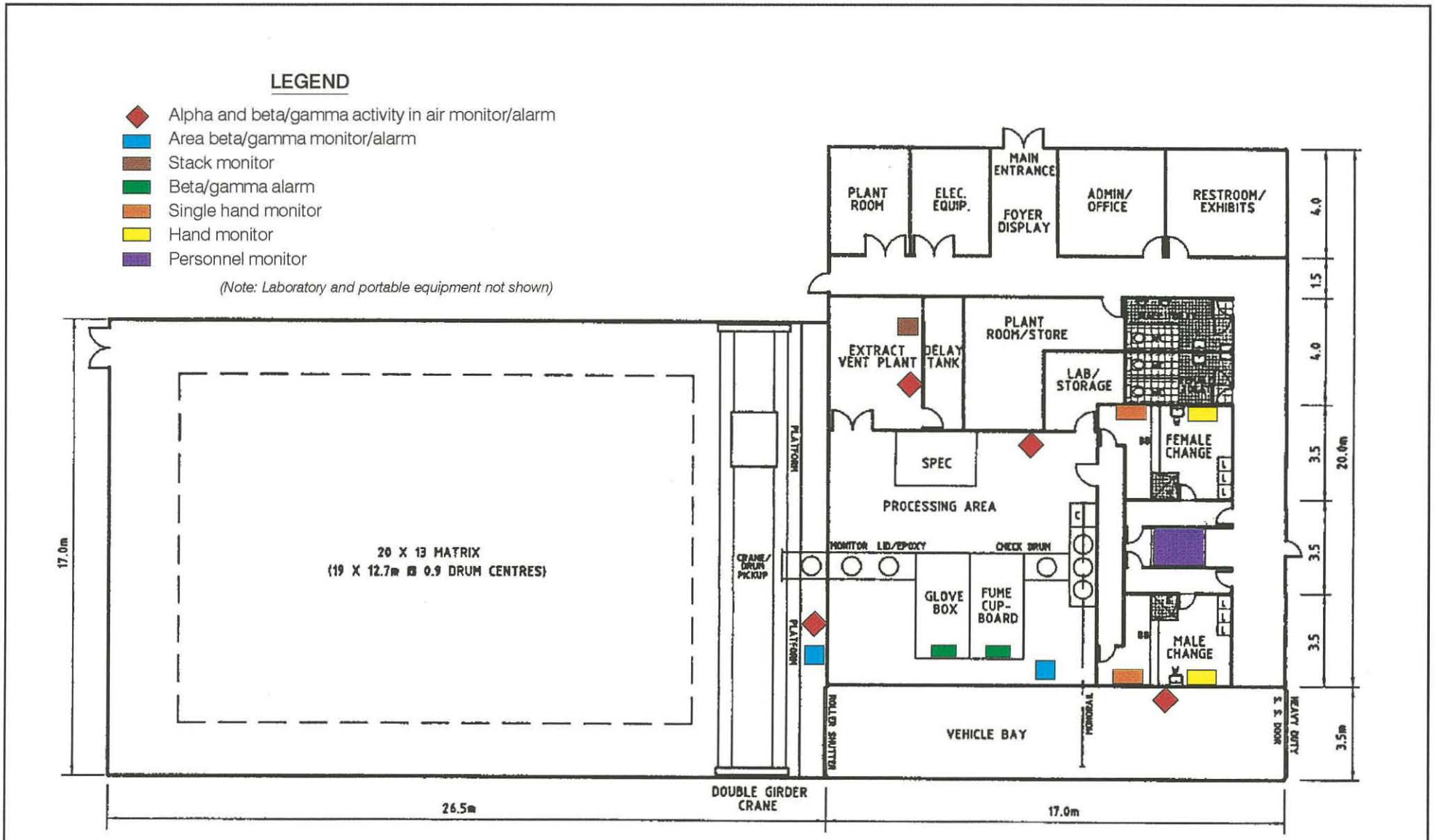

Figure 9.1 Installed Radiological Environmental Monitoring

10 CONCLUSIONS AND RECOMMENDATIONS

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Radiological Assessment

This section summarises the main points from the assessment of hazards at the LRWF. Full details are provided in the assessment in Section 5.6.

10.1.1 Normal Discharges

The preliminary dose uptake assessment indicates that dose uptake is likely to be acceptable for Years 2 onwards. Year 1 levels are within limits but above investigation limits and therefore further analysis is suggested. Assessment of internal worker dose is also suggested.

A preliminary assessment of liquid and gaseous discharges indicates they will meet current Hong Kong Guidelines and dose limits for the public.

10.1.2 Unplanned Events

A preliminary assessment of a dropped load incident and road/sea accident involving either a storage drum or Package external to the LRWF suggests the consequences to be tolerable. It is also noted that transport will be in accordance with IAEA Regulations and that these are internationally accepted as providing safe methods of transport.

It is considered unlikely that storage drum containment will be breached within the LRWF due to a dropped load incident as the drum is always expected to be below the 'drop' height.

No significant hazards have been identified as a consequence of building services failure.

It is suggested hazards from fire are further assessed, including the potential and consequences of fire started outside the LRWF. The lack of available prompt assistance is noted. It is also noted that the epoxy in the storage drum annulus is thought to be flammable. Items to be considered in fire design/assessment are noted.

It is noted that the facility should withstand extreme weather conditions, and the risk from the nearby helipad is identified as needing to be considered.

It is noted that the emphasis should be placed on consignors to ensure only waste acceptable to the LRWF is delivered to the facility. It is noted that the wrong type of waste could pose hazards during transportation and handling particularly if a liquid waste is sent. It is also noted that the consequences to an operator erroneously attempting to repack higher activity waste could be significant.

It is noted that due to the relatively low payload of the storage drum the potential exists to exceed its weight limits although a relatively simple method of protection is identified.

Finally, it should be realised this assessment has considered radiological safety. In the design of the facility the hazards from conventional operations should not be over-looked. For example the most serious consequences following a dropped load incident may be

injury to a nearby operator due to the weight of the drum rather than a radiological hazard.

10.2 Ecology

The impacts of the proposed LRWF on the terrestrial ecology are considered to be low and of local significance. When the detailed EIA is undertaken it would be desirable to include slope restoration and grassland/shrub re-establishment in the mitigation measures.

The rare Chinese White Dolphin and Black Finless Porpoise are known to utilise the waters around Siu A Chau, south Lantau and Tai A Chau. However, any impacts from the project are likely to be extremely localised. With regard to potential impacts on marine mammals, piling work for construction of the jetty is the most critical aspect. Construction of the jetty lasts only four and a half months. With careful planning, the use of the least disturbing construction methods and scheduling of the works programme to avoid critical seasons for these mammals (generally October to December) potential impacts could be reduced to low levels. It is recommended that the tender document specifies construction of the jetty be curtailed from October to December.

The possible use of the island by Green Sea Turtles has not been confirmed, but the most sensitive area is likely to be the main sand beach, which is not affected by the proposal. The shoreline of the site is lined with cobbles and is not the type of habitat conducive to egglaying by turtles.

Effect on benthic communities is short term and reversible. The area affected is localised and less than 0.03 ha. The species inhabiting sandy substrata will be adapted to disturbance and will recolonise disturbed areas rapidly. Species of rock and boulder substrata have been found to be typical of similarly exposed shallow rocky areas in Hong Kong. Although there are two types of coral in Sum Wan, they are small isolated colonies and are not of particular conservation importance. Construction methods will be specified which will be sufficient to protect most of the bay.

Because of the low level of radioactivity of any active liquid arisings, the small quantity of such arisings, the infrequent discharge (if permitted) and the short residence time of fish fry in shallow waters, the likelihood of fish fry being exposed to levels of radioactivity considerably higher than background is considered to be small. Potential for bioaccumulation and trophic transfer of radioactive substances is also considered to be very low.

With careful control on jetty construction work, it is likely that any impacts would be minimal and localised to the piling itself. After construction, the pier piles would form a colonisation surface of benefit to marine life.

Siu A Chau Island is one of the few areas, both terrestrial and marine, where habitats are not already under pressure or threat. However, the nature and small scale of the LRWF indicates that with suitable mitigation measures, these concerns may not be justified.

It can be concluded that there is no unacceptable marine ecological impact. No ecological survey is deemed necessary if the design features in this report are maintained.

10.2.1 Proposed monitoring

A detailed inventory and abundance assessment of the plant species present on the site should be collected for the purposes of record and establishing replacement vegetation. Regular monitoring should take place on the stored topsoil/turf to ensure that it is in a reasonably healthy state for reuse at the end of construction.

10.3 Water Quality

Although there is no surface fresh water at the proposed site, the water quality in Sum Wan and the surrounding marine areas is of generally high quality. This is to be expected in an area remote from the polluting influences of urbanised and industrialised or intensively farmed catchments.

Potential impacts arising during construction may include increased suspended solid matter in site run-off or organic pollution from foul effluent. As the scale of construction is not large, anticipated impacts are likely to be small. Nevertheless, some soil and rock excavation is required to create the site platform and concrete mixing and laying will occur on-site and therefore mechanisms have been recommended that will reduce the potential for impacts caused by site run-off. Similarly, means to reduce the potential for pollution from fuel spillage on site have been suggested.

During operation, there will be no adverse water quality impact when the LRWF is operated as a'dry facility'. When discharges of active liquid arisings are permitted, there will be minimal water quality impacts as discharges will be of extremely small volume and will be infrequent. The volume of dilution available in the open water off Siu A Chau is likely to be large and thus the effect of discharges will mostly not be measurable. Occasional discharges of very dilute low-level radioactive effluent, if required, should have negligible impact, but discharge limits should be assessed and set on a site-specific basis at the detailed design stage, based on the location of the discharge, the radionuclides likely to be present, possible food-chain pathways, accepted transfer factors and the dispersion characteristics of the area. A monitoring tank will be provided at the facility to intercept all active waste and low and high level alarms will be provided on the tank. The contents of the tank will be monitored for radioactivity prior to being pumped out or otherwise treated prior to disposal.

Small amounts of fuel, batteries, bottled gases and epoxy monomers are likely to be used during operations, but do not pose a significant risk to water quality if precautions are taken during handling.

10.4 Air Quality

As expected for this remote site, air quality would generally be of good quality. There are no known sensitive receivers for whom construction or operation of the LRWF may pose a problem. Nevertheless, given the pristine nature of the area, certain precautions have been recommended to minimise the discharges of materials, vapours and gases during construction and from the operational use of the facility.

Operational measures taken to protect workers in the LRWF, such as the negative pressure ventilation system (from less active to potentially most active areas), together with the use of control mechanisms including high efficiency particulate (HEPA) filters,

will reduce the potential environmental impacts to negligible levels.

10.5 Noise

Existing noise levels in the area are likely to be at very low background levels. Noise will be generated during construction work, particularly during the site preparation stage. There are, however, due to distance and natural shielding, no sensitive receivers who could be affected.

10.6 Transport

There is no existing transport infrastructure at the site. The small scale of the construction works and the consequently low volume and frequency of marine traffic employed for construction, should present no difficulties. Similarly, the operational need for delivery by sea will be very infrequent (at most perhaps daily visits in the initial month and a single visit per month thereafter) and thus effects on transport will be negligible.

Collection and delivery of waste to the LRWF is outside the scope of this assessment, however, initial collection of waste from QRE tunnels will probably require some traffic management. Delivery of future arisings will be from a variety of sources at infrequent intervals and should require no special arrangements.

10.7 Historical and Cultural Heritage

There are no listed sites of archaeological importance at the site. Similarly, there are no known grave sites or Fung Shui interest in the area. Impacts during construction and operation are therefore not likely.

10.8 Visual Amenity

The proposed site is within an area which is recognised as being a significant landscape and recreational asset and being environmentally sensitive. The area is particularly vulnerable to visual intrusion. Within this framework, the proposed site is the one identified in the Site Selection Report [Ref. 2] as being least suitable in terms of visual impact criteria. It is therefore inevitable that locally the proposal will have a significant visual impact.

Notwithstanding the above, the specific topography of Siu A Chau will largely limit the visual intrusion to the Sum Wan area and to the sea views from the south-east.

The proposal is for quite a large facility, especially compared to the small scale of the island, although the operational characteristics of the facility should allow for the incorporation of visual impact mitigation measures.

The mitigation strategy should be based upon the criteria of minimising the impact by drawing on natural forms and materials. The mitigation measures should concentrate on minimising the visual impact of the facility itself, although screening may be a possibility. The mitigation strategy should be taken forward by means of the performance specification, which identifies the relevant mitigation criteria.

While the proposal will definitely result in a notable visual impact, every effort should be made to minimise its extent. The above measures form a basis upon which this can be achieved. The computer-generated photo-montage indicates the likely visual impact that could arise from the proposal, following the above recommendations.

10.9 Solid Waste

Mechanisms to prevent the unsightly accumulation or open burning of waste during the construction phase have been recommended. With suitable control, and given the small scale of the construction works, there should be minimal potential for impacts. Similarly, generation of solid waste during operation of the LRWF should be extremely low. All such wastes should be removed from the island for suitable disposal elsewhere whenever the workforce depart from the facility on their regular visits.

10.10 Terms of Reference for the Stage 2 EISA

This report, as the Stage 1 Environmental Impact and Safety Assessment (EISA) report, deals only with the proposed outline design and is therefore only presented in sufficient detail to allow identification of significant problems and to allow for suggested mitigation measures to be incorporated into the overall design philosophy. It is clear that a Stage 2 EISA will need to be produced during the detailed design stage as the successful contractors will inevitably refine the outline design.

A number of issues require more detailed consideration and these are presented below, together with an outline of the factors to be considered in the Stage 2 EISA report.

- detailed justification and a safety case needs to be made for the particular design and operation of the LRWF which should include justification of radioactive dose uptake for both workers and members of the public under normal operation and unplanned incidents.

- recommendations, to the satisfaction of EPD, on discharge limits of radioactive liquid effluent, to enable the facility to operate as a 'wet facility'. Detailed justification and a safety case needs to be made for any discharges of radioactive effluent. Such discharge limits should be set on a site-specific basis with reference to the accepted annual limit of intake for each nuclide, the available dilution, major pathways and accepted transfer factors. It is anticipated that this could be achieved by a standard modelling approach. Discharges would be licensed by the Radiation Board.

- assessment of internal worker dose.

- hazards from fire.

- monitoring and audit during construction.

- radiological monitoring during operation.

- mitigation measures during construction:
  - jetty construction
  - slope restoration and grassland/shrub re-establishment

- as the visual aspects of the area are of critical importance, the detailed design should be pursued with sympathetic architectural consideration for integration of the LRWF into the surroundings.

- consideration should be given to detailed mechanisms, including the use of environmental performance clauses, for enforcing contract conditions during the construction and operational phases.

10.11 Release of Information to the General Public

The LRWF project has been de-classified and the public are already aware, through a press release, of the outline proposal. Members of the relevant District Board have been made aware of the preferred location of the LRWF. The current Stage 1 EISA report will serve to inform administrators within Government and decision-makers, including the District Board.

A certain amount of information has already been made public and therefore the continued flow of information is important if potential criticisms are to be avoided. Because of the very sensitive nature of the project and the widespread ignorance and generally unfounded fear of radioactivity by the general public, it is essential that correct information and education concerning the project is provided. Most projects dealing with waste, and especially radioactive waste, suffer from the so-called 'NIMBY' syndrome (Not In My Back Yard). It is inevitable that a lack of accurate information will only serve to reinforce this unwelcome situation.

