

Annex A1

# Contamination Assessment Plan (CAP)



# Contamination Assessment Plan for Decommissioning of the Co-Combustion Pilot Plant at Tap Shek Kok

**Green Island Cement Company Limited**

7 January 2008

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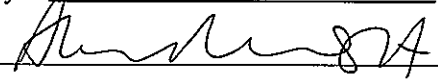
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Green Island Cement Company Limited

## Decommissioning of the Co-Combustion Pilot Plant at Tap Shek Kok

January 2008

For and on behalf of ERM-Hong Kong, Limited
Approved by: <u>Alastair McNair Scott</u>
Signed: <u></u>
Position: <u>Partner</u>
Date: <u>7<sup>th</sup> January 2008</u>

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## TABLE OF CONTENTS

<b>1</b>	<b>INTRODUCTION</b>	<b>1</b>
<b>1.1</b>	<b>BACKGROUND TO THE STUDY</b>	<b>1</b>
<b>1.2</b>	<b>OBJECTIVE OF THE CAP</b>	<b>1</b>
<b>1.3</b>	<b>ENVIRONMENTAL LEGISLATION AND NON-STATUTORY GUIDELINES</b>	<b>2</b>
<b>2</b>	<b>SITE APPRAISAL</b>	<b>3</b>
<b>2.1</b>	<b>SITE SETTING</b>	<b>3</b>
<b>2.2</b>	<b>SITE DESCRIPTION</b>	<b>3</b>
<b>2.3</b>	<b>PROPOSED DECOMMISSIONING OF CCPP</b>	<b>4</b>
<b>2.4</b>	<b>SITE HISTORY</b>	<b>5</b>
<b>3</b>	<b>POTENTIAL SOURCES OF SOIL AND GROUNDWATER CONTAMINATION</b>	<b>8</b>
<b>3.1</b>	<b>POTENTIAL HISTORICAL SOURCES</b>	<b>8</b>
<b>3.2</b>	<b>POTENTIAL CURRENT SOURCES</b>	<b>8</b>
<b>3.3</b>	<b>POTENTIAL FUTURE SOURCE</b>	<b>10</b>
<b>3.4</b>	<b>CONCEPTUAL MODEL OF POTENTIAL POLLUTANT LINKAGE</b>	<b>10</b>
<b>4</b>	<b>POTENTIAL HUMAN HEALTH AND ENVIRONMENTAL IMPACTS</b>	<b>12</b>
<b>4.1</b>	<b>EVALUATION OF IMPACTS</b>	<b>12</b>
<b>4.2</b>	<b>POTENTIAL IMPACTS</b>	<b>12</b>
<b>5</b>	<b>SITE INVESTIGATION PLAN</b>	<b>15</b>
<b>5.1</b>	<b>INTRODUCTION</b>	<b>15</b>
<b>5.2</b>	<b>PROPOSED SITE INVESTIGATION</b>	<b>15</b>
<b>6</b>	<b>CONCLUSIONS AND RECOMMENDATIONS</b>	<b>19</b>
<b>6.1</b>	<b>CONCLUSIONS</b>	<b>19</b>
<b>6.2</b>	<b>RECOMMENDATIONS</b>	<b>19</b>
	<b>ANNEXES</b>	
<b>ANNEX A</b>	<b>THE GUIDANCE MANUAL FOR USE OF RISK-BASED REMEDIATION GOALS FOR CONTAMINATED LAND MANAGEMENT AND THE GUIDANCE NOTE FOR CONTAMINATED LAND ASSESSMENT AND REMEDIATION</b>	
<b>ANNEX B</b>	<b>SITE LAYOUT PLAN AND SITE PHOTOGRAPHS</b>	
<b>ANNEX C</b>	<b>SITE ARIAL PHOTOGRAPH</b>	
<b>ANNEX D</b>	<b>HISTORICAL PHOTOGRAPHS</b>	
<b>ANNEX E</b>	<b>PROPOSED SAMPLING LOCATIONS</b>	
<b>ANNEX F</b>	<b>RESPONSE TO COMMENTS</b>	

# 1 INTRODUCTION

## 1.1 BACKGROUND TO THE STUDY

As part of the research programme, in collaboration with the Hong Kong University of Science and Technology (HKUST), to develop a new thermal treatment process for municipal solid waste (MSW), the Co-Combustion Pilot Plant (CCPP) was constructed in a designated area inside the Green Island Cement Plant site (GICP). For the purposes of this report, the designated area in which the CCPP was constructed will be referred to as the Site. The GICP is located at Tap Shek Kok, Tuen Mun. The CCPP was constructed in 2004 and has been permanently shutdown since the completion of the pilot plant study in December 2005. Green Island Cement Company Limited (the Client) has now initiated a project to demolish the existing CCPP, to remove the disused equipment and disposal of waste materials generated thereof (the Project).

The Project is a designated project under Schedule 3, Item of Part II, Schedule 2 of the Environmental Impact Assessment Ordinance (EIAO): “Decommissioning Projects: A municipal, chemical or clinical waste incinerator”. An environmental impact assessment (EIA) study brief was issued for the Project by Environmental Protection Department (EPD) in June 2007 (EIA Study Brief No. ESB-164/2007).

In compliance with one of the EIA requirements, a contamination impact assessment should be conducted to evaluate the land contamination impact due to the past land uses at the Site. In accordance with the EIA Study Brief, a Contamination Assessment Plan (CAP) should be prepared and submitted to the Director of Environmental Protection (the Director) for endorsement prior to conducting the contamination impact assessment,

ERM-Hong Kong, Ltd (ERM) was commissioned by the Client to conduct a contamination impact assessment of the Site in accordance with the EIA study Brief requirements and this report describes the Contamination Assessment Plan (CAP) for the contamination impact assessment. A site appraisal was carried out by ERM auditors on 16 August 2007.

## 1.2 OBJECTIVE OF THE CAP

The purpose of the CAP is to provide information, guidance and instruction for characterising land contamination at the proposed project area prior to the site works for demolition of the CCPP. This CAP aims to provide systematic procedures for identifying any potential sources of land contamination, identify contaminants of concern, evaluate the potential receptors, exposure pathways (if any) and the potential impacts from such contamination to the receptors. The CAP will determine and detail the requirements, if any, for a programme for the intrusive site investigation of the Site, to identify the

nature and extent of the on site contamination. The specific tasks of the CAP include:

- Review of background information on, and land history of, the Site in relation to possible land contamination;
- Identification of potential contamination and associated impacts, risks or hazards; and
- Submission of a contamination assessment plan for agreement with the EPD prior to its implementation.

### 1.3

#### *ENVIRONMENTAL LEGISLATION AND NON-STATUTORY GUIDELINES*

The assessment of land contamination sources and the potential impacts to particular development projects will be investigated in accordance with the guidelines set out in the Environmental Protection Department's (EPD) *Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management* (the RBRG Guidance Manual), the associated *Guidance Note for Contaminated Land Assessment and Remediation*, and the EPD's *Guidance Notes for Investigation and Remediation of Contaminated Sites of Petrol Filling Stations, Boatyards, and Car Repair/Dismantling Workshop*.

The *RBRG Guidance Manual* and the *Guidance Note for Contaminated Land Assessment and Remediation* were issued by EPD on 15 August 2007 and were effective immediately (although with a transitional period of 3 months enabling use of either the Dutch B levels or the RBRGs). The RBRGs were developed for four different post-restoration land-use scenarios. The Site is classified as an Industrial Site under the RBRGs.

RBRGs for Soil and Soil Saturation Limits, and for Groundwater and Solubility Limits present the remediation goals for soil and groundwater respectively. Detected concentrations of Chemicals of Concern (COCs) in soil and/or groundwater shall be compared to their respective RBRGs for the industrial category and Non Aqueous Phase Liquid (NAPL) Trigger Levels (soil saturation limit values and solubility limit values). The *Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management* is attached in *Annex A*.

Under the *Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM), Annex 19: Guidelines for Assessment of Impacts of Sites of Cultural Heritage and Other Impacts*, consideration should be given during development and redevelopment projects to a number of potentially contaminating historical land uses, which have the potential to cause, or have caused, land contamination.

The site appraisal comprised of the review of the background information and land history in relation to possible land contamination and a site visit to identify potential sources and evidence of contamination at the Site and surrounding areas.

## 2.1

### SITE SETTING

The Site is surrounded by the remaining areas of the GICP. The immediate uses of the area surrounding the CCPP included:

- *North*: a lawn beyond which was an LPG storage to the northwest and a container office to the northeast;
- *South*: an internal road, beyond which is the PFA Grinding & Classification System;
- *East*: the operating cement kiln of GICP; and
- *West*: an internal road, beyond which was a Pack House and cement silos to the northwest and fuel underground storage tanks and dispensing station to the southwest.

The neighbours of the GICP are the Castle Peak Power Station of CLP Power Limited to the west, the Shiu Wing Steel Company steel manufacturing plant to the east, Lung Mun Road to the north and the sea shore to the south. The site layout plan is attached in *Annex B1* and an aerial photograph showing the current site conditions is presented in *Annex C*.

## 2.2

### SITE DESCRIPTION

The Site occupies an area of about 4,000 m<sup>2</sup>. It consists of a waste sorting facility or materials recovery and recycling facility (MRRF) at the front-end followed by a thermal treatment system for an integrated treatment of MSW utilizing the Co-combustion Process patented by the Client. The Co-combustion Process is a novel cement manufacturing process in which the waste provides the energy source for the calcination step, and the calcined materials are reused in the cement production kiln. During operation, the pilot plant handled no more than 24 tonnes of MSW per day on average and the cumulative duration of Pilot Plant operation was 11 weeks.

The waste used in the CCPP consisted of typical Hong Kong municipal solid waste (MSW), of which the main components were paper, plastics and putrescibles. The incoming MSW was unloaded at the reception hall (complete with impermeable paved floor) before feeding into the sorting plant. The wastewater generated from the MRRF was collected and treated at the wastewater treatment plant at GICP.

The CCPP comprised three parts, the MRRF, the main thermal treatment system,

and lime cooling system:

MRRF:

- reception Hall
- trommel screen;
- separators;
- shredder;
- belt conveyors; and
- underground storage tank (UST) for leachate wastewater;

The Main Thermal Treatment System:

- feed chamber;
- rotary kiln;
- secondary combustion chamber;
- pre-calciner;
- cyclones with tipping valves;
- gas cooler ;
- tipping valves;
- bag house filter / dust collector;
- flue gas ducting;
- induction draft fan
- discharge ducting;
- ash storage tank;
- bucket elevator; and
- urea water tank;

Lime Cooling System:

- lime storage bin;
- feed bin;
- lime ejector;
- air blower; and
- cyclone with tipping valves.

During the site visit, no activities were being carried out at the CCPP. All aboveground systems were installed over concrete paved and asphalt paved ground. The fly ash and bottom ash collected from the past CCPP operations were being stored in sealed bags in the reception hall which was concrete paved.

## 2.3

### *PROPOSED DECOMMISSIONING OF CCPP*

The proposed decommissioning of the CCPP will involve the demolition of the existing structures and concrete slab and asphalt hard surface, removal of used equipment, the removal of the concrete foundations supporting the equipment and the disposal of waste materials generated by the demolition. It is understood that the Site will then be left as an area of open space for possible future industrial use associated with the surrounding cement plant operations.

The whole of the GICP Site was formed through reclamation in the late 70's. The fill materials used were mainly from the nearby hillsides. Some sand materials were also reportedly imported to the area. The construction of the GICP commenced in 1978 and the operations of the GICP commenced in 1982.

The GICP site was approved for the purpose of manufacture of cement and cement-related products. The Site of the pilot plant is an open area reserved for a second cement kiln. Following start up of the GICP in 1982, the Site was used as an emergency stockpile for cement clinker until 1985. The Site was also used as emergency open stock pile of natural limestone imported from Japan between 1990 and 1994. The stockpile area was not paved initially. A propane storage was reportedly built in the late 1980s but was never commissioned, and was removed in March 1992.

The CCPP was constructed in June 2004 after receiving approval from the Lands Department, EPD and the Buildings Department. The continuous pilot operation commenced in October 2005 and finished in December 2005. Of note is that the combined total operating time of the pilot plant from the commissioning to the end of the operation was only 11 weeks.

Table 2.1 to 2.3 <sup>(1)</sup>, respectively, present the historical, current and anticipated future land uses of the CCPP Site. Table 2.4 shows the historical development of the CCPP and the GICP. Historical photographs showing the site development are presented in Annex D.

**Table 2.1** *Summary of Historical On Site Land Use*

Type of Facility	On Site Property Land Use	Date Began	Description	Owner or Occupier	Approx Site Area	Off Site Property Affected
None	Reclaimed land	Late 1970	Site reclamation	GIC	4,000 m <sup>2</sup>	No
Industrial	Storage area of cement clinker	1982	Reserved for storage of propane but used for cement clinker stockpiling	GIC	As above	No
Industrial	Reserved storage area	1984-1990	Not used	GIC	As above	No
Industrial	Storage area	1990-1994	Storage of limestone	GIC	As above	No
Industrial	Grassed area	1994-June 2004	Used as kiln lawn	GIC	As above	No

(1) The tables are prepared in accordance with *Standard form 3.1 from the RBRG guidance*

Type of Facility	On Site Property Land Use	Date Began	Description	Owner or Occupier	Approx Site Area	Off Site Property Affected
Industrial	Construction site	June 2004	Construction of foundations	GIC	4,000 m <sup>2</sup>	No
Industrial	CCPP	Oct 2005 – Dec 2005	11 week trial operation	GIC	As above	No

Note. Table based on Standard Form 3.1 from the RBRG guidance

**Table 2.2** *Summary of Current On Site Land Use*

Type of Facility	On Site Property Land Use	Date Began	Description	Owner or Occupier	Approx Site Area	Off Site Property Affected
Industrial	Disused trial co-combustion pilot plant	Oct 2005 to Dec 2005	Trial CCPP	Green island cement (GIC)	4,000 m <sup>2</sup>	No

Note Based on Standard Form 3.1 from the RBRG guidance

**Table 2.3** *Summary of Anticipated Future On Site Land Use*

Type of Facility	On Site Property Land Use	Date Began	Description	Owner or Occupier	Approx Site Area	Off Site Property Affected
Industrial	Open space	2008?	Site to be left as open grassed area in the immediate term.	GIC	4,000 m <sup>2</sup>	No

**Table 2.4** *Site Historical information for the GICP and CCPP Site*

Time	GICP	CCPP Site
late 1970s	Site reclamation	-
Before 1982	Construction of the cement plant	-
1982	Operation of the GICP cement kiln began	Reserved for propane storage and used as emergency stock pile of cement clinker until 1985
1984-1990	Operation of the cement kiln suspended	Reserved for propane storage and left vacant
1990-1994	Operation of the cement kiln restarted	Reserved for propane storage and used as emergency storage of limestone imported from Japan
1992	Continuous operation of the GICP	Propane storage was built but never commissioned. It was removed in March 1992.
After 1994	Continuous operation of the GICP	Rehabilitated as a kiln lawn until the construction of CCPP
Dec 2001	Clinker production was suspended	Rehabilitated as a kiln lawn until the construction of CCPP
Jun 2004	Clinker production was suspended	Construction of the CCPP foundation

<b>Time</b>	<b>GICP</b>	<b>CCPP Site</b>
Apr 2005	Clinker production was suspended	First load commissioning test of the CCPP
Jul 2005	Clinker production was suspended	Second load commissioning test of the CCPP
Oct 2005	Clinker production was suspended	Continuous operation of the CCPP
Dec 2005	Clinker production was suspended	Operation ceased after all operation data has been collected
Jan 2006	Clinker production resumed	-



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Based upon the Site appraisal and observations from the Site visit, this section identifies potential sources of soil and groundwater contamination and the associated impacts, risks or hazards.

### *3.1 POTENTIAL HISTORICAL SOURCES*

Potential historical on site sources of soil and groundwater contamination are those that may be associated with the emergency stockpiling of cement clinker during 1980s and limestone during early 1990s and the operation of the GICP.

The construction of the foundation of CCPP started in June 2004. Most of the top soil was reportedly excavated for the foundation construction during that time. After the foundation work, it was reported that the Site was backfilled with the original top soil and then paved with concrete and asphalt.

There are potential historical off site sources of soil and groundwater contamination associated with the continuous operation of the cement plant surrounding the Site for more than 20 years.

### *3.2 POTENTIAL CURRENT SOURCES*

The potential current on and off site sources of contamination that could affect the Site include:

#### *OFF SITE SOURCES*

- The storage and transfer of fuel (diesel oil) at the fuel underground storage tanks (UST) and dispensing station located approximately 20 m to the southwest of the Site. The USTs were reportedly constructed of single-shell steel encased in concrete with a minimum thickness of 150mm. In order to minimize risk of accidental oil leakages, the tank piping pressure tests/hydraulic tests are conducted every 5 years. The fuel dispensing station was used for filling of around 20 vehicles per day. The area was paved. The fuel UST and dispensing station will not be included in the proposed decommissioning of CCPP.
- Potential leakage of fuel from overhead fuel pipelines connecting the fuel oil storage tank (located approximately 100 m to the southwest of the Site) with the CCPP and the main cement kiln. No evidence of leakage was observed during the site visit.

#### *ON SITE SOURCES*

- The storage and handling of MSW used in the pilot tests. It is noted that prior to being fed into the rotary kiln, all the wastes were received, stored and sorted in the MRRF, which was an enclosed building with concrete

floor. All leachate and wastewater generated in the building was collected in an enclosed drainage system leading to an underground storage tank (UST) and then transferred for treatment at GICP. The likelihood of the MSW or leachate / wastewater causing contamination below the impermeable concrete floor is considered to be negligible.

- Leakage and/or spillage from the UST for leachate generated from the MRRF. The UST is a steel tank and its integrity has been checked to ensure no leakage prior to use. The tank was used for a short period of time (11 weeks) during the operations of the CCPP only and no evidence of leakage/damage was observed. Therefore the likelihood of the leachate / wastewater contaminating the soil around the tank and groundwater is considered to be very low. Moreover, the waste handled at the MRRF was municipal solid waste and the leachate generated from the operation of the MRRF would be expected to have been organic in nature and not expected to contain potential contaminants of concern such as heavy metals or persistent organic compounds.
- Leakage/spillage of contaminants from the ash generated from the rotary kiln system during the CCPP operation process. It is noted that all ash generated from the CCPP was collected from the kiln directly into bags and transferred for storage in the reception hall. After the completion of the pilot test, the remaining ashes were vacuumed from the units and also collected in bags. Therefore it is unlikely that anything more than very limited fugitive ash was spilled on the paved floor. The likelihood of this ash then contaminating the soil or groundwater beneath the paved floor is considered to be negligible.
- Leakage/spillage of contaminants from bottom ash quenching tank located at the bottom of the rotary kiln. It is noted that the bottom ash was quenched, collected in bags and transferred for storage in the reception hall thus limiting the potential for the contamination of the underlying soils and groundwater to negligible levels.

Locations and photos of these potential sources are presented in *Annex B2*.

The whole CCPP Site area was paved with concrete and asphalt. The wastewater from the MRRF was connected to a collection sump and was then transferred for treatment at GICP. The stormwater run-off from the outdoor plant area was collected within the GICP drainage system.

It was observed that the fuel oil transfer pipelines used overhead pipes. No oil, ash and wastewater spillage/leakage had reportedly occurred at the Site during its short period of operation and none were observed during the Site visit.

Potential current off site sources of soil and groundwater contamination are associated with the current operation of the cement plant surrounding the Site. Further off site are a power station and a steel manufacturing plant which are also industrial use.

### 3.3

#### POTENTIAL FUTURE SOURCE

The Site's future use remains industrial (manufacture of cement and cement related products) and is surrounded by remaining areas of the GICP. After decommissioning, the concrete slab and concrete foundations and sub structures will be excavated, to a maximum depth of 1.5 m. The whole Site will then be levelled using clean imported materials. The Site will remain as an open area awaiting a decision to be made in the future for industrial use. It is currently proposed that the surface of the clean imported materials will be rehabilitated into a grass lawn.

All traces of MSW and the associated CCPP will have been removed and there will not be a potential source of contamination present at the Site.

### 3.4

#### CONCEPTUAL MODEL OF POTENTIAL POLLUTANT LINKAGE

The potential pollutant linkages that could be present at the Site due to the on site activities of the CCPP are summarised in the following *Table 3.4*. As presented in the *Table 3.4* it is not considered that the activities of the CCPP have resulted in any significant pollutant linkage between an identifiable source of contamination caused by the activities of the CCPP and any receptor.

It is considered that the only potential receptors at risk might be site workers involved in decommissioning and demolition works, which is discussed in the *Section 4*.

**Table 3.4** *Conceptual Model of Potential Pollutant Linkage at the CCPP site*

Source	Pathway	Receptor	Risk
Historical storage of cement and limestone/ foundation construction	Ingestion, inhalation and skin contact.	Site workers involved in the decommissioning and demolition work	Negligible to low - The materials were stored over 10 years ago and were likely to be inert or were natural materials.
	Soil pore migration.	Ground and surface waters	None - The storage occurred over 10 years ago.
Municipal waste feedstock (MSW)	Ingestion, inhalation and skin contact.	Humans (eg Site workers during decommissioning and demolition works)	None – No MSW remains on site at the time of the site visit. MSW was stored and handled within the material recovery building which was enclosed with impermeable ground surface.
Ash residue from the thermal treatment trial	Ingestion, inhalation and skin contact.	Humans (eg Site workers during decommissioning and demolition works)	None– All ash has been collected directly from the equipment and sealed in bags.

Source	Pathway	Receptor	Risk
Liquid runoff from MSW/ash	Ingestion, inhalation and skin contacts	Humans (eg Site workers during decommissioning and demolition works)	Negligible to low - All wastewater/leachate was collected in an enclosed drainage system leading to a steel tank. Dismantling of this system may pose a health and safety risk, see <i>Section 4.2.1</i> .
Liquid runoff from MSW/ash	Soil pore water	Groundwater/ surface water	As above – Impermeable hardstanding and enclosed drainage system. No leakage of the wastewater collection UST reported.
Off site contamination sources	Migration on to the CCPP site via soil pore water or air borne dust	Humans - Site workers during decommissioning  Groundwater under the Site	Low – There was no evidence to suggest any spillages or leaks have occurred off site to such an extent as to impact the soils or groundwater underlying the Site.

#### 4.1 EVALUATION OF IMPACTS

Based on the conceptual model it is considered that the only potential receptor present at the Site, is possibly any workers involved in the excavation works. There is considered a negligible to low potential risk that any as yet unidentified contaminants may have adverse impacts to the site workers involved in the demolition and excavation of the foundations of the CCPP.

A description of general hazardous properties of typical contaminants associated with fuel storage, machinery operations and municipal waste incineration is presented for information purposes, in *Table 4.1*. It is noted that currently, based on the findings of Section 3 and 4, it is not considered likely that that any of these contaminants are present at the site.

**Table 4.1** *General Properties of Hazardous Substances*

Typical Contaminants	General Hazardous Properties
Traces of heavy metals from combustion process and lead from fuel	<ul style="list-style-type: none"> <li>• Can be toxic by ingestion and contact; and</li> <li>• Specific precautions may be required in relation to monitoring dust control during the demolition works.</li> </ul>
Petroleum hydrocarbon products from adjacent fuel storage, dispensing facilities and overhead pipelines	<ul style="list-style-type: none"> <li>• Can be toxic by contact; and</li> <li>• Concentrations may be flammable.</li> </ul>
Simple aromatic (including benzene, toluene, xylenes, and ethylbenzene) from equipment maintenance	<ul style="list-style-type: none"> <li>• Can be toxic by inhalation, ingestion and contact; and</li> <li>• May be flammable at high concentrations.</li> </ul>

#### 4.2 POTENTIAL IMPACTS

The potential impacts which may arise from any contaminated soil at the Site are considered to be the following:

- Health risks to site workers involved in the decommissioning, excavation and demolition works on site;
- Disposal of contaminated materials;
- Possible potential risks to future users of the CCPP Site.