It is not within the remit of an EISA report to provide advice on public awareness campaigns, nevertheless we would recommend that Government consider at an early stage:

- what information should be released (given that not all issues are easily presentable to a lay public)

- in what form information can be released (eg press release, exhibition, reports)

- how, and by whom the information would be released (a centralised response, perhaps with a dedicated telephone call-in information service)

- when information should be released (we recommend the earliest possible time, depending on the desired degree of involvement of the public in the decision making process)

Once the waste arisings review, outline design and the EISA report have been finalised, there should be sufficient information available for public presentation purposes and adequate cohesiveness in the supporting arguments to present a rational case. Because of the need to prepare good quality exhibition materials, this aspect therefore needs to be given immediate attention.

11 REFERENCES

11 REFERENCES

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APPENDIX A
LIST OF CONSULTEES

APPENDIX A
LIST OF ORGANISATIONS AND INDIVIDUALS CONTACTED.

Government Departments & Branches

Environmental Protection Department
Department of Health
Planning Department (District Planning Office, Lantau & Islands)
Government Secretariat: Planning, Environment & Lands Branch
Government Secretariat: Works Branch
Government Secretariat: Finance Branch
Architectural Services Department
City & New Territories Administration (Islands District Office)
Civil Engineering Department
Electrical & Mechanical Services Department
Lands Department (District Lands Office)
Marine Department
Fire Services Department
Agriculture & Fisheries Department
Drainage Services Department
Transport Department
Government Secretariat: Economic Services Branch
Government Secretariat: Trade & Industrial Branch
Government Secretariat: Health & Welfare Branch
Government Secretariat: Security Branch
Legal Department
Civil Aviation Department
Regional Services Department

Organisations & Individuals contacted for Information on Terrestrial & Marine Ecology

Gary Ades (bats)
Dr Mike Bascombe (butterflies)
Geoff Carey (birds)
Dr Richard Corlett (general ecology and plants)
Dr David Dudgeon (general ecology and freshwater habitats)
Hong Kong Birdwatching Society
Hong Kong Marine Conservation Society
Hong Kong Natural History Society
Michael Lau (amphibians and reptiles)
Skip Lazell (amphibians and reptiles)
Royal Asiatic Society
Swire Marine Laboratory, Hong Kong University
World Wide Fund for Nature, Hong Kong

Other Organisations

Shell Hong Kong Ltd.

APPENDIX 3
RECOMMENDED CONTRACT CLAUSES FOR PREVENTION OF POLLUTION FROM SITE WORKS

APPENDIX B
SPECIMEN POLLUTION CONTROL CONTRACT CLAUSES

B1 AVOIDANCE OF NUISANCE & POLLUTION

B1.1 The Contractor shall carry out the Works in such a manner as to minimise adverse impacts on the environment during execution of the Works.

B1.2 The Contractor shall take all reasonable precautions to avoid any nuisance arising from its operations. This should be accomplished where at all possible by suppression of the nuisance at source rather than abatement of the nuisance once generated.

B1.3 All works are to be carried out in such a manner as to cause as little inconvenience as possible to nearby residents, property and to the public in general, and the Contractor shall be held responsible for any claims which may arise from such inconvenience.

B1.4 The Contractor shall be responsible for the adequate maintenance and clearance of channels, gullies etc.

B1.5 Water shall be used to prevent dust rising and the Contractor shall take every precaution to prevent the excavated materials from entering into the drainage system.

B1.6 The Contractor shall comply with all current legislation and regulations including:

a) Noise Control Ordinance (Cap 400)

b) Air Pollution Control Ordinance (Cap 311)

c) Water Pollution Control Ordinance (Cap 358)

d) Dumping at Sea Act 1974 (Overseas Territory Order) 1975

e) Merchant Shipping (Oil Pollution) (Hong Kong) Order 1975

f) Summary Offences Ordinance (Cap 228)

g) Factories and Industrial Undertakings Ordinance (Cap 59)

h) Waste Disposal Ordinance (Cap 354)

i) Public Cleansing and Prevention of Nuisances (Regional Council) By-Laws (Cap 132)

j) Building Ordinance (Cap 123)

k) Building Ordinance (Application to New Territories) Ordinance (Cap 121)

l) Public Health and Municipal Services Ordinance (Cap 132)

m) Waste Disposal (Chemical Waste) (General) Regulation (Cap 354)

The above listed regulations (a) to (m) are not intended to be exhaustive and will not absolve the contractor of general environmental protection liabilities and responsibilities under any other regulations which are deemed to be relevant and from time to time come into effect.

B2 NOISE POLLUTION CONTROL

B2.1 The Contractor shall comply with and observe the Noise Control Ordinance and its subsidiary regulations in force in Hong Kong.

Non-Statutory Noise Control

B2.2 In addition to the requirements imposed by the Noise Control Ordinance, to control noise generated from equipment and activities for the purpose of carrying out any construction work other than percussive piling during the time period from 0700 to 1900 hours on any day not being a general holiday (including Sundays), the following requirements shall also be complied with:

(i) The noise level measured at 1 m from the most affected external facade of any noise sensitive receivers from the construction work alone during any 30 minute period shall not exceed an equivalent sound level (L_{eq}) of 75 dB(A).

Housekeeping Clauses to Promote Noise Consciousness at Site

B2.3 Before the commencement of any work, the Engineer may require the methods of working, equipment and sound-reducing measures intended to be used on the Site to be made available for inspection and approval to ensure that they are suitable for the project.

B2.4 The Contractor shall devise, arrange methods of working and carry out the Works in such a manner so as to minimise noise impacts on the surrounding environment, and shall provide experienced personnel with suitable training to ensure that these methods are implemented.

B2.5 The Contractor shall ensure that all plant and equipment to be used on site are properly maintained in good operating condition and noisy construction activities shall be effectively sound-reduced by means of silencers, mufflers, acoustic linings or shields, acoustic sheds or screens or other means to avoid disturbance to any nearby noise sensitive receivers.

B2.6 Notwithstanding the requirement set out in clause B2.2 (i) above and subject to compliance with statutory requirements, the Engineer may upon application in writing by the Contactor, allow the use of any equipment and the carrying out of any construction activities provided that he is satisfied the application is of

absolute necessity or of emergency nature, and not in contravention with the Noise Control Ordinance in any respect.

B2.7 For the purposes of the above clauses, any domestic premises, hotels, hostel, temporary housing accommodation, hospital, medical clinic, educational institution, place of public worship, library, court of law, performing arts centre or office building shall be considered a noise sensitive receiver.

B2.8 The Contractor shall, when necessary, apply as soon as possible for a construction noise permit in accordance with the Noise Control (General) Regulations, display the permit as required and copy to the Engineer. The Contractor is to note that neither the Authority nor its employees can influence the issue or terms of a construction noise permit.

B3 DUST SUPPRESSION MEASURES

B3.1 The Contractor shall undertake at all times to prevent dust nuisance as a result of his activities. Any air pollution control systems installed shall be operated whenever the plant is in operation.

B3.2 The Contractor shall at his own cost, and to the satisfaction of the Engineer, install effective dust suppression equipment and take such other measures as may be necessary to ensure that the statutory criteria are not exceeded.

B3.3 In the process of material handling, any material which has the potential to create dust shall be treated with water.

B3.4 Where dusty materials are being discharged to vehicle from a conveying system at a fixed transfer point, a three-sided roofed enclosure with a flexible curtain across the entry shall be provided. Exhaust should be provided for this enclosure and vented to a fabric filter system.

B3.5 Stockpiles of sand and aggregate greater than $20m^3$ shall be enclosed on three sides, with wall extending above the pile and 2 meters beyond the front of the pile. In addition, water sprays shall be provided and used both to dampen stored materials and when receiving raw material.

B3.6 The Contractor shall frequently clean and water open areas to minimise the fugitive dust emissions.

B3.7 The Contractor shall restrict all motorised vehicles to a maximum speed of 8km per hour and confine haulage and delivery vehicles to designated roadways inside the site. Areas of roadway longer than 100m where movement of motorised vehicles exceeds 100 vehicular movements/day or as directed by the Engineer shall be furnished with a flexible pavement surfacing.

B3.8 Permanent conveyor belts shall be fitted with windboards, and conveyor transfer points and hopper discharge areas shall be enclosed to minimise emission of dust. All conveyors carrying materials which have the potential to create dust shall be totally enclosed and fitted with belt cleaners.

B3.9 Bulk storage of cement or pulverised fuel ash shall not be permitted.

B4 CONSENT TO OPERATE EQUIPMENT AND PROCESSES

B4.1 The Contractor shall not install any furnace, boiler or other plant or equipment or use any fuel that might in any circumstance produce smoke or any other air pollution without the prior consent of the Engineer. Unless specifically instructed by the Engineer, the Contractor shall not light fires on site for the burning of debris or any other matter.

B4.2 The Contractor's attention is drawn to the Air Pollution Control Ordinance and its subsidiary legislation, particularly the Air Pollution (Furnaces, Ovens and Chimneys) (Installation and Alteration) Regulations and the Air Pollution Control (Smoke) Regulations.

B5 REMOVAL OF WASTE MATERIAL

Liquid Waste

B5.1 The Contractor shall not permit any sewage, waste water or effluent containing sand, cement, silt or any other suspended or dissolved material to flow from the site onto any adjoining land or sea or allow any waste matter or refuse to be deposited anywhere within the site or onto any adjoining land and shall have all such matter removed from the site.

B5.2 The Contractor shall be liable for any damages caused to adjoining land through his failure to comply with clause B5.1.

B5.3 The Contractor shall be responsible for temporary training, diverting or conducting of open streams or drains intercepted by any works and for reinstating these to their original courses on completion of the Works.

B5.4 The Contractor shall be responsible for adequately maintaining any existing site drainage system at all times including removal of solids in sand traps, manholes and stream beds.

B5.5 Any proposed stream course and nullah temporary diversions shall be submitted to the Engineer for agreement one month prior to such diversion works being commenced. Diversions shall be constructed to allow the water flow to discharge without overflow, erosion or washout. The area through which the temporary diversion runs is to be reinstated to its original condition or as agreed by the Engineer after the permanent drainage system has been completed.

B5.6 The Contractor shall furnish, for the Engineer's information, particulars of the Contractor's arrangements for ensuring that material from any earthworks does not wash into the drainage system. If at any time such arrangements prove to be ineffective the Contractor shall take such additional measures as the Engineer shall deem necessary and shall remove all silt which may have accumulated in the drainage system whether within the Site or not.

Solid Waste

B5.7 The Contractor shall segregate all inert construction waste material suitable for reclamation or land formation and shall dispose of such material at such public dumping area(s) as may be specified from time to time by the Director of Civil Engineering Services.

B5.8 Inert material deemed unsuitable for reclamation or land formation and all non-inert construction waste material deemed unsuitable for reclamation or land formation and all other waste material shall be disposal of at a public landfill.

B5.9 Chemical waste as defined by Schedule 1 of the Waste Regulations (Chemical 1992, should be stored in accordance with approved methods defined in the Regulations and the chemical waste disposed of at the Chemical Waste Treatment Facility located at Tsing Yi.

B5.10 The Contractor's attention is drawn to the Waste Disposal Ordinance, the Public Health the Municipal Services Ordinance and the Water Pollution Control Ordinance.

B5.11 Any dredged material shall be disposed of at an approved marine dumping ground.

B6 DISCHARGE INTO SEWERS AND DRAINS

B6.1 The Contractor shall not discharge directly or indirectly (by runoff) or cause or permit or suffer to be discharged into any channel, stream-course or sea any effluent or foul or contaminated water or cooling or hot water without the prior consent of the Engineer who may require the Contractor to provide, operate and maintain at the Contractor's own expense, within the premises or otherwise, suitable works for the treatment and disposal of such effluent or foul or contaminated or cooling or hot water. The design of such treatment works shall be submitted to the Engineer for approval not less than one month prior to the commencement of construction or as agreed by the Engineer.

B6.2 All water and other liquid waste products arising on the Site shall be collected, removed from Site via a suitable and properly designed temporary drainage system and disposed of at a location and in a manner that shall not cause either pollution or nuisance. In addition, the effluent shall comply with the standards stated in the "Technical Memorandum on Standards for Effluent discharged into Drainage and Sewerage Systems, Inland and Coastal Waters" for the appropriate Water Control Zone, whether or not the Zone has been declared as one subject to control of discharges.

B6.3 If any office, site canteen or toilet facilities are erected, foul water effluent shall be directed to a foul sewer or to a sewage treatment facility either directly or indirectly by means of pumping or other means approved by the Engineer.

B6.4 The Contractor's attention is drawn to the Buildings Ordinance, Water Pollution Control Ordinance and the Technical Memorandum "Standards for Effluent Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters" issued by EPD.

APPENDIX C
PROPOSED ENVIRONMENTAL MONITORING AND AUDIT REQUIREMENTS

APPENDIX C
PROPOSED ENVIRONMENTAL MONITORING AND AUDIT REQUIREMENTS
(Non-radiological)

C1 Levels of Monitoring

C1.1 Baseline Monitoring

Baseline monitoring of water quality and ecology before the project starts is recommended to ascertain the site area's existing conditions and for setting the trigger, action and target (TAT) levels for aquatic discharges. Monitoring of background conditions for air and noise is not necessary. The recommendations for ecological monitoring are given in Section 10.1.1.

C1.2 Compliance Monitoring

Compliance monitoring of water quality during construction should be undertaken to assess the environmental impacts caused by the project, and to facilitate prompt action if and when problems arise. Other impacts are so minor that no operational monitoring is recommended.

C2 Monitoring Schedule

The Environmental Team (ET; see section 8 of EISA report) will be responsible for undertaking both baseline and compliance monitoring and audits as outlined above. Specifics in terms of parameter, location and frequency/schedule are presented below.

C2.1 Baseline Monitoring

Air Quality

Monitoring is not required. Baseline conditions are expected to be good.

Noise

Monitoring is not required. Baseline conditions are expected to be good.

Marine Water Quality

Monitoring of temperature, dissolved oxygen (DO, in both mg/l and % saturation), optical turbidity (with suspended solids (SS) calibration) at each monitoring station labelled W shown in Figure C1. Samples are to be taken at both mid-flood and mid-ebb tides, 4 times per week for 2 weeks, respectively at 1 m below water surface, mid level, and 1 m above sea bed. At the station shown as WS, a logging water quality instrument should be deployed for the complete working day (07:00-19:00) at approximately mid-depth to measure conductivity, temperature, optical turbidity and DO at least every 5 minutes.