##### 4.2.1 Health Risk to Site Workers

The demolition works will include the dismantling of equipment, the breaking and removal of; the concrete slab, the reinforced concrete footing plinths and the blinding layer (limited to the areas where the foundations

have to be demolished) and removal of all waste materials. Although considered unlikely, site construction workers may become exposed to contaminated soil materials during the demolition and removal of substructures. The main exposure routes for site construction workers are skin contact with potentially toxic or harmful contaminants in the surrounding soils or accidental ingestion of contaminated material through poor hygiene, eating and smoking on site.

Based on the results of the intrusive investigation, and as required, appropriate mitigation measures will be used in breaking any potential linkage between contaminated materials and site workers. This may include but not limited to identification and use of Personal Protection Equipment (PPE), using mechanical equipment for sub structure and UST removal and transport to limit human contact to underlying soil and groundwater. The H&S mitigation measures will be described in the Project's Health & Safety Plan. The appointed Contractor(s) for the decommissioning and demolition works should prepare a Health and Safety (H&S) plan, prior to the commencement of the demolition works. The Contractor(s) should also ensure that all site workers are aware of the requirements outlined in the H&S plan, as well as capable of reacting to any identified contamination concerns.

#### **4.2.2 Disposal of Contaminated Materials**

The excavation to be carried out as part of the demolition will be limited to the concrete sub-structures only and no soil will be excavated from the Site. The work will not involve the handling or disposal of potentially contaminated soil that may be underneath the concrete/steel installations due to be demolished/excavated.

In addition, there is currently no further development planned for the Site and no buildings or associate piling or construction activities will be carried out at the Site.

The excavation depth will be limited to the bottom of the current foundation and UST, which are both located approximately 1.5 m bgl. The groundwater in the surrounding area is reported at approximately 2.5 to 4 m bgl <sup>(1)</sup>. The proposed excavation for the demolition works will therefore be above the groundwater level and no groundwater extraction from the excavated areas will be required and no contact with groundwater is expected.

Should any ingress water (such as from precipitation) need to be removed from the excavation area, the water will be disposed of in *the existing on-site waste water treatment system*.

#### **4.2.3 Potential Health Risks to Future Users**

After completion of decommissioning and demolition works, the whole Site will be levelled using clean imported fill materials which will effectively cover

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(1) Based on information from ERM's previous projects in nearby areas.

or cap the whole area. The Site will be left as an open space awaiting any future industrial use decision and is to be grassed for aesthetic purposes.

The potential for human contact with the underlying materials after the completion of the levelling and capping work (approximate thickness of one metre) is not considered likely. As such no pollutant linkage to human is anticipated at the Site after the completion of decommissioning and demolition works.

It is noted that capping of a site so as to isolate metal contamination from users could be considered as a remediation action (*Ref. Appendix III of the EPD Guidance Note for Contaminated Land Assessment and Remediation*). This scenario may be applicable for the Site and thus could be considered an appropriate remedial option should metal contamination be detected.



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## 5.1 INTRODUCTION

As mentioned in the earlier sections, no soil excavation or groundwater extraction will be required for the Project and no potentially contaminated materials requiring disposal will be generated from the Site. Human exposure to potentially contaminated material will be limited to possible site worker contact during the excavation of the foundations and substructures.

The following site investigation programme is proposed to provide additional information for the site area to offer a level of confidence on the presence and (if found) the concentrations of contaminants in the underlying soil materials and help in the formulation of a site specific health and safety plan.

The objectives of contamination sampling are in general to:

- identify if the soil below ground surface within the Project site is contaminated; and
- if contaminants are present, determine their concentrations.

The following investigation programme has been developed based on the *Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management* (RBRG Guidance Manual) and the associated Guidance Notes, and the EPD's *Guidance Notes for Investigation and Remediation of Contaminated Sites of Petrol Filling Stations, Boatyards, and Car Repair/Dismantling Workshop*.

## 5.2 PROPOSED SITE INVESTIGATION

### 5.2.1 Soil Sampling

#### *Underground Storage Tank (UST) for Wastewater*

It is proposed that soil sampling be undertaken at two locations (S1/S2 and S3/S4) adjacent to the UST to identify whether soil surrounding the UST is contaminated.

Two (2) soil samples are proposed to be taken at each sampling location using trial pits at below the concrete slab and asphalt hard surface and at the bottom of the UST (ie at 1.5 m below ground level, m bgl) <sup>(1)</sup>. It is proposed that a mechanical excavator will be used to break the concrete slab and asphalt hard surface and then to excavate trial pits to 1.5 m bgl to facilitate soil sampling. Soil samples will be sampled manually using a hand auger or alternative manual means, such as a trowel. *Figure E1, Annex E* shows the proposed sampling locations at the UST.

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(1) The UST dimension is (1 m (wide) x 4 m (Length) x 1.5 m (depth).

## Remaining Areas of the CCPP

Four (4) subsurface soil sampling locations are proposed to be located around the CCPP area to provide information on the level of contaminants in the subsurface soil around the CCPP.

Based on the review of the site history and historical pictures of the site, in particular during the site formation (see *Annex D*), the shallow geology underlying the site is anticipated to comprise homogeneous fill materials (consisting of decomposed granites, rocks, boulders from nearby hills mixed with imported sand materials). The proposed sampling locations are therefore located along the CCPP structure focussing where foundations are located and at similar intervals to provide coverage of the proposed area where underground subsurface disturbance will occur during the demolition. The proposed sampling locations are shown in *Figure E2, Annex E*.

To determine the presence and extent of contamination from the surface soil <sup>(1)</sup> and in the fill materials <sup>(2)</sup>, two (2) soil samples will be taken from each sampling location at just below the concrete pavement and at 1.5 m bgl. A mechanical excavator will be used to break the concrete pavement and then to excavate trial pits to 1.0 to 1.5 m to facilitate soil sampling (depths depend on the depth of the foundation in each area). Soil samples will be sampled manually using a hand auger or similar manual means.

### 5.2.2 Analytical Parameters & Procedures

All samples will be analysed by a HOKLAS accredited laboratory for the parameters listed in *Table 5.2* below.

**Table 5.2** *Methods of Analysis for Soil Samples*

Parameter	Referenced Analytical Method
Total Petroleum Hydrocarbons (TPH) fractions including C6-C8, C9-C16 and C17-C35	USEPA Method 8015
Simple Aromatics (e.g. benzene, toluene, ethyl benzene, and xylenes) (BTEX)	USEPA Method 8260
<u>Heavy metals:</u>	
Antimony (Sb), Arsenic (As), Barium (Ba), Cadmium (Cd), Chromium III and VI (Cr III and Cr VI), Cobalt (CO), Nickel (Ni), Copper (Cu), Lead (Pb), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Tin (Sn), and Zinc (Zn)	USEPA Method 6020A/7000 ICPMS

**Note:** The TPH fractions and list of heavy metals are based on the RBRGs list.

*Table 5.3* summarises the proposed sampling programme.

- (1) It is anticipated that any contamination from the CCPP operations will have entered the underlying soils from the surface as no subsurface pipelines or channels were located within the CCPP.
- (2) It was reported that the original fill material was excavated from the site for the foundation construction during the construction of the CCPP which was then backfilled on site. The site was used for storage of materials prior to the CCPP construction.

**Table 5.3** *Sampling Locations and Parameters for Site Investigation*

<b>Sample</b>	<b>Sampling Location</b>	<b>Depth of Sampling</b>	<b>Sampling Parameters</b>	<b>No of Samples to be taken</b>
S1/S2	Located to the north of the UST.	Underneath concrete pavement and at 1.5 m	Heavy metals, TPH, BTEX	2
S3/S4	Located to the south of the UST.	Underneath concrete pavement and at 1.5 m	Heavy metals, TPH, BTEX	2
S5/S6	Located to the east of the rotary kiln.	Underneath concrete pavement and at 1.5 m	Heavy metals, TPH, BTEX	2
S7/S8	Located to the west of the cyclones.	Underneath concrete pavement and at 1.5 m	Heavy metals, TPH, BTEX	2
S9/S10	Located to the south of the CCPP and north of the overhead fuel pipelines connecting the fuel oil storage tank (located approximately 100 m to the southwest of the CCPP).	Underneath concrete pavement and at 1.5 m	Heavy metals, TPH, BTEX	2
S11/S12	Located to the northwest of the reception hall and to the southeast of the fuel underground storage tanks and dispensing station.	Underneath concrete pavement and at 1.0 m	Heavy metals, TPH, BTEX	2
QC	To be collected on a random basis	Underneath concrete pavement or at 1.5 m	Heavy metals, TPH, BTEX	1
			<b>Total no. of samples</b>	<b>13</b>

### 5.2.3 *Sample Duplication*

One field duplicate soil sample will be taken every 20 soil samples collected during the land contamination investigation. The duplicate samples will be collected on a random basis and submitted to the HOKLAS accredited laboratory for the purpose of quality control (QC)/quality assurance (QA).

### 5.2.4 *Sampling Programme*

The sampling programme will be undertaken with strict adherence to appropriate protocols so as to minimise the potential for cross-contamination between sampling locations. The sampling methodologies are based on methods developed by the US EPA, adapted to Asian standards of operation and practice, as appropriate. These methods include decontamination procedures, sample collection, preparation and preservation, and chain of custody documentation, as outlined below. The volume of soil and groundwater samples to be collected should be confirmed with the analytical laboratory taking into account the sample analysis requirements (ie soil

samples are normally required to be 2 kg in weight) and sample preservation procedures.

#### **5.2.5 *Sample Collection***

Stainless steel hand augers will be used for soil sampling. The equipment used for sample collection will be decontaminated (as described in *Section 5.2.6*) prior to each sampling. Clean latex gloves will be worn and changed before each new sample is collected.

All samples will be placed directly into laboratory supplied pre-cleaned sample bottles and labeled with a permanent waterproof marker.

All samples will be transported under appropriate chain-of-custody documentation, as described below, in clean coolers with ice packs at a temperature of approximately +4°C. Samples will be delivered to the laboratory as soon as possible after collection, noting the recommended maximum holding times.

#### **5.2.6 *Decontamination Procedures***

Sampling equipment used during the course of the site investigation will be thoroughly decontaminated, to minimize the potential for cross-contamination. All equipment will be decontaminated using a non-phosphate soap solution and water, with a distilled water rinse to clean all smaller pieces of equipment, in particular those used to sample materials such as sampling augers, hand excavation and grab samples. Larger equipment and materials that do not come in direct contact with the samples may be steam cleaned using mains water, where possible, or at a minimum pressure jet washed with mains water. This cleaning procedure will be repeated after use at each sampling location to avoid potential cross contamination between locations, and during sampling, to ensure that any contamination from the surface of the Site does not affect deeper substrata.

During sampling and decontamination activities, disposable latex/nitrile gloves will be worn to prevent transfer of contaminants from other sources. Any disposable equipment will be disposed as general waste after each use.

#### **5.2.7 *Analytical Laboratory***

Analysis of samples will be carried out by an appropriate, HOKLAS certified analytical laboratory located in Hong Kong or another qualified overseas laboratory. The laboratory shall maintain high standards of analytical and technical services for the detection of trace organic contaminants. All analysis should be conducted according to standard procedures set by the US EPA, APHA, ASTM along with internal QA/QC procedures.

### 6.1 CONCLUSIONS

The assessment of land contamination sources and the potential impacts to particular development projects were investigated in accordance with the *RBRG Guidance*. Site appraisal comprising a site visit and the review of background information and land history in relation to possible land contamination was conducted. Potential sources of contamination and associated impacts, risks or hazards are identified in this CAP.

Excavation works proposed for the decommissioning and demolition works will be limited to the concrete sub-structures and UST. No soil excavation or groundwater extraction will be required for the Project and hence no potentially contaminated materials requiring off-site disposal will be generated from the Site.

The substructure areas of the CCPP Site will be filled using clean imported fill materials and rehabilitated as green lawn and open area. The potential for human contact with any underlying contamination in the future is considered low.

It is concluded that the risk of future exposure to any contamination is deemed negligible.

### 6.2 RECOMMENDATIONS

Although no soil excavation or groundwater abstraction will be required during the demolition of the CCPP and that no soil or groundwater material will be required to be disposed of off site, as a precautionary measure and after discussions with the EPD, a limited site investigation programme comprising subsurface soil sampling and analysis is proposed in this CAP. A total of six soil sampling locations (with a total of 13 soil samples including one soil duplicate sample) are proposed.

Following approval of this CAP, a site investigation will be carried out. A Contamination Assessment Report (CAR) will be prepared presenting the findings of the land contamination assessment programme.

The laboratory analytical results will be compared against the *RBRGs for Industrial Land Use* in the *Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management* and a conceptual model will be presented for the site.

Aside of health and safety mitigation, remediation action is not currently expected. However, if necessary, a Remedial Action Plan (RAP) will be prepared for submission to EPD for approval. The proposed remedial options will examine the relevant issues of remedial treatment versus

disposal, these options will be based on the proposed future land uses as an open grassed space, and associated potential risks based upon the site data and the EPD guidance. The RAP will also detail any further site investigation that maybe required during the Contactor's execution of the remediation work.

It is also recommended that the appointed Contractor(s) for the demolition removal prepare a Health and Safety (H&S) plan, based upon the soil results, prior to the commencement of the decommissioning and demolition works.

Annex A

The Guidance Manual for Use  
of Risk-based Remediation  
Goals for Contaminated Land  
Management and the  
Guidance Note for  
Contaminated Land  
Assessment and Remediation



**Guidance Manual for Use of Risk-based Remediation  
Goals for Contaminated Land Management**

**Hong Kong SAR Government  
Environmental Protection Department  
July 2007**

**Guidance Manual for Use of Risk-based  
Remediation Goals for Contaminated Land  
Management**

**Contents**

<b>Section 1</b>	<b>Introduction</b>	
1.1	The Problem of Contaminated Land .....	1-1
1.2	Replacement of Dutch B Levels with Risk-Based Remediation Goals (RBRGs).....	1-1
1.3	Risk-based Approach for Contaminated Land Management.....	1-2
1.4	Scope and Structure of this Guidance Manual .....	1-2
<b>Section 2</b>	<b>Development of RBRGs</b>	
2.1	Risk-based Approach.....	2-1
2.2	Development Process .....	2-1
	2.2.1 Chemicals of Concern .....	2-2
	2.2.2 Land Use Scenarios.....	2-3
	2.2.3 Identification of Exposure Pathways.....	2-4
	2.2.4 Cancer and Non-Cancer Toxicity .....	2-4
	2.2.5 Non-Aqueous Phase Liquid (NAPL) .....	2-5
2.3	Risk-based Remediation Goal Tables.....	2-6
2.4	Limitation on the Use of RBRGs .....	2-7
<b>Section 3</b>	<b>Application of RBRGs in Land Contamination Assessment</b>	
3.1	Steps for Applying RBRGs in Contaminated Land Assessment.....	3-1
<b>Section 4</b>	<b>Record Keeping and Reporting</b>	
<b>Section 5</b>	<b>General Reference</b>	

## List of Tables

Table 2.1 Risk-Based Remediation Goals (RBRGs) for Soil and Soil Saturation Limit

Table 2.2 Risk-Based Remediation Goals (RBRGs) for Groundwater and Solubility Limit

## List of Figures

Figure 1.1 Boatyards

Figure 1.2 Petrol Filling Stations

Figure 1.3 Car Repair/Dismantling Workshops

Figure 3.1 Land Contamination Assessment and Preparation of CAP, CAR and RAP

Figure 3.2 Land Contamination Assessment Process: Input and Reporting Requirements

Figure 3.3 NAPL Assessment Flowchart

## List of Standard Forms

3.1. Summary of On-Site Land Use

3.2. Soil Data Summary and Comparison to RBRGs and  $C_{sat}$

3.3. Groundwater Data Summary and Comparison to RBRGs and Solubility Limits

3.4. Soil Sample Concentrations and Exceedances of RBRGs and  $C_{sat}$

3.5. Groundwater Sample Concentrations and Exceedances of RBRGs and Solubility Limits

## Glossary

<b>Cancer Slope Factor (CSF)</b>	A plausible upper-bound estimate of the probability of a cancer response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. The cancer slope factor is given in units of the reciprocal of milligrams of chemical per kilogram of body weight per day (mg/kg-day) <sup>-1</sup> .
<b>Method Reporting Limit (MRL)</b>	The lowest amount that can be distinguished from the normal “noise” of an analytical instrument or method.
<b>Exposure</b>	Contact of a receptor with a chemical or physical agent. Exposure is quantified as the amount of the agent at the exchange boundaries of the receptor (e.g. skin, lungs, gut) and available for absorption.

<b>Exposure pathway</b>	The course a toxic chemical takes from the source area to a receptor. Each exposure pathway includes a source or release from a source, a point of exposure, and an exposure route. If the exposure point is not at the source, a transport medium is also involved.
<b>Exposure route</b>	The mechanism by which a receptor inhales, consumes, absorbs, or otherwise takes in a toxic chemical at an exposure point.
<b>Groundwater</b>	Means any water beneath the earth’s surface in the zone of saturation.
<b>Hazard quotient</b>	Ratio of the intake to the reference dose.
<b>Intake</b>	A measure of exposure expressed as the mass of a substance in contact with the exchange boundary per unit body weight per unit time (e.g. mg/kg-day). Also termed the normalized exposure rate; equivalent to administered dose.
<b>Integrated Risk Information System (IRIS)</b>	An US EPA database containing verified reference doses (RfDs) and cancer slope factors (CSFs) and up-to-date health risk and US EPA regulatory information for numerous chemicals.
<b>Non-aqueous Phase Liquid (NAPL)</b>	Chemicals that are insoluble or only slightly soluble in water that exist as a separate liquid phase.
<b>Pathway</b>	The route a toxic chemical takes to go from a source to a receptor.
<b>Quality assurance/ Quality control documentation</b>	Results of test run by the laboratory to verify the precision and accuracy of analytical tests and equipment.
<b>Receptor</b>	Any person that is or may be affected by a release of toxic chemicals.
<b>Reference Dose (RfD)</b>	An estimate of a daily exposure level for the human population including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime, or portion of a lifetime. The RfD is given in units of milligrams of chemical per kilogram of body weight per day.
<b>Release</b>	Means any spilling, leaking, pouring, emitting, emptying, discharging, injecting, pumping, escaping, leaching, dumping, or disposing of a toxic chemical into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing hazardous wastes or hazardous constituents).

<b>Remediation</b>	An action, including removal, chemical, physical, or biological treatment of soil, groundwater, or other environmental media, intended to restore or improve the land condition impacted by chemical contamination.
<b>Risk assessment</b>	An analysis of the potential for adverse effects caused by a toxic chemical at a site and to determine the need for remedial action or to develop cleanup levels where remedial action is required.
<b>Site</b>	Defined by the likely physical distribution of the toxic chemicals from a source area. A site could be an entire property or facility, a defined area or portion of a facility or property, or multiple facilities or properties.
<b>Soil</b>	Means any unconsolidated mineral and organic matter overlying bedrock that has been subjected to and influenced by geologic and other environmental factors, excluding sediment.
<b>Soil saturation limit</b>	The contaminant concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water and saturation of soil pore air have been reached.
<b>Solubility Limit</b>	The maximum amount of solute that can be dissolved in a given quantity of solvent (e.g. water) at a given temperature.
<b>Source</b>	Presence of a toxic chemical at or below the ground surface at a hazardous concentration.
<b>Toxicity value</b>	A numerical expression of a substance's dose-response relationship that is used in risk assessments. The most common toxicity values used are reference doses (RfD) for noncarcinogenic effects and cancer slope factors (CSFs) for carcinogenic effects.
<b>Water table</b>	Means the upper elevation of the surface of the saturated zone.
<b>Zone of saturation</b>	Means any part of the earth's crust in which all voids are filled with water.

## Abbreviations

<b>ASTM</b>	American Society for Testing and Materials
<b>CAP</b>	Contamination Assessment Plan
<b>CAR</b>	Contamination Assessment Report
<b>COC</b>	Chemical of Concern
<b>CSF</b>	Cancer Slope Factor
<b>CSM</b>	Conceptual Site Model
<b>DQO</b>	Data Quality Objective
<b>DNAPL</b>	Dense Non-aqueous Phase Liquid
<b>EPD</b>	Environmental Protection Department of the Hong Kong SAR
<b>HEAST</b>	Health Effects Assessment Summary Table
<b>HOKLAS</b>	Hong Kong Laboratory Accreditation Scheme
<b>IRIS</b>	Integrated Risk Information System
<b>LNAPL</b>	Light Non-aqueous Phase Liquid
<b>MRL</b>	Method Reporting Limit
<b>NAPL</b>	Non-aqueous Phase Liquid
<b>PCB</b>	Polychlorinated Biphenyl
<b>QA/QC</b>	Quality Assurance/ Quality Control
<b>RAP</b>	Remediation Action Plan
<b>RBRG<sub>soil</sub></b>	Risk-Based Remediation Goal for soil
<b>RBRG<sub>gw</sub></b>	Risk-Based Remediation Goal for groundwater
<b>RfD</b>	Reference Dose
<b>RR</b>	Remediation Report
<b>SI</b>	Site Investigation
<b>SVOC</b>	Semi-volatile Organic Chemical
<b>TPH</b>	Total Petroleum Hydrocarbons
<b>US EPA</b>	United States Environmental Protection Agency
<b>VOC</b>	Volatile Organic Chemical
<b>WHO</b>	World Health Organisation

# Section 1 INTRODUCTION

## 1.1 Purpose of this Guidance Manual

This *Guidance Manual for Use of Risk-Based Remediation Goals (RBRGs) for Contaminated Land Management* (Guidance Manual) introduces the background of RBRGs and presents instructions for comparison of soil and groundwater data to the RBRGs. Included in this guidance are RBRGs for soil and groundwater protective of human health for 54 chemicals of concern.

The RBRGs have been designed to protect the health of people who could potentially be exposed to land impacted by chemicals, under four broad post-restoration land-use categories. They are intended to be used as site assessment criteria that will be appropriate on a stand-alone basis for the majority of sites in Hong Kong, where human health is the only significant receptor that needs to be protected. On sites where this is not the case e.g. where groundwater quality needs to be protected as it is abstracted on site or nearby for industrial use, irrigation or drinking, where surface water quality may be impacted or where significant ecological receptors are potentially impacted, then the RBRGs will not be appropriate and other criteria will be required. These other criteria could include drinking water standards or ecological protection criteria.

The philosophy of the RBRGs is that, in being risk-based, they tailor the extent of remediation required to the level of risk under certain land-uses. For example as residential land-use is more sensitive than industrial land-use the land would need to be remediated to a greater extent.

The Guidance Manual is organized as follows:

- Section 1 – Introduction
- Section 2 – Development of RBRGs
- Section 3 – Application of RBRGs in Land Contamination Assessment
- Section 4 – Record Keeping and Reporting
- Section 5 – General Reference

Detailed information (e.g. exposure parameters, site assumptions, toxicity information, chemical properties) on the derivation of the RBRGs is provided in the *Background Document on Development of Risk-Based Remediation Goals for Contaminated Land Management* (Background Document).

The Guidance Manual should be used in conjunction with the new Guidance Note for Contaminated Land Assessment and Remediation (which replaces the ProPECC Note PN3/94), and the Guidance Notes for Investigation and Remediation of Contaminated Sites of Petrol Filling Stations, Boatyards and Car Repair/Dismantling Workshops. Copies of these may be downloaded from: [http://www.epd.gov.hk/epd/english/envir\\_standards/non\\_statutory/esp\\_non\\_stat.html](http://www.epd.gov.hk/epd/english/envir_standards/non_statutory/esp_non_stat.html)

## 1.2 The Problem of Contaminated Land

Contaminated land is caused by spillage, leakage or disposal of toxic chemicals to the ground. Soil at or below the ground surface and sometimes groundwater may be contaminated depending on the subsurface conditions. Contaminated land is a health concern if the public is exposed to toxic chemicals through the impacted soil or groundwater. In Hong Kong, examples of industrial or commercial activities that may potentially cause land contamination include boatyards, petrol filling

stations, vehicle repair/maintenance or dismantling workshops, metal or mechanical workshops or oil installations etc. (Figures 1.1, 1.2 and 1.3). The potentially polluting activities generally involve (i) underground oil or chemical storage in tanks that may leak due to corrosion, or (ii) operations that may cause spillage of chemicals. Ground surface condition is also a factor affecting the severity of contamination. Spillage over bare soil results in more serious contamination than that over a capped surface.