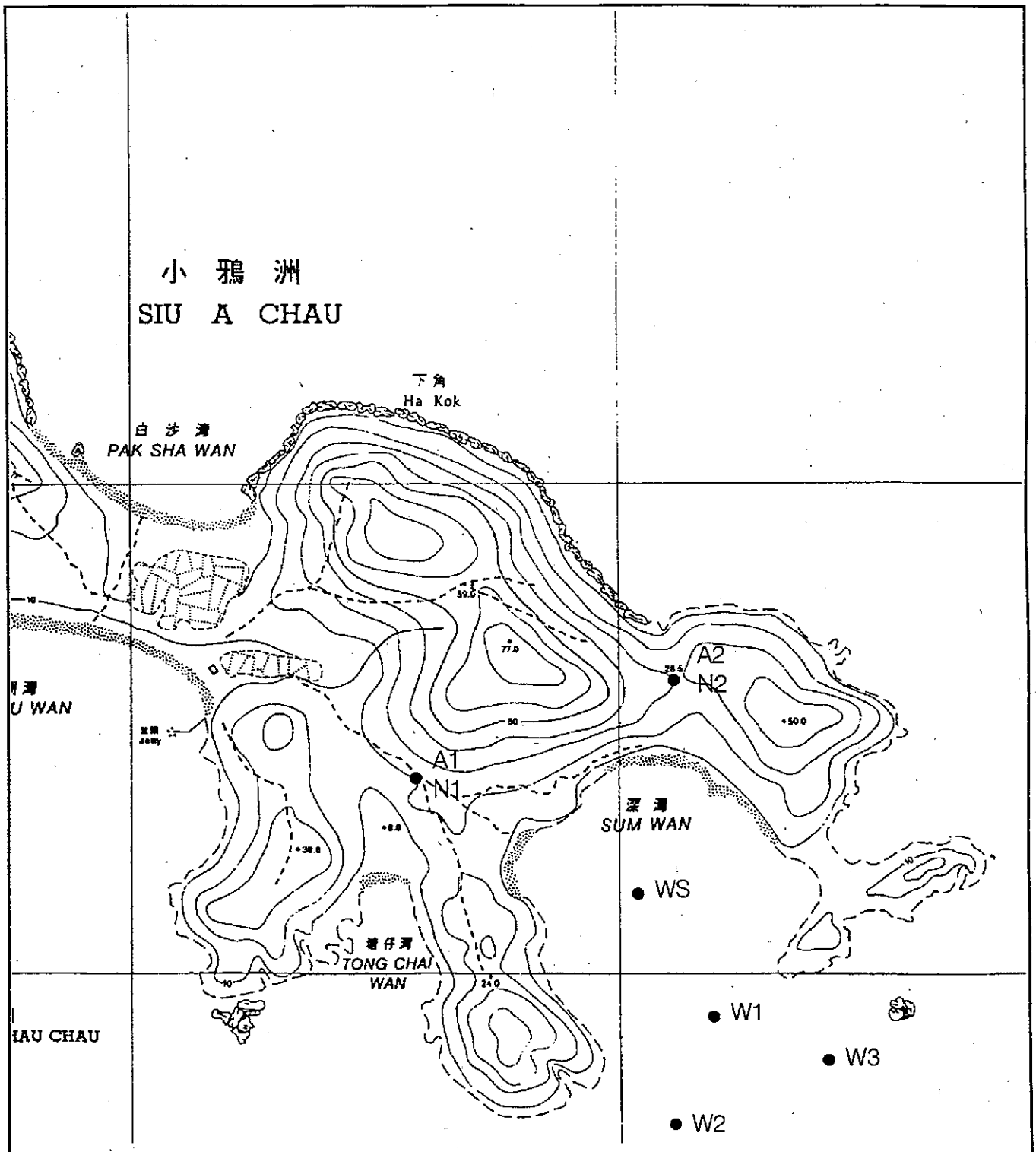

Figure C1 Proposed Sampling Locations

C2.2 Construction Phase Compliance Monitoring

Air Quality

As there are no sensitive receivers, monitoring of air quality for compliance purposes is not required, however, should EPD consider it necessary to monitor typical conditions during construction, two locations have been identified and are marked on Figure C1.

Noise

As there are no sensitive receivers, monitoring of noise for compliance purposes is not required, however, should EPD consider it necessary to monitor typical conditions during construction, two locations have been identified and are marked on Figure C1.

Marine Water Quality

Monitoring of DO, temperature, SS and turbidity at the water monitoring stations during construction of the off-loading facilities. Samples to be taken at both mid-flood and mid-ebb tides, 3 times per week at 1 m below water surface, mid level, and 1 m above sea bed, respectively. At the station shown as WS, a logging water quality instrument shall be deployed for the complete working day (07:00-19:00) at approximately mid-depth to measure conductivity, temperature, optical turbidity and dissolved oxygen at least every 5 minutes.

C2.3 Operational Phase Compliance Monitoring

Air Quality

No monitoring required.

Noise

No monitoring required.

Marine Water Quality

No monitoring required.

A summary of baseline and compliance monitoring schedule is given in Table C1

Table C1 Summary of Baseline and Compliance Monitoring Programme

Subject	Period	Parameters	Location	Frequency
Marine Water Quality	Baseline	Spot readings:DO, temperature, SS & turbidity at mid-ebb and mid-flood. Logging of conductivity, temperature, depth, SS and DO every 5 mins for 12 hours.	At W stations - 1 m below surface - mid level - 1 m above sea bed At station WS	4 times per week for 2 weeks prior to commencement of pertinent construction activity. N.B. 2 consecutive readings of *in-situ* parameters to agree within 25%, else retake measurements.
	Construction	Spot readings:DO, temperature, SS & turbidity at mid-ebb and mid-flood. Logging of conductivity, temperature, depth, SS and DO every 5 mins for 12 hours.	At W stations - 1 m below surface - mid level - 1 m above sea bed At station WS	3 times per week during construction of unloading facility. N.B. 2 consecutive readings of *in-situ* parameters to agree within 25%, else retake measurements.

C3 Trigger, Action, and Target Levels

The basic method of recording any change in the environmental conditions is through monitoring of noise, air and water quality. It is an accepted practice to apply a preset range of Trigger, Action and Target (TAT) levels as a framework for interpreting monitoring results. These levels are defined as follows:

Trigger - trigger levels provide an indication of deteriorating ambient environmental quality

Action - action levels indicate the necessity to adopt appropriate remedial actions to prevent the environmental quality from going beyond the target limits. If levels go above target, appropriate remedial action, including critical review of plant and work methods would be required

Target - target levels are stipulated in relevant pollution control ordinances, Hong Kong Planning Standards and Guidelines. These are the maximum levels at which the works could be permitted to proceed

Upon completion of baseline monitoring, the TAT levels for this project may be established in accordance with the criteria given in Table C2

Table C2 Water TAT Levels

Parameter		Trigger Level	Action Level	Target Level
Marine Water Quality	As specified in Table C1.	95% ile of baseline[1] on one tide	Average of Target and Trigger Level	WQOs[2] or 99%ile of baseline[1] for parameters with no WQO.

Note: 1 calculated using a one tailed student's t distribution.

2 DO: 4mg/l (depth average); 2mg/l (bottom); in the event of running background level (measured at the control stations) below the WQO, the target level will be a level 30% below the running background, or 2mg/l, whichever is greater

SS: discharge not to raise the natural ambient level by 30%, nor an accumulation of SS

C4 TAT Action Plans

The action plan as determined by the frequency of complaints and/or exceedance of the compliance monitoring levels is given in Table C3.

Table C3 Action Plan For Exceedance of TAT Levels

Event	Action	
	Environmental Team	Site Manager & Contractor
Breach of Trigger Value	• Inform EPD, contractor & project manager immediately	• Check working methods/practices to identify any immediate causes; take appropriate remedial action if necessary. Inform ET of action taken.
Breach of Action Level	• Inform EPD, contractor & project manager immediately • Propose remedial action and check if it is taken • Continue monitoring after completion of remedial action to confirm action is effective • Record event in monitoring report for submission to contractor and EPD	• Check working methods/practices to identify any immediate causes; take appropriate remedial action if necessary • Undertake detailed check of working methods and practices • Assist ET to devise mitigation measures. • Carry out appropriate remedial action as recommended by ET. • Ensure corrective action has been undertaken and is effective • Amend method statement, if appropriate • Inform ET of action taken within 2 days of notification.
Breach of Target Level	• Inform EPD, contractor & project manager immediately • Increase monitoring frequency • Propose remedial action and check if it is taken • Continue monitoring after completion of remedial action to confirm action is effective • Complete Monitoring Report and submit to contractor and EPD	• Under take immediate check of activities and employ any appropriate mitigation. • In extreme cases cease activities • Assist ET to devise mitigation measures. • Carry out appropriate remedial action as recommended by ET. • Ensure corrective action has been undertaken and is effective • Amend method statement, if appropriate • Inform ET of action taken within 1 day of notification.

C5 Monitoring Methodology

C5.1 Marine Water Monitoring

Two consecutive readings of temperature, dissolved oxygen (DO) concentration, DO % saturation, temperature and turbidity will be taken at each location at 1 m below surface, mid-depth and 1 m above bottom *in-situ* at mid-ebb and mid-flood. If the two consecutive readings do not agree to within 25%, the readings should be

discarded and repeated.

Samples collected in the field for laboratory analysis of suspended solids (SS) should be individually numbered, recorded, stored in a cold box and delivered to the laboratory within 24 hours. SS determinations should be carried out in accordance with APHA Standard Methods for the Examination of Water and Wastewater, 17 Edition, 1989 analysis no. 2540D.

Logging of conductivity, temperature, depth, SS and DO should be undertaken every 5 mins for 12 hours at the appropriate location.

C6 Monitoring Equipment

The following monitoring equipment is suggested.

C6.1 Marine Water Quality

For marine water quality monitoring, the equipment in Table C4 or those with similar specifications should be used.

Table C4 Water Quality Monitoring Equipment

Equipment Function	Manufacturer	Model Name/Number
Turbidity Measurement	Hach	2100P
Dissolved Oxygen and Temperature Measurement	YSI	Model 58 DO meter with 30m cable and YSI 5739 probe with YSI 5795A submersible stirrer for *in situ* DO measurements; YSI Model 33 conductivity meter for salinity for calibrating DO meter; YSI temperature sensor for temperature measurement.
Navigation and Positioning	Magellan	NAV 5000D or compass, where satellites are unavailable
Sampling at Depth for SS Determinations	Kahlsico	Kahlsico Water Sampler with vented drain and messenger
Depth Finding	Seafarer	Model 701 Echo Sounder
Logging WQ parameters	Seabird	SBE-19 Seacat with OBS and DO sensor.

C7 Equipment Calibration

All monitoring equipment shall be maintained in calibration at all times. Re-calibration should be carried out in accordance with requirements stated in this

Appendix or that recommended by the manufacturers, whichever is more stringent. Where applicable calibrations shall be carried out by HOKLAS accredited laboratories.

C7.1 Marine Water Monitoring

DO Meter	The DO meter shall be calibrated against the results of standard Winkler titration every 2 months. The temperature sensor shall be calibrated using a standard certified reference thermometer with an accuracy of 0.5 degrees Celsius. The DO meter shall be standardised every day before use.
Turbidimeter	The Turbidimeter shall be calibrated every two months using standard formazin solutions. It shall be standardised with reference formazin gel solutions every time before use or calibrated against simulataneous field samples of SS.
Balance	The balance shall be calibrated against an internationally traceable standard at intervals recommended by the manufacturer.
Multi-parameter logging Instrument	Shall be calibrated in laboratory conditions in accordance with manufacturers instructions and standardised on site each day.

C8 Audit Requirements

C8.1 Construction Phase Audit

Construction phase audit should be carried out in conjunction with the construction compliance monitoring programme. The audit will be conducted during each monitoring event by the ET. The audit will check:

- implementation status of mitigation measures specified
- sources of environmental pollution
- compliance with environmental legislation.

This should include checks on the following:

Air Quality

- Weather condition
- Maintenance and/or use of:
  - water spray on construction sites, access roads and stockpiles
  - dust covers on stockpiles and trucks
  - site cleanliness
  - plant engines and filtration equipment
- Vehicle speed on unpaved roads

Noise

- Weather condition
- Use and maintenance of construction plant
- Use, maintenance and effectiveness of noise enclosures and barriers
- Hours of operation
- Location of noise emitting plant on site
- Presence of any significant noise source beyond the site boundary
- Number of powered plant in use on site

Water Quality

- Weather
- Operation of sedimentation, pH adjustment and sewage treatment facilities
- Volume of sediments/oil in the basins and drains
- Direct discharge of sediment-loaded washwater/run-off, if any
- Discolouration of water
- Storage and maintenance of any fuel and chemical stores.
- Spillage/leakage of oil, fuel, paint or chemicals within site

In the event of any non-compliance, the ET will notify the contractor and remedial action will need to be taken where appropriate. Non-compliance of pollution control procedures, remedial action, effectiveness of the action, and possible recommendations will be addressed in monthly Monitoring and Audit Reports and in action plans to be issued within 24 hours of a TAT exceedance.

Audit findings will be presented in a monthly Monitoring and Audit Report. The report will identify any unanticipated impacts and improvements, and requirements for future monitoring programme.

C8.2 Operational Phase Audit

A post-project audit shall be carried out when the facility becomes operational. The audit should review:

- environmental management practises in terms of achieving environmental performance requirements
- the effectiveness of mitigation measures
- the effectiveness of, and requirements for, on-going monitoring programme
- compliance with environmental legislation
- possible improvements in environmental control in the event of non-compliance.

A post-audit report should be submitted to DEP within 10 days after completion of the audit.

C9 Data Recording

Standard pro-formas shall be used for recording field data. The data shall then be input into a computerised database. These will serve as a systematic method of

recording and storing data. In the event of complaints or evidence of unacceptable environmental impacts being obtained from the monitoring results, these data should be easy to reference.

Monitoring staff should record observations regarding activities/events that could affect the monitoring results.

C9.1 Environmental Complaints Response Procedures

The EPD hotline shall be used to receive complaints regarding environmental quality impacts arising from the project area. Any complaints received should be passed to the ET. The following steps should be taken upon receipt of complaints:

- log complaint and date of receipt onto the complaint database
- investigate the complaint to determine its validity, and to assess whether the source of the problem is due to recurring works activities
- if complaint is valid and due to works, identify mitigation measures
- undertake additional monitoring and audit to verify the situation as necessary, and address the issue in the monthly Monitoring and Audit report
- log the data and results of the investigation onto the database
- notify complainants of results of complaint investigation
- audit procedures to ensure that any valid reason for complaint does not recur.

C10 Reporting

A monthly Monitoring and Audit Report should be prepared within 10 days of the end of each month with the first report due in the month after construction commences. Reports shall be submitted to the contractor and DEP. The report shall include:

Executive Summary - A brief summary of the main points of the report.

Project Data - A synopsis of the project organisation, project programme, and management liaison structure.

Monitoring & Audit Requirement - Summary of monitoring parameters, TAT levels, action plans, environmental protection requirements in contract documents, land lease and engineering conditions. In addition an implementation status report shall be provided indicating the level of implementation of those requirements.

Monitoring Methodology - Monitoring equipment used, calibration schedule, locations, duration and frequency.

Monitoring Results - Parameter, date, time, environmental conditions and locations. Results should be presented as full page graphs of each parameter on a cumulative time basis at all the stations with TAT levels clearly shown on the graph.

Audit Result - Review of pollution sources and working procedures in the event of non-compliance with environmental monitoring levels; action taken in the event of non-compliance; and follow up procedures related to earlier non-compliance actions. Summary of the number of TAT level exceedances in the month. List of active construction noise permits.

Complaint - Liaison and consultation undertaken, subsequent action, database of telephone/written complaints, location of complaints, action plan, and follow-up procedures.

Appendices - Appropriate drawings/tables of monitoring locations, sensitive receiver locations, environmental monitoring and audit requirements.

It should be noted that under normal circumstances, non-compliance and remedial action will be addressed in the monthly Environmental Monitoring and Audit reports, but would also need to be dealt with on a day to day basis through the issue of action plans detailing deviations from the specification and requesting the contractor to correct the deviations.