Before a contaminated site is re-developed or handed back from a tenant/purchaser/allocatee to the Government, it is necessary to assess the level of contamination by collecting soil and groundwater samples for laboratory analyses. If contamination is above an acceptable level, defined by a set of standards or remediation goals, remediation is required to render the site safe for future use.

## 1.3 Replacement of Dutch B Levels with Risk-Based Remediation Goals (RBRGs)

Historically, Hong Kong has no locally-derived contaminated land standards. The Dutch B levels of the Netherlands referenced in the Practice Note for Professional Persons for Contaminated Land Assessment and Remediation, ProPECC PN3/94 issued by EPD in 1994, have been used up to the present.

Contaminated land standards specifically derived for Hong Kong are necessary to replace the Dutch B levels for three reasons. Firstly, the Dutch government has already developed a new set of risk-based standards to replace the Dutch B levels. Secondly, the Dutch B levels were developed to protect the people and environment in the Netherlands only which means that they are not entirely suitable for Hong Kong. Thirdly, the world-wide practice is for each country to develop country specific standards based on a risk assessment approach to suit their local environmental conditions and community needs. This risk approach means that decisions on defining a site as contaminated, and hence the level of remediation required, are made based on the potential risks to receptors and the intended land-use.

To bring Hong Kong in line with the international practice and to replace the Dutch B levels, a set of locally-derived contaminated land standards, the RBRGs, has been developed for four types of land-use in Hong Kong to protect the local human receptors. This Guidance Manual explains the risk-based approach and guides users in applying the RBRGs to their contaminated sites.

## 1.4 Risk-Based Approach for Contaminated Land Management

The RBRGs were developed using a risk-based approach which means that decisions on contaminated soil and groundwater remediation will be based on the nature and extent of the potential risks that are posed to human receptors as a result of exposure to chemicals in the soil and/or groundwater. This approach acknowledges that there are some low levels of exposure to the contaminants that will pose minimal risks to the receptors. RBRGs have been developed as threshold contaminant concentrations, below which hazards or risks to human health arising from exposure to soil and/or groundwater are considered minimal. These target hazard and risk levels will be quantified in subsequent chapters of this document. Remediation of contaminated soil or groundwater that poses such minimal risks would not be necessary for the protection of public health. When concentrations of soil or groundwater are detected above the RBRGs, cleanup will be required. The risk-based approach also facilitates the use of Hong Kong data in respect of typical working

schedules, soil conditions, meteorological conditions, typical building designs, etc. to suit local conditions. This approach provides a specifically relevant and technically defensible framework for the assessment of contaminated sites as well as promotes cost-effective remediation in Hong Kong.



Figure 1.1 – Boatyards



Figure 1.2 – Petrol Filling Stations



Figure 1.3 – Car Repair / Dismantling Workshops

## Section 2 DEVELOPMENT OF RBRGs

### 2.1 Risk-based Approach

Managing contaminated land using the risk-based approach involves taking the source-pathway-receptor into consideration before making decisions on the assessment and remediation of contaminated land. This involves construction of a conceptual site model (CSM), which is the qualitative description of the ways in which receptors can be exposed to site contamination, and is developed to provide an overall understanding of the site. For exposure to be considered possible, some mechanism ('pathway') must exist by which contamination from a given source can reach a given receptor. Such complete 'source-pathway-receptor' exposure mechanisms are commonly termed 'pollutant linkages'.

The term exposure pathway is used to describe a potentially complete source-pathway-receptor linkage, i.e. where a chemical in the environment has a means by which it can reach a human receptor. There are different exposure pathways for different types of land-use which represent different physical settings. Also, the ways in which people come into contact with contaminated soil and/or groundwater, including the intensity and frequency of contact, are largely dependent on the type of land-use. It was therefore necessary to identify the relevant land-use scenarios in Hong Kong and develop a set of RBRGs for each land-use.

### 2.2 Development Process

The RBRGs were developed based on the principles in risk assessment calculation which can be expressed as:

Exposure Concentrations x Exposure Factors x Toxicity = Risk

Where:

<b>X</b>	times or multiply by
Exposure Concentrations	Chemical concentrations that people are exposed to, i.e. RBRGs
Exposure Factors	Describe how people are exposed to the chemicals
Toxicity	Level of toxicity of the chemicals
Risk	Level of health risk acceptable to the public

As shown, RBRGs can be determined based on the risk assessment technique provided that the risk level, toxicity level and exposure factors are known.

RBRGs are concentrations in soil and groundwater protective of human health. The RBRG development process consisted of the following key steps:

- Identify the chemicals of concern (COCs) for Hong Kong.
- Define the different types of land-use where these chemicals may be found.
- Identify the human receptors who could come into contact with these chemicals at contaminated sites.

- Identify the exposure pathways through which the receptors could come in contact with these chemicals at contaminated sites.
- Identify the equations, models, and toxicity information that could be used to develop RBRGs to protect the receptors exposed to COCs.
- Collect information specific to Hong Kong on land-use, building design, site conditions, and people's behavior, to develop RBRGs protective of human health.

Relevant overseas methodologies such as ASTM (1995), ASTM (2000) and CCME (1996) were used in establishing the RBRGs with input of local data as far as possible, resulting in standards more suited to the Hong Kong conditions. The RBRGs were locally derived using established methods and the risk-based approach and are more objective, consistent, and scientifically defensible while at the same time able to ensure a satisfactory level of protection to the public.

For certain chemicals, the calculated RBRGs are higher than the concentrations where a separate, non-aqueous phase may be present in soil or groundwater. Chemicals that exist in this form, referred to as non-aqueous phase liquid (NAPL), can be difficult to locate, contain, or treat and require special consideration USEPA (1992). Screening criteria were developed for NAPL in soil and groundwater that must be considered along with RBRGs to determine whether a site requires further action. The development of NAPL screening criteria is also discussed in the following sections.

### 2.2.1 Chemicals of Concern

RBRGs have been developed for 54 COCs which were selected on the basis that either they are known to occur in the Hong Kong environment, or are in use locally.

The COCs are grouped into the following chemical classes:

- Volatile organic chemicals (VOCs) – 13 chemicals
- Semi-volatile organic chemicals (SVOCs) – 19 chemicals
- Metals – 15 chemicals
- Dioxins and Polychlorinated Biphenyls (PCBs) – 2 chemicals
- Petroleum carbon ranges – 3 groups
- Other inorganic compounds – 1 chemical
- Organometallics – 1 chemical

Soil and groundwater collected at sites contaminated with petroleum should be analyzed using a method that can fractionate the material into categories based on carbon numbers. Whilst toxicity values are generally not provided for Total Petroleum Hydrocarbons (TPH) as a whole, toxicity information is available for individual petroleum carbon fractions. Therefore, RBRGs have been developed for three separate hydrocarbon ranges as follows:

- C6-C8 (Carbon numbers from 6 to 8)
- C9-C16 (Carbon numbers from 9 to 16)
- C17-C35 (Carbon numbers from 17 to 35)

Note that the list of 54 COCs was compiled to the best of EPD's knowledge on what may reasonably be found in contaminated sites in Hong Kong.

In practice, the number and types of chemicals to be analyzed should not be dictated by the 54 COCs, but by the past and present chemical usage/storage activities on-site. Users of this Guidance Manual are advised to select only those COCs from the RBRG list that are relevant to their sites for laboratory testing. On the other hand, if a study of the past and present uses of a site reveals that there may be COCs specific to the site that are not in the list of 54, those specific COCs should be included in the test programme even though they do not appear in the RBRG list.

For any COC outside the list of 54, the user should propose, with justifications, the appropriate standard/remediation goal to be set for agreement with EPD.

### 2.2.2 Land-use Scenarios

RBRGs were developed for four different post-restoration land-use scenarios reflecting the typical physical settings in Hong Kong under which people could be exposed to contaminated soil and groundwater. Sets of RBRGs have been developed to protect workers at industrial sites, the public visiting public parks, and residents in urban and rural areas. Separate sets of RBRGs have been developed according to different land-uses, because it has been shown that the ways in which people come into contact with contaminated soil and/or groundwater, including the intensity and frequency of their contact, are largely dependent on the type of land-use. A description of each land-use scenario is as follows:

- Urban residential** – Sites located in an urban area where main activities involve habitation by individuals. The typical physical setting is a high rise residential building situated in a housing estate that has amenity facilities such as landscaped yards and children playground. The receptors are residents who stay indoors most of the time except for a short period each day, during which they are outdoors and have the chance of being in direct contact with soil at landscaping or play areas within the estate.
- Rural residential** – Sites located in a rural area where main activities involve habitation by individuals. These sites typically have village-type houses or low rise residential blocks surrounded by open space. The receptors are rural residents who stay at home and spend some time each day outdoor on activities such as gardening or light sports. Degree of contact with soil under the rural setting is more than that of the urban setting both in terms of the intensity and frequency of contact.
- Industrial** – Any site where activities involve manufacturing, chemical or petrochemical processing, storage of raw materials, transport operations, energy production or transmission etc. Receptors include those at sites where part of the operation is carried out directly on land and the workers are more likely to be exposed to soil than those working in multi-storey factory buildings.
- Public parks** – Receptors include individuals and families who frequent parks and play areas where there is contact with soil present in lawns, walkways, gardens and play areas. Parks are considered to be predominantly hard covered with limited areas of predominantly landscaped soil. Furthermore, public parks are not considered to have buildings present on them.

### 2.2.3 Identification of Exposure Pathways

For each land-use, consideration was given to ways in which contact with chemicals could occur. The term exposure pathway is used to describe the course a chemical takes from its source area to reach an individual. Each exposure pathway has the following components:

- A source
- A release and transport mechanism (if exposure occurs away from the source)
- A point or location of exposure
- An exposure route by which the chemical enters the human body (the skin, inhalation, ingestion)

For the four land-use categories, it was assumed that exposure could occur in two ways:

- by direct contact with soil (see explanation below) and/or
- by inhalation of vapors if volatile chemicals migrate from soil or groundwater into the air of a building constructed on top of residual contamination.

Thus, there are two combinations of exposure pathways:

- **Soil** – includes direct contact through dermal contact and incidental ingestion of soil, as well as inhalation of particulates and volatile emissions in the ambient air from surface soil and inhalation of subsurface soil contamination in residential or industrial buildings.
- **Groundwater** – includes inhalation of volatiles from subsurface groundwater in residential or industrial buildings.

RBRGs were developed to be protective of each of these two exposure pathways, however, not all exposure pathways are relevant to all land-use categories. For example, public parks are open space areas with good ventilation. They do not generally have occupied buildings in which indoor air could be impacted by the underlying soil. The exposure pathway of indoor air impact therefore would not be applicable to public parks.

The following four different types of RBRGs, have been developed for the land-use categories that are marked with ✓:

	Type of RBRG	Soil					Groundwater
	Pathway	Ingestion of surface soil	Dermal contact with surface soil	Volatiles from surface soil	Particulates from surface soil	Subsurface volatiles indoor	Volatiles indoor from groundwater
Land-use Scenario	Urban Residential	✓	✓	✓	✓	✓	✓
	Rural Residential	✓	✓	✓	✓	✓	✓
	Industrial	✓	✓	✓	✓	✓	✓
	Public Parks	✓	✓	✓	✓		

Compared to other developed countries, the only significant land-use/pathway combination not recommended for Hong Kong is ingestion of contaminated groundwater as drinking water. The elimination is based on the fact that groundwater is generally not used for potable purposes in Hong Kong and this situation is unlikely to change in the future.

### 2.2.4 Cancer and Non-Cancer Toxicity

Chemicals are classified as to whether they exhibit cancer and/or non-cancer health effects.