APPENDIX D
DOSE UPTAKE ASSESSMENT

	DOSE UPTAKE ASSESSMENT - QRE drums into Vault containing Th-232											
Activity Number	Activity	Time (mins)	Distance (cm) Operator 1	Operator 2	Operator 3	Instantaneous Dose (μSv/h) Operator 1	Operator 2	Operator 3	Dose from Activity (μSv) Operator 1	Operator 2	Operator 3	Remarks/Comments
1	**Loading drum onto road vehicle at QRE**											
1.1	Grapple drum	1	30	30		220	220		3.67	3.67		
1.2	Lift drum onto road vehicle	2	50	150		115	25		3.83	0.83		
1.3	Secure and ungrapple drum	2	30	30		220	220		7.33	7.33		
2	**Transport to dock**											
2.1	Drive vehicle to dock	15	200	200		20	20		5.00	5.00		20 miles @ 5 miles/h
3	**Transfering drum from road to sea vessel**											Assume two lifts required
3.1	Grapple drum	1	30	30		220	220		3.67	3.67		
3.2	Lift drum off road vehicle onto dockside	2	50	150		115	25		3.83	0.83		
3.3	Ungrapple drum	1	30	30		220	220		3.67	3.67		
3.4	Drum held temporarily	30	500	500		20	20		10.00	10.00		Dose taken as 200 cm
3.5	Grapple drum	1	30	30		220	220		3.67	3.67		
3.6	Lift drum onto sea vessel	2	50	150		115	25		3.83	0.83		
3.7	Secure and ungrapple drum	2	30	30		220	220		7.33	7.33		
4	**Transfer to Siu A Chau**											
4.1	Boat transfer to Siu A Chau	60	200	200		20	20		20.00	20.00		1 Hour transfer assumed
5	**Off loading at Siu A Chau**											
5.1	Summons obtain transfer vehicle	10	200	distant		20	0		3.33	0.00		
5.2	Grapple drum	1	30	30		220	220		3.67	3.67		
5.3	Lift drum from boat onto transfer vehicle	2	50	150		115	25		3.83	0.83		
5.4	Ungrapple drum and secure on transfer vehicle	2	30	30		220	220		7.33	7.33		
6	**Transfer to LRWF**											
6.1	Transfer to LRWF	2	150	150		25	25		0.83	0.83		
6.2	Open road bay door	1	150	300		25	20		0.42	0.33		Dose taken as 200 cm for Op. 2
6.3	Drive transfer vehicle into road bay	1	150	150		25	25		0.42	0.42		
6.4	Close road bay door	1	150	300		25	20		0.42	0.33		Dose taken as 200 cm for Op. 2
7	**Transfer into Vault**											
7.1	External radiation and contamination monitoring	3	30	30		220	220		11.00	11.00		
7.2	Open road bay/vault door	1	150	300		25	20		0.42	0.33		Dose taken as 200 cm for Op. 2
7.3	Drive transfer vehicle into Vault	1	150	150		25	25		0.42	0.42		
7.4	Prepare drum for crane lift	1	30	30		220	220		3.67	3.67		
7.5	Crane lift into storage location	5	200	200		124	124		10.33	10.33		Assume 200 cm from line of 20 Th-232 drums in Vault
7.6	Log data	1	N/k	N/k		10	10		0.17	0.17		Max normal background for active area assumed
	ASSUMPTIONS					**Total dose for one drum of Th-232**			**122.08**	**106.50**		
1	Each drum transported separately											
2	Dose from drum based on Th-232 with spec. activity of 3500 Bq/g					**Total dose for 60 drums of Th-232**			**7325**	**6390**		
3	Same operator always subject to highest dose opearations											
4	All operations undertaken by same two operators											
5	Minimum time for any operation 1 minute											

DOSE UPTAKE ASSESSMENT - QRE drums into Vault containing Pm-147

Activity Number	Activity	Time (mins)	Distance (cm) Operator 1	Distance (cm) Operator 2	Distance (cm) Operator 3	Instantaneous Dose (µSv/h) Operator 1	Instantaneous Dose (µSv/h) Operator 2	Instantaneous Dose (µSv/h) Operator 3	Dose from Activity (µSv) Operator 1	Dose from Activity (µSv) Operator 2	Dose from Activity (µSv) Operator 3	Remarks/Comments
1	**Loading drum onto road vehicle at QRE**											
1.1	Grapple drum	1	30	30		1	1		0.02	0.02		
1.2	Lift drum onto road vehicle	2	50	150		1	1		0.03	0.03		
1.3	Secure and ungrapple drum	2	30	30		1	1		0.03	0.03		
2	**Transport to dock**											
2.1	Drive vehicle to dock	15	200	200		1	1		0.25	0.25		20 miles @ 5 miles/h
3	**Transfering drum from road to sea vessel**											Assume two lifts required
3.1	Grapple drum	1	30	30		1	1		0.02	0.02		
3.2	Lift drum off road vehicle onto dockside	2	50	150		1	1		0.03	0.03		
3.3	Ungrapple drum	1	30	30		1	1		0.02	0.02		
3.4	Drum held temporarily	30	500	500		1	1		0.50	0.50		Dose taken as 200 cm
3.5	Grapple drum	1	30	30		1	1		0.02	0.02		
3.6	Lift drum onto sea vessel	2	50	150		1	1		0.03	0.03		
3.7	Secure and ungrapple drum	2	30	30		1	1		0.03	0.03		
4	**Transfer to Siu A Chau**											
4.1	Boat transfer to Siu A Chau	60	200	200		1	1		1.00	1.00		1 Hour transfer assumed
5	**Off loading at Siu A Chau**											
5.1	Summons obtain transfer vehicle	10	200	distant		1	1		0.17	0.17		
5.2	Grapple drum	1	30	30		1	1		0.02	0.02		
5.3	Lift drum from boat onto transfer vehicle	2	50	150		1	1		0.03	0.03		
5.4	Ungrapple drum and secure on transfer vehicle	2	30	30		1	1		0.03	0.03		
6	**Transfer to LRWF**											
6.1	Transfer to LRWF	2	150	150		1	1		0.03	0.03		
6.2	Open road bay door	1	150	300		1	1		0.02	0.02		Dose taken as 200 cm for Op. 2
6.3	Drive transfer vehicle into road bay	1	150	150		1	1		0.02	0.02		
6.4	Close road bay door	1	150	300		1	1		0.02	0.02		Dose taken as 200 cm for Op. 2
7	**Transfer into Vault**											
7.1	External radiation and contamination monitoring	3	30	30		1	1		0.05	0.05		
7.2	Open road bay/vault door	1	150	300		1	1		0.02	0.02		Dose taken as 200 cm for Op. 2
7.3	Drive transfer vehicle into Vault	1	150	150		1	1		0.02	0.02		
7.4	Prepare drum for crane lift	1	30	30		1	1		0.02	0.02		
7.5	Crane lift into storage location	5	200	200		124	124		10.33	10.33		Assume 200 cm from line of 20 Th-232 drums in Vault
7.6	Log data	1	N/k	N/k		10	10		0.17	0.17		Max normal background for active area assumed
	ASSUMPTIONS					**Total Dose for one drum of Pm-147**			12.92	12.92		
1	Each drum transported separately											
2	Dose assumed to be 1 µSv/hr at all distances					**Total dose for 75 drums of Pm-147**			968.75	968.75		
3	Same operator always subject to highest dose opearations											
4	All operations undertaken by same two operators											
5	Minimum time for any operation 1 minute											

DOSE UPTAKE ASSESSMENT - QRE drums into Vault containing Misc. waste

Activity Number	Activity	Time (mins)	Distance (cm)			Instantaneous Dose (μSv/h)			Dose from Activity (μSv)			Remarks/Comments
			Operator 1	Operator 2	Operator 3	Operator 1	Operator 2	Operator 3	Operator 1	Operator 2	Operator 3	
1	**Loading drum onto road vehicle at QRE**											
1.1	Grapple drum	1	30	30		220	220		3.67	3.67		
1.2	Lift drum onto road vehicle	2	50	150		115	25		3.83	0.83		
1.3	Secure and ungrapple drum	2	30	30		220	220		7.33	7.33		
2	**Transport to dock**											
2.1	Drive vehicle to dock	15	200	200		20	20		5.00	5.00		20 miles @ 5 miles/h
3	**Transfering drum from road to sea vessel**											Assume two lifts required
3.1	Grapple drum	1	30	30		220	220		3.67	3.67		
3.2	Lift drum off road vehicle onto dockside	2	50	150		115	25		3.83	0.83		
3.3	Ungrapple drum	1	30	30		220	220		3.67	3.67		
3.4	Drum held temporarily	30	500	500		20	20		10.00	10.00		Dose taken as 200 cm
3.5	Grapple drum	1	30	30		220	220		3.67	3.67		
3.6	Lift drum onto sea vessel	2	50	150		115	25		3.83	0.83		
3.7	Secure and ungrapple drum	2	30	30		220	220		7.33	7.33		
4	**Transfer to Siu A Chau**											
4.1	Boat transfer to Siu A Chau	60	200	200		20	20		20.00	20.00		1 Hour transfer assumed
5	**Off loading at Siu A Chau**											
5.1	Summons obtain transfer vehicle	10	200	distant		20	0		3.33	0.00		
5.2	Grapple drum	1	30	30		220	220		3.67	3.67		
5.3	Lift drum from boat onto transfer vehicle	2	50	150		115	25		3.83	0.83		
5.4	Ungrapple drum and secure on transfer vehicle	2	30	30		220	220		7.33	7.33		
6	**Transfer to LRWF**											
6.1	Transfer to LRWF	2	150	150		25	25		0.83	0.83		
6.2	Open road bay door	1	150	300		25	20		0.42	0.33		Dose taken as 200 cm for Op. 2
6.3	Drive transfer vehicle into road bay	1	150	150		25	25		0.42	0.42		
6.4	Close road bay door	1	150	300		25	20		0.42	0.33		Dose taken as 200 cm for Op. 2
7	**Transfer into Vault**											
7.1	External radiation and contamination monitoring	3	30	30		220	220		11.00	11.00		
7.2	Open road bay/vault door	1	150	300		25	20		0.42	0.33		Dose taken as 200 cm for Op. 2
7.3	Drive transfer vehicle into Vault	1	150	150		25	25		0.42	0.42		
7.4	Prepare drum for crane lift	1	30	30		220	220		3.67	3.67		
7.5	Crane lift into storage location	5	200	200		124	124		10.33	10.33		Assume 200 cm from line of 20 Th-232 drums in Vault
7.6	Log data	1	N/k	N/k		10	10		0.17	0.17		Max normal background for active area assumed
	ASSUMPTIONS				**Total dose for one drum of Misc. waste**				**122.08**	**106.50**		
1	Each drum transported separately											
2	Misc. waste assumed to have same rad. levels as Th-232				**Total dose for 65 drums of Misc. waste**				7935.42	6922.5		
3	Same operator always subject to highest dose opearations											
4	All operations undertaken by same two operators											
5	Minimum time for any operation 1 minute											

	DOSE UPTAKE ASSESSMENT - Packages into Drums Pm-147											
Activity	Activity	Time	Distance (cm)			Instantaneous Dose (μSv/h)			Dose from Activity (μSv)			Remarks/Comments
Number		(mins)	Operator 1	Operator 2	Operator 3	Operator 1	Operator 2	Operator 3	Operator 1	Operator 2	Operator 3	
1	**Loading drum onto road vehicle at Waste consignor**											
1.1	Grapple package	1	30	30		1	1		0.02	0.02		
1.2	Lift Package onto road vehicle	2	50	150		1	1		0.03	0.03		
1.3	Secure and ungrapple package	2	30	30		1	1		0.03	0.03		
2	**Transport to dock**											
2.1	Drive vehicle to dock	15	200	200		1	1		0.25	0.25		20 miles @ 5 miles/h
3	**Transfering drum from road to sea vessel**											Assume two lifts required
3.1	Grapple package	1	30	30		1	1		0.02	0.02		
3.2	Lift package off road vehicle onto dockside	2	50	150		1	1		0.03	0.03		
3.3	Ungrapple package	1	30	30		1	1		0.02	0.02		
3.4	Drum held temporarliy	30	500	500		1	1		0.50	0.50		
3.5	Grapple package	1	30	30		1	1		0.02	0.02		
3.6	Lift package onto sea vessel	2	50	150		1	1		0.03	0.03		
3.7	Secure and ungrapple package	2	30	30		1	1		0.03	0.03		
4	**Transfer to Siu A Chau**											
4.1	Boat transfer to Siu A Chau	60	200	200		1	1		1.00	1.00		One hour transfer assumed
5	**Off loading at Siu A Chau**											
5.1	Summons obtain transfer vehicle	10	200	distant		1	1		0.17	0.17		
5.2	Grapple package	1	30	30		1	1		0.02	0.02		
5.3	Lift package from boat onto transfer vehicle	2	50	150		1	1		0.03	0.03		
5.4	Ungrapple package and secure on transfer vehicle	2	30	30		1	1		0.03	0.03		
6	**Transfer to LRWF**											
6.1	Transfer to LRWF	2	150	150		1	1		0.03	0.03		
6.2	Open road bay door	1	150	300		1	1		0.02	0.02		
6.3	Drive transfer vehicle into road bay	1	150	150		1	1		0.02	0.02		
6.4	Close road bay door	1	150	300		1	1		0.02	0.02		
7	**Transfer into Waste Processing Area**											
7.1	External radiation and contamination monitoring	3	30	30		1	1		0.05	0.05		
7.2	Grapple package	1	30	30		1	1		0.02	0.02		
7.3	Open road bay/waste processing area door	1	150	200		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
7.4	Grapple package for lift into waste processing area	1	30	30		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
7.5	Lift package into waste temporary holding area	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
7.6	Close road bay/waste procseeing area door	1	150	200		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
7.7	Ungrapple package in temporary holding area	1	30	30		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
7.8	Hold package	N/k	distant	distant		10	10		0.00	0.00		Assume max background active area dose of 10 μSv/h
8	**Transfer package to gamma spec**											
8.1	Grapple package	1	30	30		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
8.2	Lift onto trolley	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
8.3	Move to gamma spec	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
8.4	Transfer onto gamma spec	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
8.5	Gamma spec package	15	30	150		10	10		2.50	2.50		Assume max background active area dose of 10 μSv/h

	DOSE UPTAKE ASSESSMENT - Packages into Drums Pm-147											
Activity Number	Activity	Time (mins)	Distance (cm) Operator 1	Operator 2	Operator 3	Instantaneous Dose (µSv/h) Operator 1	Operator 2	Operator 3	Dose from Activity (µSv) Operator 1	Operator 2	Operator 3	Remarks/Comments
9	**Transfer package to Fume/Glove box**											
9.1	Transfer package to Fume/Glove Box	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
9.2	Mate drum with Fume/Glove box	5	30	50		10	10		0.83	0.83		Assume max background active area dose of 10 µSv/h
10	**Transfer waste into drum**											
10.1	Transfer waste into drum from package	30	30	30		10	10		5.00	5.00		Assume max background active area dose of 10 µSv/h
	ASSUMPTIONS				**Total dose 1 package into drum Pm-147**				12.38	12.38		
1	Each package transported separately											
2	Dose assumed to be 1 µSv/hr at all distances				**Total dose 4 packages into drum Pm-147**				49.53	49.53		
3	Same operator always subject to highest dose opearations											
4	All operations undertaken by same two operators											
5	Minimum time for any operation 1 minute											

DOSE UPTAKE ASSESSMENT - Full (repackaged waste) drums into Vault Pm-147												
Activity Number	Activity	Time (mins)	Distance (cm) Operator 1	Distance (cm) Operator 2	Operator 3	Instantaneous Dose (µSv/h) Operator 1	Instantaneous Dose (µSv/h) Operator 2	Operator 3	Dose from Activity (µSv) Operator 1	Dose from Activity (µSv) Operator 2	Operator 3	Remarks/Comments
1	**Transfer empty drums from Vault to Fume/Glove box**											
1.1	Crane pick up and recover drum from Vault onto trolley	5	200	200		124	124		10.33	10.33		Assume 200 cm from line of 20 Th-232 drums in Vault
1.2	Open Vault/waste processing area door	1	200	200		124	124		2.07	2.07		Assume 200 cm from line of 20 Th-232 drums in Vault
1.3	Transfer drum onto waste processing area	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
1.4	Close vault/waste processing area door	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
1.5	Quality check of drum	10	30	30		10	10		1.67	1.67		Assume max background active area dose of 10 µSv/h
1.6	Transfer drum to fume/golve box	1	10	10		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
1.7	Mate drum with fume/glove box	2	10	10		10	10		0.33	0.33		Assume max background active area dose of 10 µSv/h
2	**Load drums (see package into drums assessment)**											
3	**Transfer drum to lidding station & lid drum**											
3.1	Release drum from fume/glove box	2	30	30		10	10		0.33	0.33		Assume max background active area dose of 10 µSv/h
3.2	Monitor for contamination	3	30	30		10	10		0.50	0.50		Assume max background active area dose of 10 µSv/h
3.3	Transfer drum to lidding station	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
3.4	Lid drum	10	30	50		10	10		1.67	1.67		Assume max background active area dose of 10 µSv/h
3.5	Prepare epoxy	10	50	200		10	10		1.67	1.67		Assume max background active area dose of 10 µSv/h
3.6	Fill drum with epxoy	15	50	150		10	10		2.50	2.50		Assume max background active area dose of 10 µSv/h
3.7	Allow epoxy to set	1440	distant	distant		0	0		0.00	0.00		
3.8	Place in 'bung'	2	30	30		10	10		0.33	0.33		Assume max background active area dose of 10 µSv/h
4	**Final Monitoring**											
4.1	Move drum to gamma spec	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
4.2	Transfer to gamma spec	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
4.3	Gamma spec	15	50	150		10	10		2.50	2.50		Assume max background active area dose of 10 µSv/h
4.4	Transfer to waste processing area/vault trolley	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
4.5	Radiation and Contamination Monitoring	3	30	30		10	10		0.50	0.50		Assume max background active area dose of 10 µSv/h
5	**Transfer to Storage location**											
5.1	Open vault/waste processing area door	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
5.2	Transfer drum into vault	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
5.3	Close vault/waste processing area door	1	200	200		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
5.4	Prepare drum for crane lift	1	30	30		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
5.5	Crane lift into storage location	1	200	200		124	124		2.07	2.07		Assume 200 cm from line of 20 Th-232 drums in Vault
5.6	Log data	1	N/k	N/k		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
	ASSUMPTIONS					**Total repackaged 1 drum Pm-147**			28.47	28.47		
1	Same operator always subject to highest dose											
2	All operations undertaken by same two operators					**Total repackage 2 drums Pm-147**			56.93	56.93		
3	Minimum time for any operation 1 minute											

DOSE UPTAKE ASSESSMENT - Packages into Drums Misc.