Chemicals are also classified as to whether they are associated with health effects via one or more routes of exposure, e.g., ingestion, dermal and/or inhalation exposures. Toxicity indices, including cancer slope factors (CSFs) and reference doses (RfDs) (protective of non-cancer effects) are necessary to develop RBRGs.

In general, RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of adverse effects during a lifetime. The CSF is a measure of the cancer potency of a chemical. Conservatism and safety factors are built into both RfDs and CSFs to account for the fact that many of these values are based on animal, rather than human studies.

Toxicity indices for RBRG development were derived from a number of sources including the US Environmental Protection Agency's (EPA) Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEASTs), US Department of Energy's Risk Assessment Information System (RAIS), the World Health Organisation (WHO) publications, the UK and the Netherlands contaminated land guidance documents. Values published on the RAIS were assessed for reliability before being used for RBRG development.

RBRGs protective of cancer health effects and non-cancer health effects are calculated separately. In the event that a chemical was associated with both cancer and non-cancer health effects, both a cancer-based RBRG and a noncancer-based RBRG were developed. The lower of these two RBRGs was selected as the final RBRG.

RBRGs protective of the cancer endpoint were based on an excess life time cancer risk of one in a million ( $10^{-6}$ ). RBRGs protective of noncancer endpoints were based on a hazard quotient of 1.0. A hazard quotient of 1.0 signifies that the derived RBRG, which is the environmental concentration, is equal to the reference dose (RfD) concentration. This concentration is the level at which no adverse effects are expected. In most cases, the RfD incorporates a safety factor so that with a hazard quotient of 1.0, a margin of safety would exist.

### 2.2.5 Non-Aqueous Phase Liquid (NAPL)

NAPL is a general term that refers to any organic liquid present in the environment as a separate distinct phase. The liquid may consist of a single pure chemical (e.g., benzene) or a complex mixture of chemicals (e.g., gasoline).

Two categories of NAPL are recognized: (1) dense non-aqueous phase liquids (DNAPLs) which are heavier than water; and (2) light non-aqueous phase liquids (LNAPLs) which are lighter than water. Examples of DNAPLs include PCBs, trichloroethylene and tetrachloroethylene. Examples of LNAPLs include gasoline, jet fuel, and toluene. LNAPLs released into soil in sufficient quantities may migrate vertically through the soil and eventually encounter the groundwater zone where the NAPL displaces water. DNAPLs released into the soil in sufficient quantities may penetrate deep into the soil with movement below the groundwater table.

Chemicals in this state can be difficult to locate, contain, or treat, and require special consideration for the following reasons:

- Released LNAPLs and DNAPLs can migrate vertically through the subsurface due to gravity, or laterally due to capillary suction. Given a large enough release, LNAPL will encounter the groundwater zone where it spreads laterally and begins to dissolve into groundwater. Once the surface LNAPL release ceases, subsurface spreading of LNAPL

slows as the forces driving migration dissipate. However the dissolved phase may begin to migrate down gradient. Any such movement in the LNAPL plume can result in a significant expansion of the contaminated area and could result in imminent hazards or chronic risks to underground structures (e.g., sewers, basements) or to nearby surface waters and associated aquatic resources. DNAPLs can proceed below the groundwater table, and their flow may be enhanced by the presence of fractures in the soil or bedrock.

- When such NAPLs accumulate, they become pockets of essentially neat (i.e., undiluted) chemicals and could present a significant health threat (imminent hazard as well as chronic risk) to exposed receptors. Direct exposure to pockets of NAPLs could involve significantly greater exposures/uptakes than would be associated with similar organic chemicals that are present as sorbates on soil or solutes in groundwater.
- Pockets of NAPLs can act as long-term sources of contamination to the nearby environment via volatilization and dissolution. Vapors from volatilization may migrate to ambient air or to underground structures. Solutes from dissolution will migrate to groundwater. Such pockets of NAPL are not commonly depleted rapidly by such volatilization/dissolution, nor by degradation, so that the material acts as a source of pollution for many years or decades.

For these reasons, screening criteria (soil saturation limits,  $C_{sat}$ ) were developed for NAPLs in soil and solubility limits for NAPL in groundwater for the more mobile organic chemicals. These criteria must be considered in addition to RBRGs to determine whether a site requires further action.

### 2.3 Risk-Based Remediation Goal Tables

RBRGs for Soil and Soil Saturation Limits (Table 2.1) and RBRGs for Groundwater and Solubility Limits (Table 2.2) present the remediation goals for soil and groundwater respectively. Each table presents a list of the COCs and RBRGs for the relevant land-use categories. Detected concentrations of COCs in soil and/or groundwater are to be compared to their respective RBRGs for the appropriate land-use category. COCs for which no groundwater RBRGs are provided were lacking either the appropriate toxicity values or physical/chemical property values necessary to calculate the RBRGs, or they were not considered to be volatile (i.e. volatile chemicals are those with Henry's Law Constant  $>10^{-5}$ ).

Table 2.1 presents the soil saturation limits ( $C_{sat}$ ) for the more mobile organic chemicals (with molecular weight less than 200 g/mol).  $C_{sat}$  is the concentration at which a chemical can, in theory, be present in the environment as NAPL. Table 2.2 presents the Solubility Limits for organic chemicals in groundwater. Solubility Limits were only calculated for those COCs with Henry's Law Constant  $>10^{-5}$ . For these chemicals, detected concentrations must be compared to both the RBRG and  $C_{sat}$ /Solubility Limits to determine whether further action is required at the site. The  $C_{sat}$  and Solubility Limits serve as trigger levels indicating the potential for NAPL to be present. The issue of NAPL is of less concern for chemicals with molecular weights greater than 200 g/mol as chemicals with higher molecular weights are considered to be less mobile.

A non risk-based 'ceiling limit' is given as  $10^4$  mg/kg for soil and  $10^4$  mg/L for groundwater for the relatively less toxic inorganic, volatile and semi-volatile contaminants.

Instruction for comparing site data to RBRGs and  $C_{sat}$ /Solubility Limits is presented in Section 3.



## 2.4 Limitation on the Use of RBRGs

The RBRGs have been developed in consideration of environmental conditions, activities and building designs typical in Hong Kong. Conservative yet realistic assumptions have also been made on the degree of exposures that can occur to residents, workers and the public but only the common, important and complete exposure pathways have been included in the derivation of the RBRGs. Users of this Manual must familiarize themselves with the assumptions behind the derivation of these RBRGs before adopting them for their sites of concern. In particular, they must satisfy themselves that all exposure pathways important to their sites of concern have been considered in the derivation of the RBRGs in this manual.

### Groundwater Utilization

An example of unusual activity which may lead to an exposure pathway not considered in the derivation of the RBRGs in this manual is the extraction of groundwater from within the site or locations close to the site for beneficial use, such as for drinking or irrigation. Where such exposure pathways exist, the user needs to conduct a separate assessment of the risks posed through such pathways. There are standards for drinking water in Hong Kong and these must be adhered to.

### Ecological Receptors

The users should note that ecological receptors are not specifically covered by the RBRGs. The reason for this is that the brownfield sites in Hong Kong are primarily former industrial or in some cases commercial premises. Today these sites will be re-developed for residential, commercial or government/institutional use. It is highly unlikely that a contaminated site in Hong Kong will be re-developed for agricultural uses or into a nature conservation area. In the rare event that protection of ecological resources becomes necessary at a particular site, a focused ecological risk assessment (ERA) should be carried out to assess the ecological risks, in addition to applying the RBRGs. An ecological risk assessment is effectively a detailed consideration of the mechanisms and probability of exposure of ecological receptors to contamination and a characterization of the potential adverse effects which may arise from this exposure. There is considerable guidance available on ERA including: CCME (1996) and USEPA (1998).

### Landscaping Plants

There is a chance that a contaminated site may be re-developed into a public park. RBRGs were derived for this land-use to protect the park users (see Section 2.2.2). No remediation standards were set to protect landscaping plants which are the major ecological receptors in a public park. The reason for this is that uncontaminated off-site soil with suitable soil characteristics, instead of the original site soil, is normally used for planting. The imported soil is then mixed with soil conditioners and fertilizers to make it suitable for planting use. Project proponents also have the option of planting more hardy landscaping plants that are resistant to contamination.

### Conceptual Site Model

It will be necessary for those investigating contaminated land to build a conceptual model that describes the sources of contamination, the potential receptors and the pathways by which one may reach the other. In rare circumstances where significant ecology receptors are potentially impacted or where groundwater abstraction, surface water quality or other receptors are potentially at risk then the RBRGs will not be protective of these receptors. Site investigators will need to undertake a more detailed risk assessment that selects different, more appropriate criteria such as drinking water guidelines to protect groundwater abstractions. It is envisaged that this circumstance will be rare in Hong Kong. When encountered, site investigators will be required to have their risk assessments reviewed and approved by the EPD.

**Table 2.1**  
**Risk-Based Remediation Goals (RBRGs) for Soil & Soil Saturation Limit**

Chemical	Risk-Based Remediation Goals for Soil				
	Urban Residential (mg/kg)	Rural Residential (mg/kg)	Industrial (mg/kg)	Public Parks (mg/kg)	Soil Saturation Limit (Csat) (mg/kg)
<b>VOCs</b>					
Acetone	9.59E+03	4.26E+03	1.00E+04*	1.00E+04*	***
Benzene	7.04E-01	2.79E-01	9.21E+00	4.22E+01	3.36E+02
Bromodichloromethane	3.17E-01	1.29E-01	2.85E+00	1.34E+01	1.03E+03
2-Butanone	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	***
Chloroform	1.32E-01	5.29E-02	1.54E+00	2.53E+02	1.10E+03
Ethylbenzene	7.09E+02	2.98E+02	8.24E+03	1.00E+04*	1.38E+02
Methyl tert-Butyl Ether	6.88E+00	2.80E+00	7.01E+01	5.05E+02	2.38E+03
Methylene Chloride	1.30E+00	5.29E-01	1.39E+01	1.28E+02	9.21E+02
Styrene	3.22E+03	1.54E+03	1.00E+04*	1.00E+04*	4.97E+02
Tetrachloroethene	1.01E-01	4.44E-02	7.77E-01	1.84E+00	9.71E+01
Toluene	1.44E+03	7.05E+02	1.00E+04*	1.00E+04*	2.35E+02
Trichloroethene	5.23E-01	2.11E-01	5.68E+00	6.94E+01	4.88E+02
Xylenes (Total)	9.50E+01	3.68E+01	1.23E+03	1.00E+04*	1.50E+02
<b>SVOCs</b>					
Acenaphthene	3.51E+03	3.28E+03	1.00E+04*	1.00E+04*	6.02E+01
Acenaphthylene	2.34E+03	1.51E+03	1.00E+04*	1.00E+04*	1.98E+01
Anthracene	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	2.56E+00
Benzo(a)anthracene	1.20E+01	1.14E+01	9.18E+01	3.83E+01	
Benzo(a)pyrene	1.20E+00	1.14E+00	9.18E+00	3.83E+00	
Benzo(b)fluoranthene	9.88E+00	1.01E+01	1.78E+01	2.04E+01	
Benzo(g,h,i)perylene	1.80E+03	1.71E+03	1.00E+04*	5.74E+03	
Benzo(k)fluoranthene	1.20E+02	1.14E+02	9.18E+02	3.83E+02	
bis-(2-Ethylhexyl)phthalate	3.00E+01	2.80E+01	9.18E+01	9.42E+01	
Chrysene	8.71E+02	9.19E+02	1.14E+03	1.54E+03	
Dibenzo(a,h)anthracene	1.20E+00	1.14E+00	9.18E+00	3.83E+00	
Fluoranthene	2.40E+03	2.27E+03	1.00E+04*	7.62E+03	
Fluorene	2.38E+03	2.25E+03	1.00E+04*	7.45E+03	5.47E+01
Hexachlorobenzene	2.43E-01	2.20E-01	5.82E-01	7.13E-01	
Indeno(1,2,3-cd)pyrene	1.20E+01	1.14E+01	9.18E+01	3.83E+01	
Naphthalene	1.82E+02	8.56E+01	4.53E+02	9.14E+02	1.25E+02
Phenanthrene	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	2.80E+01
Phenol	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	7.26E+03
Pyrene	1.80E+03	1.71E+03	1.00E+04*	5.72E+03	
<b>Metals</b>					
Antimony	2.95E+01	2.91E+01	2.61E+02	9.79E+01	
Arsenic	2.21E+01	2.18E+01	1.96E+02	7.35E+01	
Barium	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Cadmium	7.38E+01	7.28E+01	6.53E+02	2.45E+02	
Chromium III	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Chromium VI	2.21E+02	2.18E+02	1.96E+03	7.35E+02	
Cobalt	1.48E+03	1.46E+03	1.00E+04*	4.90E+03	
Copper	2.95E+03	2.91E+03	1.00E+04*	9.79E+03	
Lead	2.58E+02	2.55E+02	2.29E+03	8.57E+02	
Manganese	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Mercury	1.10E+01	6.52E+00	3.84E+01	4.56E+01	
Molybdenum	3.69E+02	3.64E+02	3.26E+03	1.22E+03	
Nickel	1.48E+03	1.46E+03	1.00E+04*	4.90E+03	
Tin	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
Zinc	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	
<b>Dioxins / PCBs</b>					
Dioxins (I-TEQ)	1.00E-03	1.00E-03	5.00E-03	1.00E-03	
PCBs	2.36E-01	2.26E-01	7.48E-01	7.56E-01	
<b>Petroleum Carbon Ranges</b>					
C6 - C8	1.41E+03	5.45E+02	1.00E+04*	1.00E+04*	1.00E+03
C9 - C16	2.24E+03	1.33E+03	1.00E+04*	1.00E+04*	3.00E+03
C17 - C35	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+04*	5.00E+03
<b>Other Inorganic Compounds</b>					
Cyanide, free	1.48E+03	1.46E+03	1.00E+04*	4.90E+03	
<b>Organometallics</b>					
TBTO	2.21E+01	2.18E+01	1.96E+02	7.35E+01	