Activity Number	Activity	Time (mins)	Distance (cm)			Instantaneous Dose (μSv/h)			Dose from Activity (μSv)			Remarks/Comments
			Operator 1	Operator 2	Operator 3	Operator 1	Operator 2	Operator 3	Operator 1	Operator 2	Operator 3	
1	**Loading drum onto road vehicle at Waste consignor**											
1.1	Grapple package	1	30	30		5	5		0.08	0.08		
1.2	Lift Package onto road vehicle	2	50	150		5	5		0.17	0.17		
1.3	Secure and ungrapple package	2	30	30		5	5		0.17	0.17		
2	**Transport to dock**											
2.1	Drive vehicle to dock	15	200	200		5	5		1.25	1.25		20 miles @ 5 miles/h
3	**Transfering drum from road to sea vessel**											Assume two lifts required
3.1	Grapple package	1	30	30		5	5		0.08	0.08		
3.2	Lift package off road vehicle onto dockside	2	50	150		5	5		0.17	0.17		
3.3	Ungrapple package	1	30	30		5	5		0.08	0.08		
3.4	Drum held temporarliy	30	500	500		5	5		2.50	2.50		
3.5	Grapple package	1	30	30		5	5		0.08	0.08		
3.6	Lift package onto sea vessel	2	50	150		5	5		0.17	0 17		
3.7	Secure and ungrapple package	2	30	30		5	5		0.17	0.17		
4	**Transfer to Siu A Chau**											
4.1	Boat transfer to Siu A Chau	60	200	200		5	5		5.00	5.00		One hour transfer assumed
5	**Off loading at Siu A Chau**											
5.1	Summons obtain transfer vehicle	10	200	distant		5	5		0.83	0.83		
5.2	Grapple package	1	30	30		5	5		0.08	0.08		
5.3	Lift package from boat onto transfer vehicle	2	50	150		5	5		0.17	0.17		
5.4	Ungrapple package and secure on transfer vehicle	2	30	30		5	5		0.17	0.17		
6	**Transfer to LRWF**											
6.1	Transfer to LRWF	2	150	150		5	5		0.17	0.17		
6.2	Open road bay door	1	150	300		5	5		0.08	0.08		
6.3	Drive transfer vehicle into road bay	1	150	150		5	5		0.08	0.08		
6.4	Close road bay door	1	150	300		5	5		0.08	0.08		
7	**Transfer into Waste Processing Area**											
7.1	External radiation and contamination monitoring	3	30	30		5	5		0.25	0.25		
7.2	Grapple package	1	30	30		5	5		0.08	0.08		
7.3	Open road bay/waste processing area door	1	150	200		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
7.4	Grapple package for lift into waste processing area	1	30	30		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
7.5	Lift package into waste temporary holding area	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
7.6	Close road bay/waste procseeing area door	1	150	200		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
7.7	Ungrapple package in temporary holding area	1	30	30		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
7.8	Hold package	N/k	distant	distant		10	10		0.00	0.00		Assume max background active area dose of 10 μSv/h
8	**Transfer package to gamma spec**											
8.1	Grapple package	1	30	30		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
8.2	Lift onto trolley	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
8.3	Move to gamma spec	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
8.4	Transfer onto gamma spec	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 μSv/h
8.5	Gamma spec package	15	30	150		10	10		2.50	2.50		Assume max background active area dose of 10 μSv/h

DOSE UPTAKE ASSESSMENT - Packages into Drums Misc.

Activity Number	Activity	Time (mins)	Distance (cm) Operator 1	Distance (cm) Operator 2	Distance (cm) Operator 3	Instantaneous Dose (µSv/h) Operator 1	Instantaneous Dose (µSv/h) Operator 2	Instantaneous Dose (µSv/h) Operator 3	Dose from Activity (µSv) Operator 1	Dose from Activity (µSv) Operator 2	Dose from Activity (µSv) Operator 3	Remarks/Comments
9	**Transfer package to Fume/Glove box**											
9.1	Transfer package to Fume/Glove Box	1	50	150		10	10		0.17	0.17		Assume max background active area dose of 10 µSv/h
9.2	Mate drum with Fume/Glove box	5	30	50		10	10		0.83	0.83		Assume max background active area dose of 10 µSv/h
10	**Transfer waste into drum**											
10.1	Transfer waste into drum from package	30	30	30		10	10		5.00	5.00		Assume max background active area dose of 10 µSv/h
	ASSUMPTIONS				**Total dose 1 package into drum misc. waste**				**21.92**	**21.92**		
1	Each package transported separately											
2	Dose from each package assumed to be 5 µSv/h at all distances				**Total dose 10 packages into drum misc. waste**				**219.17**	**219.17**		
3	Same operator always subject to highest dose opearations											
4	All operations undertaken by same two operators											
5	Minimum time for any operation 1 minute											

DOSE UPTAKE ASSESSMENT - Full (repackaged waste) drums into Vault Misc Wastes

Activity Number	Activity	Time (mins)	Distance (cm)			Instantaneous Dose (µSv/h)			Dose from Activity (µSv)			Remarks/Comments
			Operator 1	Operator 2	Operator 3	Operator 1	Operator 2	Operator 3	Operator 1	Operator 2	Operator 3	
1	**Transfer empty drums from Vault to Fume/Glove box**											
1.1	Crane pick up and recover drum from Vault onto trolley	5	200	200		124	124		10.33	10.33		Assume 200 cm from line of 20 Th-232 drums in Vault
1.2	Open Vault/waste processing area door	1	200	200		124	124		2.07	2.07		Assume 200 cm from line of 20 Th-232 drums in Vault
1.3	Transfer drum onto waste processing area	1	50	150		10	10		0.17	0.17		
1.4	Close vault/waste processing area door	1	50	150		10	10		0.17	0.17		
1.5	Quality check of drum	10	30	30		10	10		1.67	1.67		
1.6	Transfer drum to fume/golve box	1	10	10		10	10		0.17	0.17		
1.7	Mate drum with fume/glove box	2	10	10		10	10		0.33	0.33		
2	**Load drums (see package into drums assessment)**											
3	**Transfer drum to lidding station & lid drum**											
3.1	Release drum from fume/glove box	2	30	30		220	220		7.33	7.33		
3.2	Monitor for contamination	3	30	30		220	220		11.00	11.00		
3.3	Transfer drum to lidding station	1	50	150		115	25		1.92	0.42		
3.4	Lid drum	10	30	50		220	115		36.67	19.17		
3.5	Prepare epoxy	10	50	200		115	20		19.17	3.33		
3.6	Fill drum with epxoy	15	50	150		115	25		28.75	6.25		
3.7	Allow epoxy to set	1440	distant	distant		0	0		0.00	0.00		
3.8	Place in 'bung'	2	30	30		220	220		7.33	7.33		
4	**Final Monitoring**											
4.1	Move drum to gamma spec	1	50	150		115	25		1.92	0.42		
4.2	Transfer to gamma spec	1	50	150		115	25		1.92	0.42		
4.3	Gamma spec	15	50	150		115	25		28.75	6.25		
4.4	Transfer to waste processing area/vault trolley	1	50	150		115	25		1.92	0.42		
4.5	Radiation and Contamination Monitoring	3	30	30		220	220		11.00	11.00		
5	**Transfer to Storage location**											
5.1	Open vault/waste processing area door	1	50	150		115	25		1.92	0.42		
5.2	Transfer drum into vault	1	50	150		115	25		1.92	0.42		
5.3	Close vault/waste processing area door	1	200	200		20	20		0.33	0.33		
5.4	Prepare drum for crane lift	1	30	30		220	220		3.67	3.67		
5.5	Crane lift into storage location	1	200	200		124	124		2.07	2.07		Assume 200 cm from line of 20 Th-232 drums in Vault
5.6	Log data	1	N/k	N/k		10	10		0.17	0.17		
	ASSUMPTIONS				**Total repackaged 1 drum misc. waste**				**182.63**	**95.30**		
1	Same operator always subject to highest dose											
2	All operations undertaken by same two operators				**Total repackage 2 drums misc.waste**				**365.27**	**190.60**		
3	Minimum time for any operation 1 minute											
4	Misc.waste assumed to have same rad. levels as Th-232 drum											

	DOSE UPTAKE ASSESSMENT - Empty drums into Vault											
Activity Number	Activity	Time (mins)	Distance (cm) Operator 1	Distance (cm) Operator 2	Distance (cm) Operator 3	Instantaneous Dose (μSv/h) Operator 1	Instantaneous Dose (μSv/h) Operator 2	Instantaneous Dose (μSv/h) Operator 3	Dose from Activity (μSv) Operator 1	Dose from Activity (μSv) Operator 2	Dose from Activity (μSv) Operator 3	Remarks/Comments
1	**Transfer drums from outside LRWF into Vault**											
1.1	Open road bay door	1	150	300		0	0		0.00	0.00		
1.2	Drive in transfer vehicle	1	150	150		0	0		0.00	0.00		
1.3	Close Road bay door	1	150	300		0	0		0.00	0.00		
1.4	Inspect drum	5	30	30		0	0		0.00	0.00		
1.5	Open road bay/vault door	1	150	300		10	10		0.17	0.17		Assume nominal 10μSv/h dose
1.6	Transfer drum into Vault	1	150	150		10	10		0.17	0.17		Assume nominal 10μSv/h dose
1.7	Prepare drum for crane lift	1	30	30		124	124		2.07	2.07		Assume 200 cm from line of 20 Th-232 drums in Vault
1.8	Crane lift into Vault	5	200	200		124	124		10.33	10.33		Assume 200 cm from line of 20 Th-232 drums in Vault
1.9	Log data	1	N/k	N/k		10	10		0.17	0.17		Assume max background for active area
	ASSUMPTIONS					**Total for 1 empty drum**			**12.90**	**12.90**		
1	All 60 empty drums are placed in the Vault in Year 1											
	when some waste is already in situ.					**Total for 60 empty drums**			**774.00**	**774.00**		
2	Same operator always subject to highest dose operation											
3	All operations undertaken by same two operators											
4	Minimum time for any operation 1 minute											

APPENDIX E
INITIAL HAZARD IDENTIFICATION

ITEM NO.	CAUSE	CONSEQUENCE	MITIGATING FEATURE
1	**Waste From QRE**		
1.1	Drum dropped while being lifted onto road transport	If drop height > 3m containment may be breached	Type 'A' package should be drop tested to 1.2m
		If drop height < 3m containment less likely to fail	HK Govt require package to be drop tested to 3m
			Only solid waste involved therefore dispersal limited
1.2	Vehicle involved in Road Accident	Depends on severity - Worst case scenario severe damage to drum and release of contents	Type 'A' package would be OK for normal transport conditions
			Labelled package would warn of Radioactive contents
			Dispersion limited as only solid items should be present
1.3	Drum dropped at transfer from road to sea	Depends on severity - Possible release of contents &/or dropped in harbour	Type 'A' package should be drop tested to 1.2m
			HK Govt require package to be drop tested to 3m
1.4	Boat accident	Depends on severity - Possible release of contents to harbour/sea.	Type 'A' package would be OK for normal transport
1.5	Drum dropped during off loading at Siu A Chau	As 1.3	As 1.3
1.6	Road transport to LRWF		
	(a) On jetty	As 1.2 or 1.3	As 1.2 or 1.3
	(b) On Road	As 1.2	As 1.2 except note no other vehicles on road ie will only involve the transport vehicle

ITEM NO.	CAUSE	CONSEQUENCE	MITIGATING FEATURE
1.7	Crane or other handling equipment drops drum in LRWF	If containment broken possible release of drum contents	Type 'A' package tested for 1.2m drop
			HK government requirement to drop test to 3m - no lift above this height believed to be necessary in LRWF
			Spillage contained in building if containment of drum breached
			Solid Waste will limit dispersal
2	**Waste From Consignors in Waste Packages**		
2.1	Package dropped while being loaded onto transport vehicle	Possible breach of containment	Package will meet IAEA Regs and be required to be suitable for normal handling and be subject to drop test (height dependent on weight)
			Only solid waste involved therfore dispersal limited
2.2	Vehicle involved in Road traffic accident	As 1.2	Transported in accordance with IAEA Regs
			Labelled package will warn of Radioactive contents
2.3	Package dropped at transfer from road to sea	As 1.3	Package will meet IAEA Regs
2.4	Boat accident	As 1.4	Package wiil meet IAEA Regs
2.5	Drum dropped during offloading at Siu A Chau	As 2.3	As 2.3
2.6	Road transport to LRWF		
	(a) On jetty	As 2.2 or 2.3	As 2.2 or 2.3

ITEM NO.	CAUSE	CONSEQUENCE	MITIGATING FEATURE
	(b) On road	As 2.2	As 2.2 except note no other vehicles on road ie will only involve transport vehicle
2.7	Waste not of type specified		
	(a) High radioactivity	Possible high dose to operators	Consider incorporation of beta/gamma alarm
	(b) Different physical form (eg liquid, etc)	Liable to spill	Will be continued in active area
		Potential Contamination of Operators	Repackaging will take place in suitable environment eg fume hood/cupboard
	(c) Operator injured by sharp object	Possible ingestion of radioactive material	
2.8	Overweight/overfilling of drum/package		
	(a) Overfill drum (by volume)	Lid will not fit	Waste can be removed from drum
	(b) Overfill drum (by weight)	Handling/drum equipment failure	Consider incorporation of load cell or design of drum/drum handling equipment to cater for max conceivable weight or safety cut out.
2.9	Operator attempts to repack 'high' active waste	As 2.7(a) but potentially dose to operator could be very high depending on waste	
2.10	Fire in LRWF	Possible damage to drums and release of activity	Fire detection & suppression systems
2.11	Ventilation system failure	Loss of normal vent flows	LWRF designed to be passively safe
			Limited areas/quantities of loose contamination

APPENDIX F
SPECIES RECORDED DURING TRANSECT SURVEY IN SUM WAN, SIU A CHAU

Fauna and flora recorded at Siu A Chau

Flora:	
Phaeophyceae	*Ralfsia verrucosa*
Rhodophyceae	*Gelidium pusillum*
	Crustose coralline spp.
	Erect coralline spp.
	Jania undulata
	Hildenbrandia rubra
Fauna:	
Porifera	*Halichondria spp.*
	Haliclona spp.
Coelenterata	
Hydrozoa	*Pennaria spp.*
Anthozoa	
Zoantharia	
Sclerentinia	Faviidae spp.
	Poritidae spp.
Scyphozoa	*Cyanea nosakii*
Polyzoa	*Schizophorella unicornis*
	Unidentified polyzoa spp.
Annelida	*Spirorbis foraminosus*
Mollusca	
Gastropoda	*Cellana toreuma*
	Monodonta labio
	Chlorostoma rustica
	Siphonaria atra
	Batillaria sordida
	Morula spp.
	Thais luteostoma
	Planaxis sulcatus
Arthropoda	
Crustacea	*Tetraclita squamosa*
	Balanus spp.
	Clibanarius spp.
Echinodermata	
Holothuridea	*Holothuria leucospilota*
Echinoidea	*Anthocidaris crassispina*
Chordata	
Ascidiacea	*Styela spp.*
Actinopterygii	*Epinephelus fario*
	Thalassoma lunare
	Microcanthus strigatus
	Chaetodon modestus
	Entomacrodus stellifer
	Pomacentridae spp.
	Siganidae spp.

APPENDIX G
RESPONSES TO COMMENTS ON THE DRAFT EISA REPORT

RESPONSES TO COMMENTS ON THE DRAFT EISA REPORT LOW-LEVEL RADIOACTIVE WASTE STORAGE FACILITY

COMMENTS	RESPONSES
From : EPD, Headquarters Ref : EP 122/R1/2 IV Date : 26 April 1995	
Comments by Special Waste Facilities Group	
1.1 *Pg 1 Section 1.1 Background to project para 1 line 4*	
"Over one hundred potential sites" should be changed to "Several inland and island potential sites".	Noted. Text amended.
1.2 *Pgs 7 & 8 Section 2.4.2 Marine Ecology and Fisheries*	
1.2.1 Para 1 lines 4 & 5	
Information of D of A&F's letter ref (17) in AF DVL 13/92 dated 22.3.95 regarding the potential Marine Park should be incorporated.	Noted. Text amended.
1.2.2 Para 6 & 9	
It is concluded in the Section 10.2 that the marine ecological "impacts are likely to be extremely localised". In view of the small scale of the jetty construction and the short construction period (which can be further minimized), please review whether the survey and investigation of the marine ecology and fisheries are justified to be undertaken in this Project.	The need for further survey in Sum Wan will need to be addressed at the detailed design stage. It is unlikely further marine ecology survey would be required if the current design concept is adopted.
1.3 *Pg 19 Section 4.1.2 Marine Ecology and Fisheries para 1 line 2*	
Same comment as in 1.2.	Noted.
1.4 *Pg 26 Section 4.5.2 Operation para 1 and 3*	
As confirmed to you recently, the DBO contractor will collect and transport the repackaged waste from the QRE tunnels store to the LRWF on Siu A Chau. The future waste arising will be transported to an assigned collection point by the waste producers, and then collected and transported to the LRWF by the DBO contractor. This section should be revised accordingly.	Your revisions are noted.
1.5 *Pg 36 Table 5.1*	
The table is missing.	Noted. Summary table for information provided in Appendix D was omitted.

1.6	*Pg 62 Section 6.7.2 Precise Siting: Ensuring a Smooth Fit With the Landscape, the last sentence*	
	Problem of ingress of underground water and deterioration by plant growth should be considered. These have been problems of the QRE tunnels store.	The design concept referred to has not been progressed further. Should this be desired, then potential problems will be investigated at the detailed design stage.
1.7	*Pg 66 Section 7.1.5 and Pg 68 Section 7.2*	
	As discussed at the meeting with the RHKPF recently, you should consider the option of initiating the incident procedures by the DBO contractor (instead of by the government officials). Please incorporate this option and make your recommendation.	The DBO contractor could be made responsible for complete site security monitoring as discussed at the meeting. This should be incorporated into the contract document.
1.8	*Pg 68 Section 7.2.1 Fire*	
	As discussed recently, the radiological monitoring and protective equipment used during the event of incident should be provided to the relevant government departments by the DBO contractor.	Noted.
1.9	*Pg 78 Section 10.3 Water Quality para 3*	
	Retention tank for monitoring the effluent and the pumped discharge should be mentioned in the recommendation.	Noted. Text amended.
1.10	*Pg 80 Section 10.10 Terms of Reference for the Detailed Stage 2 EISA sub-para 1 of para 2*	
	The proposed timing does not match the construction programme. The comment in 2.2 is relevant.	As the best time for such a survey is prior to the detailed design, Government should consider the appropriateness of a separate study.
1.1	*Pg B1 Appendix B, B1.5*	
1.11.1	The subheading "(f)" should be an error.	Noted. Text amended.
1.11.2	Radiation Ordinance (Cap 303) should be included.	Radiation Ordinance is not relevant during construction, but will be included in the contract documents.

Comments by Strategic Assessment Group

The following should be included in the report:

2.1	*Section 1.2 Site Selection Process*	
	The environmental issues that have been addressed in the site selection process (the potential landuse conflict with proposed LNG terminal at North Soko should also be included).	We have already been instructed by EPD, upon the advice of the IDB, not to make reference to potential land use conflict with the proposed LNG terminal. The site selection process and the relevant report were referenced in Section 1.2.

2.2	The assessment works have been carried out to address the issues identified in (2.1) above in the site selection process.	All environmental and safety issues relevant to the outline design have been addressed.
2.3	The reasons for selecting the site for Sum Wan on North Soko for the LRWF (details of why the other three not being selected should also be given in this report).	Reasons for site selection have been addressed in detail in the site selection report.
2.4	The comments from other government departments, in particular AFD, on the ecological issues and marine habitat in the vicinity of the selected site.	Comments from relevant Government Departments have been sought and are addressed in the report.
2.5	Responses during public consultation e.g. Islands DB presentation.	As for 2.4.

Comments by Monitoring and Audit Group

3.1	Please make sure the EM&A Manual will be prepared as a stand alone document and submitted for our comments/agreement (contact Mr Terrence TSANG, at Tel. : 2835 1151).	A separate EM&A Manual is not required by the Brief. The Contractor may be required to submit such a document at the detailed design stage.

Comments by Waste and Water Service Group

4.1	The discharge of active-area effluent is a concern even though the volume of such discharge is low.	Noted.
4.2	The risk of contaminated effluent discharge was estimated to be low (Section 5.4.3). However, this risk was predicted based on many assumptions on future operations. Furthermore, the Technical Memorandum (TM) prohibits the discharge of radioactive substances. In order to comply with TM and minimize the risk of radiation, the generation of liquid effluent should be avoided as a precautionary approach.	Noted. The Design Concept of the LRWF (which is a dry store) is to avoid contaminated waste discharges. However, the facility may generate some effluent under certain conditions and therefore this must be considered. We have been advised by our client and by DH that the TM would be revised so that it would not explicitly prohibit discharge of radioactive substances in effluent (see Section 4.2.2 para 2). It should be noted that hospitals, educational establishments and industrial users of radioactive materials regularly discharge radioactive effluent to sewer.
4.3	Section 5.4.3 - It is indicated here that the active liquid discharges will arise from the change rooms, cleaning floors or other areas, and possible liquor from decontamination of drums or equipment. It appears that these activities could be carried out in the dry. The design and operational procedures of the facility should aim for no generation of liquid effluent from the active area.	Noted. This is the design basis for the facility (see first sentence of Section 5.4.3). Clearly at the present stage of design a number of assumptions have needed to be made and a pessimistic approach to these has been adopted. It is planned that liquid effluents will be minimised as far as reasonable and many of the arisings are only routed through the 'active' effluent system are at worst suspect active (e.g. changeroom effluents under normal operations would not be active). In considering the process to adopt (i.e. dry or wet) a number of factors need to be considered including potential environmental impact, potential dose to members of the public, dose to operators etc. In this case it is considered that the discharge of the low levels of activity is the best solution. Processes for clean up of effluent are not justified due to the low levels of effluent expected.

4.4	Section 6.2, 1st para - The water quality control and mitigation measures during the construction phase should follow those specified in the ProPECC paper on construction site drainage (PN 1/94).	Noted.
4.5	Section 6.2, 3rd para - If effluent discharge is unavoidable, what kind of treatment will be used to reduce the radioactivity in active effluent before discharge?	The type of treatment will need to be decided at the time that discharge is required, dependant on volume, specific activity and types of radionuclides present. Various methods exist for solidification, volume reduction, or selective removal of nuclides (e.g. ion-exchange resins).
4.6	Section 4.2.2 - Please consult the Local Control Office (Territory South) of EPD regarding the 2nd para about an agreement between EPD and DH on issuing a licence for the discharge of radioactive substances. TM actually prohibits the discharge of radioactive substances. It is premature to discuss licencing before the EIA is completed and prior to justification on the need to generate active effluent.	Noted.

Comments by Air Policy Group

5.1	*Section 4.3.4 on pg 23* Radon is only an issue in confined space. Could the consultants please clarify whether the "significant" in the fifth line of the first para should have been "insignificant"?	Radon release is only a potential issue internal to the LRWF. Therefore the effect on ambient air quality will be insignificant.

From : Fire Services Department
Ref : (8) in FSD L/M 3065/95
Date : 25 April 1995

	I have no objection in principle to the proposed LRWF at Siu A Chau. The provisions of helicopter landing pad and marine access jetty are also supported. However, you are advised to take into consideration of the following marine access requirements to facilitate the approach of fireboat for fire fighting and rescue operation:	The provision of a jetty and berthing area of the dimension specified appears too onerous. The cost of extending the proposed jetty into deeper water, and/or extensive dredging, would appear to be prohibitively costly and would cause unnecessarily adverse environmental impacts. Alternative options will be discussed with FSD.
(i)	the depth of the jetty should not be less than -4.5m Chart Datum (CD);	
(ii)	a berthing length of not less than 50m should be provided;	
(iii)	the jetty should be suitable for the berthing of a vessel of 500 tons displacement; and	
(iv)	an approach navigation channel with a depth of not less than -4.5m CD should also be provided to the jetty.	

From : Gov't Secretariat, SPEL
Ref : (73) in PELB(E) 55/03/76(95)V
Date : 21 April 1995

I have no comments on the draft Environmental Impact and Safety Assessment Report for the captioned facility.

From : Gov't Secretariat, Finance Branch
Ref : (34) in FIN C9/43 (95) Pt 2
Date : 30 March 1995

I have no comment on the draft Environmental Impact and Safety Assessment Report.

From : Gov't Secretariat, Works Branch
Ref : (39) in WB (W) 1673/70/DR
Date : 7 April 1995

I have no comments on the EISA report.

From : Civil Engineering Department
Ref : GCP 1/10/456
Date : 19 April 1995

General Note: Since these comments and responses were submitted, reference to siesmic design has been deleted from the EISA report and will be considered fully in the document dealing with the Outline Design, which is a more appropriate place for such information.

1. *Section 5.6.6 Seismic*

(a) Para 2

A reference should be given for the statement that ". . . the most significant earthquake recorded in Hong Kong being approximately magnitude 3.5 on the Richter Scale". The period of observation should also be stated.	The consultants will look in more detail at requirements to be able to complete the specification in the Tender Documents.
Previous studies by consultants for the GEO revealed that the seismicity of the Guangdong Province is low to moderate. Earthquakes of magnitude much higher than 3.5 have been recorded (British Geological Survey Technical Report WC/92/17, 1992, refers). The potential damaging effect of such larger earthquakes in the vicinity of Hong Kong may be higher than that of small earthquakes occurring within the Territory itself.	Noted. We shall review the reference and obtain further data from the Royal Observatory and other relevant sources.

(b) Para 3

References should be given for the 'text books on seismic engineering'.	Noted.

The design base shear due to earthquakes should be assessed from the magnitudes of earthquakes expected, their epicentres, ground motion attenuation characteristics and seismic responses of the proposed structures. It is not sufficiently reliable to say that a design loading of 5% should be applied for an earthquake of magnitude 5.5.	Noted.
(c) Para 4	
Following on from (b) above, the inference that the return period of a magnitude 5.5 event is 1 in 120 years or more is not justified.	Noted.
The amplification effect of a low-rise building can be much larger than that of a bridge. Hence, the conclusion that wind loading will be the dominant criterion rather than seismic loading is incorrect and a proper assessment of the effects of earthquakes should be carried out.	Noted.
2. *Monitoring*	
With respect to radiological monitoring, I presume that natural background radioactivity levels on Siu A Chau (composed of granite) will be taken into account.	Natural background radiation will be accounted for. We would suggest that a survey is carried out on site prior to construction of the LRWF to provide a datum level.

From : Gov't Secretariat, Secretary for Security
Ref : (31) in SBCR 1/1336/86 Pt 9
Date : 4 April 1995

Please be informed that we have no comments on [the initial EISA report].

From : Department of Health
Ref : (60) in DH/RHU B5/8 XII
Date : 22 April 1995

(i) *Section 1.2, para 2, line 3*	
The Department of Health is the regulatory authority under the Radiation Ordinance.	Noted. Text amended.
(ii) *Section 3.1, para 2, last line*	
Please revise the site area basing on the comments given by Chief Land Surveyor/NT copied to you under my (59) in DH/ RHU B5/8 XII dated 22.4.95.	Noted. Text amended.
(iii) *Section 3.3, para 1, line 2*	
I commented on the conceptual design report that the operation block can be a two-storey building.	Noted.

(iv)	*Section 3.4.3.1, Lines 8 and 17*	
	The term 'higher activity' may be replaced with 'higher transport index' or 'higher external dose-rate', which are technically more accurate.	We note your comment and agree that radiation levels will be higher. However please note that the radioactive content of the material (e.g. number of Bq) will also be higher.
(v)	*Section 3.4.3.2, line 2*	
	'occupational workers' should be replaced with 'classified workers'.	Noted. Text amended.
(vi)	*Section 3.5, line 9*	
	'on-going operation' should be replaced with 'management'.	Noted. Text amended.
(vii)	*Figure 3.1*	
	There have been no changes on the layout despite my earlier comments on the conceptual design.	Figure shall be updated.
(viii)	*Section 4.1.1, para 4, line 1*	
	'radiation' should be replaced with 'radioactive'.	Noted. Text amended.
(ix)	*Section 4.2.2, para 2, line 5*	
	A licence should be obtained from the Radiation Board.	Noted. Text amended.
(x)	*Section 4.3.1, para 2*	
	The use of HEPA filtration for air treatment should be mentioned.	Noted. Text amended.
(xi)	*Section 4.5.2, para 1, line 2*	
	Delivery of existing waste to the LRWF will be made by the DBO contractor.	Your revision is noted.
(xii)	*Section 4.5.2, para 3*	
	The whole paragraph should be revised on the basis of my comment in (xi) above.	Noted.
(xiii)	*Section 4.5.2, para 4*	
	The requirement of a permit from the DH to transport radioactive materials should be mentioned.	Noted. Text amended.

(xiv) *Section 5.3.1, item (c)*

Replace 'the guidelines of the NRPB' with 'the dose limits prescribed in the Radiation Ordinance'.

Noted. Text amended. We note your comment but would note that the Radiation Ordinance limits are higher than NRPB guidelines (assuming constraints are applied) and do not provide such comprehensive guidance on limits as the NRPB documents. Furthermore it would no longer be accurate to credit all the limits in the list of bullet points on pg 33 to the Radiation Ordinance since as far as we are aware these are not quoted in the Radiation Ordinance. Clearly other references in the EISA report would need to be changed to be consistent with the reference to the Radiation Ordinance.