Notes:

- (1) For Dioxins, the cleanup levels in USEPA Office of Solid Waste and Emergency Response (OSWER) Directive of 1998 have been adopted. The OSWER Directive value of 1 ppb for residential use has been applied to the scenarios of "Urban Residential", "Rural Residential", and "Public Parks", while the low end of the range of values for industrial, 5 ppb, has been applied to the scenario of "Industrial".
- (2) Soil saturation limits for petroleum carbon ranges taken from the Canada-Wide Standards for Petroleum Hydrocarbons in Soil, CCME 2000.
- (3) \* indicates a 'ceiling limit' concentration.
- (4) \*\*\* indicates that the Csat value exceeds the 'ceiling limit' therefore the RBRG applies.

**Table 2.2**  
**Risk-Based Remediation Goals (RBRGs) for Groundwater and Solubility Limit**

Chemical	Risk-Based Remediation Goals for Groundwater			
	Urban Residential (mg/L)	Rural Residential (mg/L)	Industrial (mg/L)	Solubility Limit (mg/L)
<b>VOCs</b>				
Acetone	1.00E+04*	1.00E+04*	1.00E+04*	***
Benzene	3.86E+00	1.49E+00	5.40E+01	1.75E+03
Bromodichloromethane	2.22E+00	8.71E-01	2.62E+01	6.74E+03
2-Butanone	1.00E+04*	1.00E+04*	1.00E+04*	***
Chloroform	9.56E-01	3.82E-01	1.13E+01	7.92E+03
Ethylbenzene	1.02E+03	3.91E+02	1.00E+04*	1.69E+02
Methyl tert-Butyl Ether	1.53E+02	6.11E+01	1.81E+03	***
Methylene Chloride	1.90E+01	7.59E+00	2.24E+02	***
Styrene	3.02E+03	1.16E+03	1.00E+04*	3.10E+02
Tetrachloroethene	2.50E-01	9.96E-02	2.95E+00	2.00E+02
Toluene	5.11E+03	1.97E+03	1.00E+04*	5.26E+02
Trichloroethene	1.21E+00	4.81E-01	1.42E+01	1.10E+03
Xylenes (Total)	1.12E+02	4.33E+01	1.57E+03	1.75E+02
<b>SVOCs</b>				
Acenaphthene	1.00E+04*	7.09E+03	1.00E+04*	4.24E+00
Acenaphthylene	1.41E+03	5.42E+02	1.00E+04*	3.93E+00
Anthracene	1.00E+04*	1.00E+04*	1.00E+04*	4.34E-02
Benzo(a)anthracene				
Benzo(a)pyrene				
Benzo(b)fluoranthene	5.39E-01	2.03E-01	7.53E+00	1.50E-03
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene				
bis-(2-Ethylhexyl)phthalate				
Chrysene	5.81E+01	2.19E+01	8.12E+02	1.60E-03
Dibenzo(a,h)anthracene				
Fluoranthene	1.00E+04*	1.00E+04*	1.00E+04*	2.06E-01
Fluorene	1.00E+04*	1.00E+04*	1.00E+04*	1.98E+00
Hexachlorobenzene	5.89E-02	2.34E-02	6.95E-01	6.20E+00
Indeno(1,2,3-cd)pyrene				
Naphthalene	6.17E+01	2.37E+01	8.62E+02	3.10E+01
Phenanthrene	1.00E+04*	1.00E+04*	1.00E+04*	1.00E+00
Phenol				
Pyrene	1.00E+04*	1.00E+04*	1.00E+04*	1.35E-01
<b>Metals</b>				
Antimony				
Arsenic				
Barium				
Cadmium				
Chromium III				
Chromium VI				
Cobalt				
Copper				
Lead				
Manganese				
Mercury	4.86E-01	1.84E-01	6.79E+00	
Molybdenum				
Nickel				
Tin				
Zinc				
<b>Dioxins / PCBs</b>				
Dioxins (I-TEQ)				
PCBs	4.33E-01	1.71E-01	5.11E+00	3.10E-02
<b>Petroleum Carbon Ranges</b>				
C6 - C8	8.22E+01	3.17E+01	1.15E+03	5.23E+00
C9 - C16	7.14E+02	2.76E+02	9.98E+03	2.80E+00
C17 - C35	1.28E+01	4.93E+00	1.78E+02	2.80E+00
<b>Other Inorganic Compounds</b>				
Cyanide, free				
<b>Organometallics</b>				
TBTO				

Notes:  
 (1) Blank indicates that RBRG could not be calculated because the toxicity or physical / chemical values were unavailable, or the condition of Henry's Law Constants > 10<sup>-5</sup> was not met for the inhalation pathway.  
 (2) Water solubilities for Petroleum Carbon Range aliphatic C9-C16 and greater than C16 generally are considered to be effectively zero and therefore the aromatic solubility for C9-C16 is used.  
 (3) \* indicates a 'ceiling limit' concentration.  
 (4) \*\*\* indicates that the solubility limit exceeds the 'ceiling limit' therefore the RBRG applies.

## Section 3

# APPLICATION OF RBRGs IN LAND CONTAMINATION ASSESSMENT

The normal contamination assessment practice in Hong Kong is illustrated in Figure 3.1. RBRGs should be used in place of the Dutch B levels to determine the need for future action and remediation at a contaminated site, during the preparation of Contamination Assessment Plan (CAP), Contamination Assessment Report (CAR) and Remediation Action Plan (RAP). Implementation of the RBRGs and an assessment of the RBRGs to chemical concentrations detected on a site should be undertaken by a competent specialist consultant.

Figure 3.2 presents the steps in the application of RBRGs in contamination investigation. The primary information required includes: (1) knowledge of the past, current and future land-uses at a site; and (2) sufficient analytical data on the concentrations of COCs in the site's soil and groundwater.

### 3.1 Steps for Applying RBRGs in Contaminated Land Assessment

Figure 3.2 presents the following six steps in contamination assessment:

Step 1: Identify land-use and select COCs

Step 2: Assess laboratory data for COCs

Step 3: Compare maximum detected concentrations to RBRGs and NAPL trigger criteria

Step 4: Point-by-point comparison

Step 5: Establish whether NAPL is present

Step 6: Incorporate results into CAR

Once information has been compiled through the steps above, it can be summarized and reported on Standard Forms 3.1 through 3.5, which are introduced in the steps below and in Section 4 of this Guidance Manual.

User instruction is provided as follows.

#### Step 1: Identify Land-use and Select COCs

The first step is to identify the past, current and future land-uses of a property. This information is typically compiled as part of the initial site appraisal (see Figure 3.1). Past and current land-use information is important for developing a list of potential COCs and for assessing the potential presence of NAPL-related chemicals at the site. During initial site appraisal, it is important to identify past and present site activities that have potential to cause contamination and to make an inventory of the chemicals manufactured, stored, used and disposed of. COCs for a site should be selected on the basis of the information collected during the initial site appraisal and not necessarily bound by the 54 COCs in Tables 2.1 and 2.2.

Standard Form 3.1 can be used to summarize the past, current and anticipated future uses of a property.

If past usage of a site was different from the current use, all past operations and site conditions, back to the time the affected property was pre-industrial, are to be provided. Maps of the layout of former operations, if available, should be attached to this standard form to illustrate the past site conditions. The type of business/facility/site, the names of the landowners, and a description of the primary products or process associated with each past use should also be specified. The number of years the business was in operation, or if the site was not in use, the number of years the property was in that condition should be indicated.

Current use information of the site, including maps showing the present layout of the site, the type of facility or business, a description of the business operations and primary products or processes, and the name of the landowner should be provided. If the site is presently vacant, this should be indicated on the standard form as well. If there is evidence that site-related contamination has migrated beyond property boundaries to downgradient properties, the types of land-use at the affected properties should be indicated.

It is always useful to examine the past and present aerial photographs of a site to help identify the historical and current conditions or activities that may have caused contamination.

The land-use classifications for any future use of the property, e.g., urban residential, rural residential, industrial or public parks should be clearly stated. Site contamination data should be compared to the RBRGs developed for the future land-use reported for the site as the applicability of each set of RBRGs is dependent on land-use. In the event that the future land-use is unknown, the most stringent set of RBRGs should be adopted as the cleanup standards so that the site will be suitable for all use after remediation. If a site is to be excavated after remediation and the excavated soil will be re-used off-site, the most stringent set of RBRGs should be adopted. As it is usually very difficult to control the exact location in which the soil will finally be re-used, adopting the most stringent RBRGs will ensure that the destination site of the soil, wherever that may be, will be suitable for all land-uses after being filled.

For any future land-use categories falling outside the four categories described in Section 2, the user of this manual needs to compare the exposure characteristics of his/her site with those described for the four categories and identify one category that most closely matches the exposure characteristics of his/her particular site in question. The RBRGs for the category that is most similar to the user's site are the applicable RBRGs for his/her site of concern. For example, if a school site has exposure characteristics most similar to that of the "urban residential" category, the RBRGs specified for the "urban residential" category should be adopted for the school site.

When applying the RBRGs to a commercial land-use scenario, a case-by-case judgment is appropriate because there are many different forms of commercial use. For example, a commercial use of a single storey building located in a rural area will likely resemble the rural residential setting, and thus the RBRGs for rural residential will apply. If a commercial use is within an urban residential building, then the RBRGs for urban residential will apply.

Examples of post-restoration land-uses and the appropriate RBRGs are as follows:

Land-use	Corresponding RBRGs	Land-use
Commercial/residential		
• urban high rise	Urban Residential	
• low rise in rural area	Rural Residential	
Commercial /Business & Offices	Urban Residential	
Schools	Rural Residential	

Public park with an indoor games hall	Lower of Public Park or Urban Residential
Warehouse & Storage	Industrial
Government, Institution & Community Facilities	Urban Residential
Roads including pedestrian walkway	Lower of Industrial or Public Park
Railways	Industrial
Open Space	Public Park
Public utilities	Industrial

### Step 2: Assess Laboratory Data for COCs

Following site investigation (Part II of Figure 3.1), a check must be made that the data collected from the site present a reasonably reliable description of the soil and groundwater contamination. Standard quality control/quality assurance (QA/QC) field procedures must be adopted during sampling and storage/transport of the samples to the laboratory. Such QA/QC procedures will ensure sample integrity and reduce the potential for cross-contamination and sample errors (e.g. erroneous concentrations of phthalates which are commonly found in plastic sampling products).