(xv) *Section 5.3.2, item (b), first sentence*

Replace with 'The radiation dose for both radiation workers and members of the public shall meet the limits prescribed by the Radiation Ordinance.

See response to (xiv).

(xvi) *Section 5.3.2, item (b), point 5*

Replace '0.3 mSv/y per year' with '1 mSv per year', delete the reference to NRPB and the Note that follows this point.

See response to (xiv).

(xvii) *Section 5.3.3, para 1, line 2*

Replace 'NRPB' with 'Radiation Ordinance'.

See response to (xiv).

(xviii) *Section 5.3.3, para 3 and 4 respectively on liquid and aerial discharge*

The limits presented do not comply with the concept laid down by the formula on page 21. In particular the formula refers to the sum total of the fractions of activities relative to the respective annual limits on intake, but Section 5.3.3 refers to <u>each</u> nuclide.

You are correct to highlight this issue as we have been proceeding on a different interpretation than that set out in Section 5.3.3. We propose to amend Section 5.3.3 to meet your requirements. Our understanding is that the formula is however separately applied for aerial and liquid discharges, i.e. two separate limits exist as described in the following equations.

$\Sigma_{ia}(A_{ai}/ALI_{al})\leq 10$
$\Sigma_{li}(A_{li}/ALI_{li})\leq 10$

where a and l refer to liquid and effluent discharges respectively.

It is assumed that the inhale ALI is used for aerial discharges and the ingest ALI is used for liquid discharges, the limits being taken from ICRP 61. We have reviewed the calculations using this interpretation and the impact is as follows:

<u>Section 5.4.3 and 5.4.4</u>
Discharges are predicted to be within normal Hong Kong guidelines although noted that only one nuclide considered (i.e. Pm-147). For

		liquid discharges Pm-147 accounts for 2.8 of the 10 units 'available'. For aerial discharges the Pm-147 only accounts for a very small fraction. Section 5.6.1.1 Unplanned release exceeds Hong Kong guidelines but this was also the case using previous interpretation and is not regarded as significant because; guidelines are understood only to apply to normal planned releases and other evaluations suggest risk is tolerate.
(xix)	Table 5.1 has been omitted.	Noted.
(xx)	*Section 5.4.1.3, para 1, line 2* Replace 'UK NRPB' with 'Radiation Ordinance'.	See response to (xiv).
(xxi)	*Section 5.4.1.3* I assume that Table 5.1 is a summary of the results presented in Appendix D. My general comments on the dose uptake assessment in Appendix D is that the assessment has taken very conservative assumptions for most parameters. This is an acceptable approach. It is expected that the assessed doses are likely to be over-estimating the actual doses, despite large uncertainties exist.	Table 5.1 is a summary of results presented in Appendix D. Your comments are noted.
(xxii)	*Pg 40, line 2* Please indicate whether air treatment by HEPA filters is considered for the gaseous discharge route.	Use of HEPA filters has been assumed for aerial discharges.
(xxiii)	*Pg 40, line 13* Replace '0.03 mSv/yr' with '0.1 mSv/y' basing on my comment in (xvi).	See response to (xiv).
(xxiv)	*Pg 46, line 7* Correct the typing error for 'calculation'.	Noted. Text amended.
(xxv)	*Pg 46, Road/Sea Transportation Incident, lines 1 and 2, and Road Accident, line 2* The word 'Mainland' should be clarified to exclude the meaning of 'places in China'.	Noted. Text amended.
(xxvi)	*Section 5.6.3.3* Radiological monitoring instruments should be provided with redundant uninterruptible power supplies or on mains chargeable batteries to avoid being affected by power failures.	Back up power supplies can be provided on radiological instruments if required. However we would suggest the DBO Contractor be left to determine this since it may not be necessary if power failures occur with an acceptably low frequency.

(xxvii) *Section 5.6.4.1*

Since ventilation and fire suppression systems are to be linked to fire detection systems, there are needs to provide redundancy and coincidence in the detection systems to minimise the chances of false alarms.

Noted. Redundancy/voting systems should be provided if the reliability of the system is unacceptable without such systems.

(xxviii) *Pg 57, para 1, line 3*

Replace 'facility' with 'jetty'.

Noted. Text amended.

(xxix) *Section 5.6.6, para 3, line 6*

Please check if '0.5 times' is really the correct factor.

This was a typo. 0.05 is correct.

(xxx) *Section 7.1.3*

The operation of the LRWF is bound by the Radiation Ordinance. Before commissioning, the DBO contractor will have to apply for a licence to possess, transport and store radioactive materials from the Radiation Board.

Noted.

(xxxi) *Section 7.1.5, para 2*

It may need to be rewritten basing on the final arrangements of a 24-hours incident command centre.

Noted. Text will be amended.

(xxxii) *Section 7.2 and its subsections*

The contingency plans should be revised basing on the final arrangements of a 24-hours incident command centre. Consideration should be given to contracting out to a private contractor. It should be clarified whether the DBOER needs to be a radiological expert. Consideration should be given to providing a central computer with modem at the LRWF, which would enable DHPD or other experts to log in remotely any where in Hong Kong for access to on-site and near-site radiological, environmental, fire and security information to facilitate emergency response actions.

Noted. If the arrangements for the 24 hour 'command centre' change then revisions will need to be made. We envisage that the DBOER should be suitably qualified in radiological matters to provide advice at times of an incident. He/she should also of course be familiar with the facility. If a modem facility is required then this can be provided although clearly there will be a cost associated with such a facility. Consideration will also need to be given to how the modem link will be established given that there are at present no telephones on Siu A Chau.

(xxxiii) *Section 9.1.1.8*

The environmental monitoring system should also measure and report ambient gamma dose rate and periodic accumulated dose. All monitoring data should be collected at an on-site central computer with dial-up log-in accessibility.

It should be possible to measure 'ambient' or a 'background' dose rate from the installed monitors in the facility.

(xxxiv) *Section 11*

A reference to the Hong Kong Radiation Ordinance, Chapter 303, Laws of Hong Kong should be included.

See response to (xiv).

From : Marine Department
Ref : (63) in PA/S 909/2/96
Date : 13 April 1995

(a) It is noted that certain assumptions have been made on the marine transportation issues even although the size and type of vessel to carry the waste materials has not yet been decided. Similarly no detailed design of the landing facility at Siu A Chau, including depth requirements alongside, has been agreed and it is therefore important that both the vessel type and size and landing facility at Siu A Chau be agreed before the Detailed EISA mentioned in Section 10.10 of the Draft EISA is carried out.

We are aware of the need to confirm the requirements for the jetty design and discussions are in progress with Marine Department and FSD.

(b) Details of the vessel loading points on Hong Kong Island (Section 3.4.1 of the Draft EISA refers) will also have to be agreed for consideration under the Detailed EISA).

Noted.

(c) It is noted that all the transport arrangements will be in accordance with the IAEA Transport Regulations. Although these regulations form the basis of the International Maritime Dangerous Goods (IMDG) Code it is important that the marine transportation of the materials in question must wholly comply with and be packaged, labelled and carried in accordance with the IMDG Code.

Noted.

From : EMSD
Ref : NU/13/02
Date : 13 April 1995

1. *Chapter 3 : Description of the Proposed Storage Facility*

It is not clear whether the total site area of 0.58 ha as stated in Section 3.1 includes the area for future extension to provide additional capacity. This may affect the site formation area required.

The site area includes for future extension of the LRWF, if required.

2. *Chapter 4 : Potential Non-Radiological Impacts*

If diesel generator is required for providing emergency power supply to the LRWF, the associated noise and air quality impacts should be considered and properly addressed.

Such impacts are considered, in this location, to be negligible. Further consideration may be required at the detailed design stage (for instance, an emergency generator is probably not required).

3.	*Chapter 5 : Preliminary Radiological Safety Assessment*	
	(a) Emergency power supply should be provided for the LRWF to sustain the continuous operation of the fire detection and suppression system, essential lighting and the essential radiological monitoring/ protection system.	Battery backing can be considered for provision of emergency power supplies. However the DBO contractor should be allowed to determine if these are necessary based on an assessment of the reliability of systems.
	(b) Table 5.1 on summary of dose uptake assessment is missing.	Noted.
	(c) The numbering of the items - "Building Services Failure" and "Wrong Waste Delivered" on page 42 should be (iii) & (vii) instead of (ii) & (vi).	Noted. Text amended.
	(d) The first sentence of page 51 - "until controlled conditions" should be replaced by "under controlled conditions".	Noted. Text amended.
	(e) Emergency water supply should be provided for personal decontamination purpose.	Noted. Showers have been specified in the outline design.
4.	*Chapter 7 : Recommended Radiological Protection & Mitigation Measures*	
	The necessity of requiring the DBO Contractor to participate in exercise/drill on the contingency plan and the necessity of specifying the response time of the Contractor during emergencies should be thoroughly examined.	It is a good idea that the DBO contractor be required to carry out/participate in an emergency exercise, and that a minimum response time should be specified.
5.	*Chapter 8 : Proposed Environmental Monitoring and Audit*	
	It is presumed that the DBO Contractor will be required in the Contract to employ qualified and independent environmental team for environmental monitoring and audit.	Your assumption is correct.
6.	*Chapter 9 : Proposed Radiological Monitoring*	
	(a) Item (a) of Section 9.1.1.6 should be portable 'dual' contamination probe(s) instead of 'duel' contamination probe(s).	Noted. Text amended.
	(b) Portable surface contamination monitors may be more appropriate than doserate meters in monitoring the incoming packages/drums.	Contamination probes are included in items (a) and (c) of Section 9.1.1.6 for monitoring incoming drums/ packages. It is envisaged that all incoming packages/ drums will be monitored on receipt for contamination.
	(c) Digital electronic personal dosimeters with audible alarm at preset dose rate and dose levels should be provided for the personnel working in waste processing and storage vault areas.	Item (e) of Section 9.1.1.6 covers this point.

(d) On-line radiological data from the Storage Facility should be related to an appropriate remote monitoring centre.

It is planned that appropriate radiological data will be relayed to the remote monitoring centre.

From : Architectural Services Department
Ref : ASD 10/96152/ENV/RAD/1
Date : 11 April 1995

(a) *Building, Structural and Building Services Systems*

The EISA Report mentioned in its Para 3.1, 3.2, 5.6.3 and 5.6.4 certain aspects of the building, structural, and building services systems' design requirements which were related with the EISA. However, the requirements and design criteria of such systems to be required in the Storage Facility were only touched minimally in the Working Paper No.1 (Basis of Design and Functional Specification) which was issued before this report. I presume that the detailed requirements will be fully addressed in your mentioned coming Working Paper No.2.

The detailed requirements will be discussed in Working Paper No.2.

(b) *3.1 - Outline Design*
3.2 - General Characteristics of the Proposal

It is noted that a sketch preliminary building layout plan is shown in the report. Whereas it is only indicative, I suggest that FSD may be approached in order to clarify the classification of the building, to preliminarily identify the areas of special risks and the necessary FS requirements. These preliminary key information will be very useful as it may have implications on the building dimensions, structural requirements and the FS systems to be required. For example, if sprinkler system is to be required, water tank may be required and the overall building height may be affected.

Our initial design approach is to classify the building as "EXTRA LIGHT hazard" which will be, of course, revised subject to comments from FSD. Dry sprinkler system and water tank will be provided. All these details will be discussed in Working Paper No.2.

(c) *5.6.3.1 Electricity Supply*

(i) The requirement of emergency power supply to essential services e.g. fire alarm and detection system, security system, monitoring system etc. should be assessed.

The requirement of emergency power supply will be assessed in Working Paper No.2.

(ii) As some areas of the Storage Facility may be classified as hazardous areas, the safety of using electrical equipment in hazardous areas should be assessed such that the requirements for electrical equipment specially designed for application in the hazardous areas in the Facility can be considered and addressed in your Working Paper No.2.

We would like to clarify that the "hazardous areas" in the Storage Facility refers to the areas where a person may be easily subject to radiation only. The electrical equipment is therefore not necessary to be specially designed for application in the hazardous areas.

(d) *5.6.4.1 - Fire Within the Building*

(i) Normally, there are relevant FSD and statutory requirements regarding the DG Stores for the storage of dangerous goods (including pressurised gas cylinders). I presume these requirements where applicable will be addressed in your coming Working Paper No.2.

It is understood that the waste stored in the facility is unlikely to be inflammable and only minimal amounts of pressurised gas cylinders will be stored.

The waste is dangerous only because of its nature of emitting radiation. Accordingly, we considered that the requirement for the storage of dangerous goods is not applicable.

(ii) *Electrical*

I presume the criteria, standards and method of cable sizing will be addressed in your coming Working Paper No.2.

Noted and Agreed.

(iii) *Mechanical Heating*

You mentioned that "neither the fire detection nor suppression design is known" at the current stage of development. However, as indicated in above item (b), the FS systems to be required may be quickly identified with preliminary discussion with FSD about this project.

As fire hazard is one of the major risks critical to the safety of the Facility, I think that it is beneficial if a preliminary assessment of fire risk can be worked out. In fact, the assessment may form part of the basis for derivation of detailed FS requirements which, I suppose, will be elaborated in your Working Paper No.2.

Fire detection system will be provided in the Facility and the alarm system is proposed to be linked to FSD.

From : Islands District Office
Ref : (44) in IS 155/1/14 II
Date : 21 April 1995

(a) *Impact on Fisheries*

- As pointed out in Section 2.4.2 of the Report, the area of Siu A Chau is a potentially important capture fisheries and marine fish culture zone. Therefore, the impact of the project on fisheries should be addressed in greater detail.

A further EISA will be commissioned as part of the detailed design. AFD have advised that the annual average fish production in the vicinity is $1500 per hectare and thus it seems unlikely that impact on fisheries would be significant.

- In case the containment of a storage drum or package is dropped into the sea, will there be any adverse impact on fisheries?

Impact will depend on the actual waste content of the drum, the circumstances of the accident (i.e. the likelihood that containment will be breached) and the location of the accident. However, drums/packages will comply with IAEA transport regulations which are internationally accepted. The probability of an accident with associated health risks has been assessed in the EISA to be very small. The risk of an accident resulting in an impact on fisheries is therefore extremely small.

(b) *Assessment of Hazards*

Section 5.6 gives an assessment on the possible hazards related to the development. Have human factors such as vandalism been taken into account when assessing the risk level of the facility? Given the remote location of the proposed development, outsiders could easily reach the site (especially after the construction of the jetty) without being noticed.

The risk and consequences of vandalism have been addressed and are considered to be insignificant. The LRWF design and security measures, including 24-hour security surveillance (remote monitoring) will minimise any risk.

From : District Lands Office, Islands
Ref : (34) in DLO/IS 10/1/10 Pt 2
Date : 2 April 1995

No comment please.

From : Planning Department
Ref : (57) in LI/D/LP/16 III
Date : 19 April 1995

1. *P. 4, Para. 2.2 - Planning Context*

Please note that according to the Interim Recommended Strategy (IRS) of the SWNT Development Strategy Review (DSR), the central portion of the island is also recommended as the potential area for tourist development.

Noted and text amended. The proposed LRWF would have very limited effect on planned use for the central portion of the island.

2. *P. 12, Para. 2.10.3 - Visual Characteristics of the Site and Environs*

With proper selection of plants and vegetation, surely, soft landscape would look better than a free standing hard structure.

Any landscaping proposals would need to take into account the natural setting and paucity of large vegetation. The use of natural exposed rock with grasses and low shrubs is most appropriate in this context.

3. *P. 17, Para. 3.4.3.3 - Manning*

Since the site will not be permanently manned, further information on how the site will be secured from outsider should be provided. You may wish to note that Siu A Chau is a popular bathing place during the summer season.

The facility will be secure from intrusion (minimal number of potential entry points, each with secure protection and remote surveillance). We are aware that the main beach area of Siu A Chau attracts summer visitors.

4. *P. 26, Para. 4.5.1 - Construction*

I doubt there is a genuine need to use helicopter (which is mainly for emergency use) to deliver some items and personnel to the site for reason of remoteness given that there is a helipad at Tai A Chau.

Paragraph refers to delivery of construction plant and equipment. However, it is most likely that delivery of all materials and equipment would be by sea.

5.	*P. 28, Para. 4.7 - Potential Visual Impact*	
	It is considered that some sort of landscaping measures should be incorporated in order to soften the hard surface of the structure. In addition, the application of natural colour to the building could also help to mitigate the visual impact.	Noted. See point 2.
6.	*P. 36, Table 5.1 - Summary of Dose Uptake Assessment*	
	It seems that Table 5.1 is missing.	Noted.
7.	*P. 61, Para. 6.1 - Ecology*	
	It is considered that all cut/fill slope should be properly turfed or hydroseeded.	Some cut slopes may be too steep for turf or hydroseeding. Some vegetation would be possible using open concrete blocks, netting, etc.
8.	*P. 64, Para. 6.7.7 - Outline Tender Approach*	
	It would also be worth considered to include in the 'Performance Specification' the criteria for incorporation of certain type of soft landscape as visual screening.	Noted.
9.	*P. 68, Paras. 7.2.1 & 7.2.1.1 - Outline Contingency Plan*	
	Since the facility is unmanned most of the time, an emergency plan with an estimate of response time from relevant parties (viz. Fire Services, DBO Contractor Emergency Representative etc.) should also be included in order to support the actions as described in the outline contingency plan.	Noted. A preliminary contingency plan is included in Section 7.2. This will be further developed by the DBO Contractor and it is agreed that an estimate of response time should be included.

From : Agriculture and Fisheries
Ref : (21) in AF DVL 13/52
Date : 18 April 1995

Further to my fax of 18th April 1995 I am to advise you that we have no comment on your draft EISA report.

APPENDIX H
RESPONSES TO COMMENTS ON THE FINAL EISA REPORT

RESPONSES TO COMMENTS ON THE FINAL EISA REPORT
LOW-LEVEL RADIOACTIVE WASTE STORAGE FACILITY

COMMENTS	RESPONSES
From : EPD, Headquarters Ref : EP 122/R1/2 VI Date : 26 May 1995	
Comments by Special Waste Facilities Group	
(1) The Report should be revised in accordance with the discussions of the EIA working group meeting held on 25.5.95 including those associated with the following issues:	
(a) option of dry facility design in connection with effluent discharge containing radioactive substances;	Noted.
(b) DBO contract to specify the jetty construction period and the latest jetty design as agreed with FSD; and	Noted.
(c) findings of the basic marine ecology survey undertaken in the week of 29.5.95, if available, and revision of the requirement of further marine ecology survey.	Noted.
(2) *Section 7.2 - Outline Contingency Plan* should be revised in accordance with the latest arrangements as agreed with RHKPF and that of the 24 hours manned remote monitoring centre operated by the DBO contractor.	Noted.
(3) 'Contractor' should be added to the end of Section 7.2.1(c).	Noted. Text amended.
From : Dept. of Health Ref : (60) in DH/RHU B5/8 XIII Date : 22 May 1995	
Page 33, Section 5.3.2(b) We have commented before to revise the first sentence to read as "The radiation dose for both radiation workers and members of the public shall meet the limits prescribed by the Radiation Ordinance." Please amend it accordingly.	Noted. Text amended.
Page 33, Section 5.3.2, 5th point Please delete the remark "(a constraint in Radiation Ordinance terms)" since it is entirely meaningless.	Noted. Text amended.

Page 33-44, Section 5.3.3

We have commented before that there is inconsistency between the concept given by the formula on page 21 and those described in this section for liquid and aerial discharges. You have responded to amend this section by making reference to the sum of fractional ALIs for individual nuclides though there are separate limits for liquid and effluent discharges. Hence, please amend the wording to reflect this.

Noted. Text amended.

Page 41, Section 5.5.1

You have listed eight items for hazard assessment of which "Seismic" is the sixth one. But in subsequent sub-sections under section 5.6, assessment on seismic hazard seems to have been omitted. Please supplement one in this aspect.

Seismic hazards to be reviewed separately.

From : Planning Department, DPO/L&I
Ref. : (36) LT/D/LP/16 (IV)
Date : 24 May 1995

Please be advised that I have no specific planning comments on the said report. However, it should be noted that the South West New Territories (SWNT) Development Strategy Review has yet to be finalized and that the Interim Recommended Strategy of the SWNT Development Strategy Review has in fact been agreed by the Development Progress Committee as a guide for planning and processing development proposals in the SWNT sub-region. Hence, you may wish to rephrase the second sentence of the first paragraph under section 2.2 on page 2 to reflect this.

Text amended.

From : Planning, Environment & Lands Branch
Ref. : (8) in PELB(E) 55/03/76(95) VII
Date : 31 May 1995

line 4 Para 2 Section 10.11 Page 81

"or radioactivity" should read "of radioactivity"

Text amended.

From : District Lands Office, Islands
Ref. : (74) in DLO/IS 10/1/10 Pt. 2
Date : 25 May 1995

My interest in the study report is regarding the timing for those proposed works under paragraph 3 relating to:

(i) The land allocation for the proposed storage facilities;

(ii) The gazetting of the jetty; and

(iii) the submission of a clearance application form (CAF).

Unless the above applications/submissions are submitted in time, they may affect your planned programme.

Gazette Notice for jetty construction has been submitted to EPD. We understand that EPD are responsible for clearance application form and land allocation matters.

From : Electrical & Mechanical Services Department
Ref. : NU/13/02
Date : 24 May 1995

Section 3.4.3.2

In addition to the handling, decontaminating, packaging and recording equipment, the Waste Processing Area should contain appropriate radiological monitoring equipment as per Chapter 9.

Noted. Refer to Section 9.1.1.3.

Table 5.1 - Summary of Dose Uptake Assessment

There is a minor arithmetic error in the calculation of the annual total dose for Operator 2. The annual total doses for Operator 2 in Year 1 and Year 2 during normal operation should be 15573 μSv and 517 μSv respectively instead of 15571 μSv and 516 μSv.

Noted. This does not affect the conclusion.

Section 5.4.1.2

As indicated in Table 5.1, the estimated amount of PM-147 to be delivered to the LRWF would be 4 packages instead of 3 packages.

Text amended.

Section 7.2.1 (c)

The type and quantity of radiological monitoring and protective equipment to be provided by the DBO Contractor as well as the future storage place for these equipment should be determined and specified. Suitable training may be required for the government emergency staff to operate these equipment during the event of an incident.

The DBO Contractor will specify equipment and formalize the contingency plan with Emergency Services.

Section 10.10

To tally with the second paragraph of Section 5.1 of the Draft Executive Summary, the last sentence of the 7th paragraph should be replaced by 'discharges likely to contain radioactive material would be licensed by the Radiation Board'.

Text amended.

From : Electrical & Mechanical Services Department
Ref. : NU/13/02
Date : 5 June 1995

Section 2.4.2

Replace the word 'reviwed' in the 2nd line of the first paragraph by 'reviewed'.

Text amended.

Section 3.4.3.2

In addition to the handling, decontaminating, packaging and recording equipment, the Waste Processing Area should contain appropriate radiological monitoring equipment as per Chapter 9.

Noted. Refer to Section 9.1.1.3.

Section 4.2.2

Replace the work 'maay' in the last line of the first paragraph by 'may'.

Text amended.

Section 5.3.1 item (c)

Replace the phrase 'as a result of normal operation of the operation of the LRWF' by 'as a result of normal operation of the LRWF'.

Text amended.

Table 5.1 - Summary of Dose Uptake Assessment

The table is missing.

Noted. Table added.

Section 5.4.1.2

according to page D-5 of Appendix D, the estimated amount of PM-147 to be delivered to the LRWF would be 4 packages instead of 3 packages.

Noted. Text amended.

Section 7.1.5

To tally with Section 7.2, the key data that require 24-hour monitoring should be relayed to a 24-hour monitoring centre manned by a private security contractor or a similar proposed by the DBO Contractor.

Noted. Text amended.

Section 7.2.1 (c)

The type and quantity of radiological monitoring and protective equipment to be provided by the DBO Contractor as well as the future storage place for these equipment should be determined and specified. Suitable training may be required for the government emergency staff to operate these equipment during the event of an incident.	Noted. This will be addressed in detail by the DBO contractor.
From : Department of Health **Ref. : (28) in DH/RHU B5/8 XIV** **Date : 5 June 1995**	
A type error on page 21, first paragraph under Section 4.2.2 Operation, the last third word of the last sentence should be 'may'.	Text amended.
From : Agriculture & Fisheries Department **Ref. : (50) in AF DVL13/52** **Date : 6 June 1995**	
(i) The results of the sub-tidal survey should be incorporated in the relevant sections of the draft Executive Summary (Section 4.1) and EISA Report (Sections 2.4.2, 4.1.2, 10.2). The flora and fauna list should also be included, perhaps as an appendix, in the draft EISA Report.	Additional text added. Appendix added.
(ii) The preliminary results of the survey indicated that two species of corals of conservation value occur in the survey area. As they are species highly sensitive to suspended sediments and will take a long period of time for recovery/recolonisation after damage, effective mitigation measures should, therefore, be devise to minimise the impacts of construction of jetty on them and included in the EISA report (Section 6.1).	Text added.
(iii) Minor comments	
<u>EISA Report</u> Section 2.4.2, Para. 1: replace 'reviwed' by 'reviewed'. Section 2.4.2, Para. 2: replace 'Swire Marine Laboratory' By 'Swire Institute of Marine Science'	Text amended.
From : Environmental Protection Department **Ref. : EP 122/R1/2 VI** **Ref. : 7 June 1995**	
<u>Comments by Special Waste Facilities Group</u> *Page 17, Section 3.4.3.4, Line 1* "Contrator" should be corrected.	Text amended.

Page 21, Section 4.2.2, Line 6

"appproach" and "maay" should be corrected. — Text amended.

Page 77, Section 10.2, Para 2

As discussed at the meeting on 25.5.1995, the months of the critical periods which should be avoided should be specified. Recommendation of incorporating the above requirement in the tender document should be included. — Text amended.

Page 80, Section 10.10, Sub-para 1 of Para 2, Last line

"EPD with the help of recommendations by DH" should be changed to "the Radiation Board". — Text amended.

Comments by Waste & Water Services Group

(i) Section 4.2.2, 2nd paragraph, 5th sentence - This sentence seems to imply that discharge would be allowed if a licence is issued under the Radiation Ordinance. This should be rewritten to clarify that a "dry facility" is required unless the detailed Stage 2 EISA demonstrates that discharge of active effluent will create no adverse impacts. A licence for discharge may also be required under the WPCO. — Noted.

(ii) Section 5.4.3, 1st paragraph - "Discharge of active effluent is prohibited before any agreement is reached with EPD on the discharge limits" should be added after the 1st sentence. "Before any agreement is reached with EPD on discharge limits" of the original 2nd sentence should be deleted. It should be made clear that the particular "Hong Kong Government" guidelines are not from EPD and the monthly limit of 500 MBq (from Radiation Ordinance) applies to protection of human health only. The impact assessment of effluent discharge is over simplified. — Text amended.

Comments by Regional assessment Group

Section 3.4.1, 1st para and Section 3.4.3.1, 1st bulletin

Department of Health has indicated at the Working Group meeting on 25.5.95 that repackaging work for the existing waste in the QRE tunnel is underway, these paras. needs to be rephrased to reflect this situation. For Section 3.4.3.1, 1st bulletin, suggest inserting "completely" between "been" and " repackaged". — Text amended.

Section 4.1.2, 1st para

Depending on the survey of rare marine species in the vicinity of the jetty construction, the consultants should include a sentence to describe whether any rare marine species will be affected by the jetty construction. — Additional text inserted.

From : Department of Health
Ref. : (31) in DH/RHU B5/8 XIV
Date : 7 June 1995

It has been estimated, in section 4.2 (p.7, last paragraph) of the draft Executive Summary as well as in section 5.4.3 (p.40, last paragraph) of the final EISA Report, that ingestion of 25 litres of sea water would give rise to the annual dose limit. In the first draft of the Report, the dose limit was set as 0.03 mSv, but subsequently, this limit has been revised to 0.1 mSv. The amount of water ingested thus need to be scaled up accordingly by about 3 folds, i.e. 75 litres, in order to reach a dose of 0.1 mSv. Please also amend the "25 litres" mentioned in the paragraph followed in the EISA Report.

Text amended.

From : Finance Branch, Government Secretariat
Ref. : (39) in FIN C9/43/(95) Pt3
Date : 7 June 1995

I have no comment on the technical details contained in the draft EISA Report and the executive summary. There is however one general question - the optimum storage capacity. With reference to paras 3.21 and 3.42 of the report, it would be useful to know whether the proposed purpose-built LRWS facility will have adequate holding capacity to take care of the existing and future arisings through carefully calculated gradual decantation of existing (decontaminated) wastes after a certain period of time so as to maintain enough space to absorb new arisings. This designed phasing-in and our capacity is important if we are to avoid the need to build a second facility in the event the first one becomes 'FULL' in say 10 or 20 years.

The facility has a design capacity for approximately 20 years of waste arisings, based on reasonably conservative assumptions regarding the volume of existing arisings and current uses. The volume generated over the next 20 years could of course change (increase or decrease). There will be spare capacity in the long term due to disposal of decayed waste (i.e. removal from the LRWF). In addition, if stacking of drums is permitted within the facility, a large amount of extra capacity would be provided (sufficient for about 80 years of arisings).

From : Civil Engineering Department
Ref. : GCP I/10/456
Date : 7 June 1995

The Civil Engineering Department has only the following minor comments to make on the captioned report and the Executive Summary for that report.

(i) It is noted that, as agreed, the matter of seismicity has now been omitted from the report and is instead covered in the Outline Design Report. Thankyou.

Noted.

(ii) In Section 1.3, para 2, of the Report and Section 1.2, para 2, of the Executive summary, it is stated that "The structural condition of the Queen's Road East tunnels has been found to be unsatisfactory etc" Please would you delete the word 'structure' as it is wrong to say that the structural condition is unsatisfactory at the present time. This Department has spent a considerable amount of money over the last few years in carrying out remedial works to the tunnels to improve their stability.

Text amended.

From : Planning Department, DPO/L&I
Ref. : (55) LI/D/LP/16 (IV)
Date : 6 June 1995

Please be advised that I have no further planning comments on the EISA report and the ES. However, it is noted that our comments made on 24.5.95 (copy attached) regarding para. 2.2 of the aforementioned documents have not been incorporated. They should be refined to reflect the real situation.

Text amended.

From : Fire Services Department
Ref. : (61) in FSD 6/130/91 II
Date : 5 June 1995

Please be advised that my previous comment dated 31.5.95 in the same series still stand. Enhanced fire safety requirements will be formulated upon receipt of formal building plans submission.

Noted.

From : Fire Services Department
Ref. : (56) in FSD 6/130/91 II
Date : 31 May 1995

I have no specific comment on the both EISA report and its Executive Summary. Yet, in light of the jetty is only -3 m PD which will only be accessible by medium fire boats, enhanced fire safety requirements will be formulated during the submission of building plans.

Noted.

From : Fire Services Department
Ref. : (57) in FSD 6/130/91 II
Date : 31 May 1995

Having taking into consideration the site constraint expressed by your Ms Lindsay Pickles and in order not to delay the project advancement, your proposal of reducing the depth of the jetty to -3.0m PD is acceptable in principle. However, as the depth of water is only sufficient to accommodate a medium fire boat, enhanced fire safety requirements will be incorporated during the building plans submission in order to provide self-contained fire protection facilities within the island.

Noted.