Laboratory analytical data should be reviewed to check that basic quality assurance and quality control protocols were followed. Any unusual problems reported by the laboratory to have prevented attainment of a method reporting limit less than the RBRG should be reported. For example, it may be difficult for a laboratory to quantify the individual constituents present in a sample contaminated with high concentrations of petroleum products. In these cases, special measures, such as sample dilution, can be employed by laboratories to maintain the lowest possible method reporting limits. In general, analytical data with method reporting limits that exceed RBRGs are considered invalid for use in assessment.

All detected chemicals must be compared to their respective RBRGs. If a chemical is reported in a quality control sample analyzed by the laboratory, i.e., a "blank", or is suspected to be a laboratory contaminant, this information should be recorded in the CAR document.

All laboratory test methods must be accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) or one of its Mutual Recognition Arrangement partners.

### Step 3: Compare Maximum Detected Concentrations to RBRGs and NAPL Trigger Criteria

The CAR document should include data summary tables for soil and/or groundwater. Standard Forms 3.2 and 3.3 can be used for this purpose. All detected chemicals are to be listed by chemical category, e.g., volatile organic chemicals, semi-volatile organic chemicals, etc. Additional statistics and information should include the following:

- Frequency of Detection – the number of times a chemical was detected divided by total number of samples collected and analyzed for that parameter.
- Range of Detected Concentration – the minimum and maximum detected concentrations for each chemical.
- Range of Method Reporting Limits – the minimum and maximum method reporting limits reported by the laboratory for each chemical.
- Analytical Method - reference for the method used to analyze each chemical.
- Land-use Category - list the relevant land-use categories.

- RBRG – list the lowest of the appropriate RBRG(s) from Table 2.1 for soil and Table 2.2 for groundwater for all the land-use categories applicable for the site. If there is no RBRG in Tables 2.1 or 2.2 for a COC found at a site, the user of this manual should propose for EPD’s agreement a suitable remediation goal for the COC.
- $C_{sat}$  or Solubility – for the soil and groundwater data summary (Standard Form 3.2 and 3.3), list the soil saturation or solubility limit from Table 2.1 and Table 2.2.

**Step 4: Point-by-Point Comparison**

A point-by-point comparison must also be presented. A point-by-point comparison involves tabulation of all sample numbers, concentrations, locations, and depths of all samples. Checks are to be placed in the appropriate columns on Standard Forms 3.4 and 3.5 for samples that exceed the soil RBRG or  $C_{sat}$  (Standard Form 3.4) and the groundwater RBRG or Solubility Limit (Standard Form 3.5). A site figure is to be submitted indicating the distribution of contamination for samples that exceed an RBRG or NAPL trigger criterion.

**Step 5: Establish whether NAPL is Present**

If the maximum detected chemical concentrations in soil exceed the  $C_{sat}$ , or the maximum detected chemical concentrations in groundwater exceed the Solubility Limit, additional assessment is required to determine whether NAPL may be present.

$C_{sat}$  and Solubility Limits represent the initial NAPL screen for soil in unsaturated subsurface zones and groundwater, respectively. The decision on whether or not the soil or groundwater at a site contains NAPL or other non-natural free liquids will likely require professional judgement and a weight-of-evidence approach to balance out potentially conflicting information. The evidence may include information on the historic land-use activities at the site, soil boring logs (visual evidence and/or hydrocarbon vapor readings), as well as soil, groundwater and soil vapor concentrations of various chemicals. An industry “rule of thumb” for groundwater DNAPL contamination is that DNAPL may be present where groundwater concentrations have been observed in excess of 1 % of the effective solubility of the compound detected. This is an approximation and should be considered as an indicator of the likely presence of DNAPL, it should be used in conjunction with the site specific details listed above.

Field observations are considered in determining the potential occurrence of NAPL. Records should be kept to indicate whether any of the following three field conditions was observed during sample collection:

1. Stained, unnaturally colored, or wet soil above the water table. The presence of NAPL may be obvious based on visual evidence of liquids in the soil, especially if the appearance is of a colored (or opaque) liquid or of a viscous liquid.
2. Petroleum or solvent odours in soil or groundwater samples.
3. Presence of sheen on water samples or bailer, or oily residual on soil samples or split spoon sampler.

If any of the above field conditions was observed, NAPL is likely to be present and remediation is required. In this instance the rules below are likely to apply (see Figure 3.3), although situations may vary on a site by site basis:

1. Site concentration greater than RBRG

If the field assessment indicates no trace of NAPL then the remediation goal will be the RBRG . If the field assessment indicates NAPL as present, then NAPL removal will be necessary and the lower of the RBRG or  $C_{sat}$  or solubility limit will be the clean-up criterion.

2. Site concentration less than RBRG

If the field assessment indicates no trace of NAPL then remediation is not required. If the field assessment indicates NAPL as present, then NAPL removal will be necessary and the lower of the RBRG or  $C_{sat}$  or solubility limit will be the clean-up criterion.

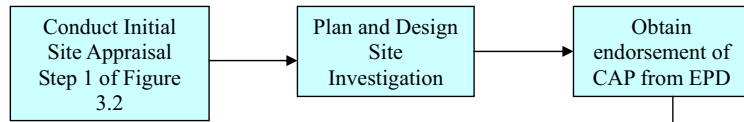
**Step 6: Incorporate Results into CAR**

The contamination assessment results, presented in Standard Forms 3.1 through 3.5 (or other similar format), should be included in the CAR along with recommendations for further actions. The presence of the following conditions indicates that contamination exists and remedial action is required at the site:

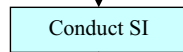
- Any detected chemical concentration in soil or groundwater exceeds an RBRG;
- Any detected chemical concentration in soil exceeds a NAPL trigger criterion and/or a chemical concentration in groundwater exceeds the solubility limit, as well as other evidence suggests that NAPL is of concern.

Figure 3.1 – Land Contamination Assessment and Preparation of CAP, CAR and RAP

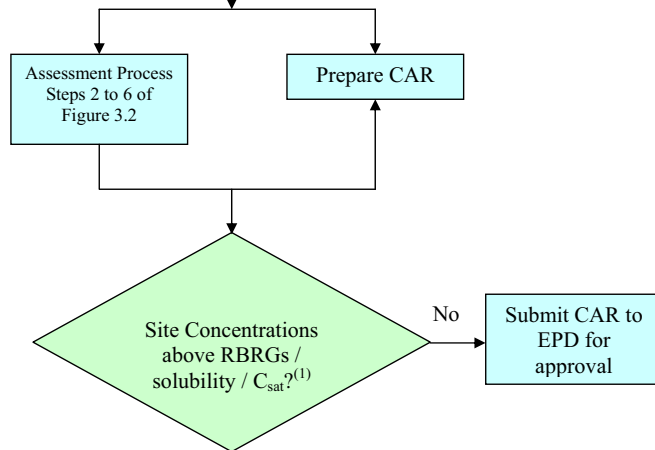
I. Contamination Assessment Plan (CAP)



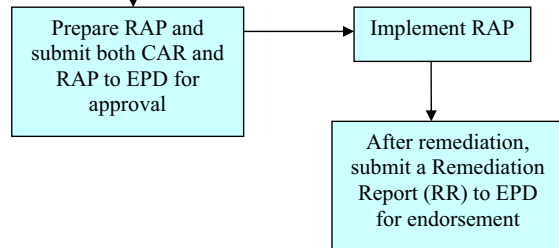
II. Site Investigation (SI)



III. Contamination Assessment Report (CAR)



IV. Remediation Action Plan (RAP)

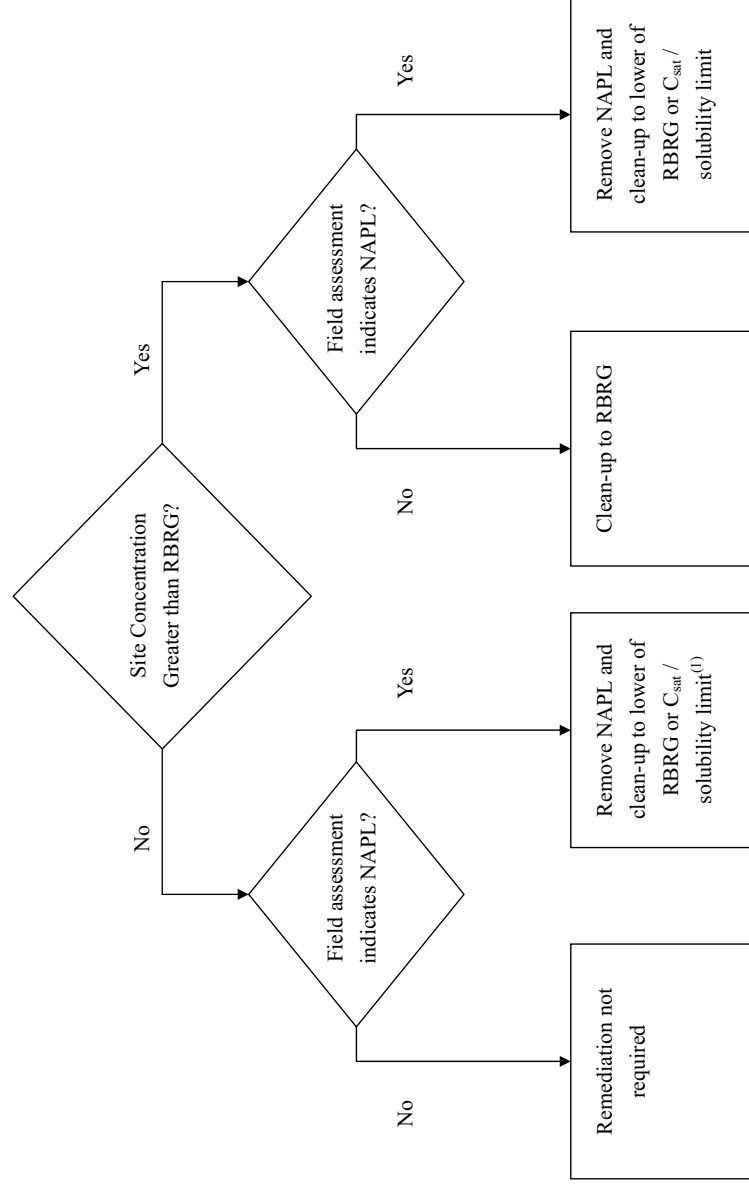


Notes:  
1. Refer to Figure 3.3 for NAPL assessment flowchart.

Figure 3.2 – Land Contamination Assessment Process: Input and Reporting Requirements

Step	Necessary Information	Prepare Standard Form
1. Identify land use and select COCs	<ul style="list-style-type: none"> <li>Past land uses and activities</li> <li>Current use of site and activities</li> <li>Future use of site and expected activities</li> <li>Maps and aerial photos of historic, current and future (if available) site layout and operations</li> <li>COC selection based on past and current activities</li> <li>Previous Site Investigation reports, if available</li> </ul>	<ul style="list-style-type: none"> <li>Form 3.1 – Summary of On-Site Land Use</li> </ul>
2. Assess laboratory data for COCs	<ul style="list-style-type: none"> <li>Soil and groundwater analytical data with method reporting limits less than RBRGs</li> <li>Soil and groundwater COC concentrations to be representative of vertical and horizontal extent of contamination</li> <li>Basic QA/QC evaluation of laboratory data noting spurious results or other reported problems</li> </ul>	
3. Compare maximum detected concentrations to RBRGs and NAPL trigger criteria	<ul style="list-style-type: none"> <li>Sample concentrations reported as mass/mass (soil) and mass/volume (water)</li> <li>Comparison of maximum concentrations in soil samples to RBRG and <math>C_{sat}</math></li> <li>Comparison of maximum concentrations in groundwater samples to RBRG and solubility limits</li> </ul>	<ul style="list-style-type: none"> <li>Form 3.2 – Soil Data Summary and Comparison to RBRGs and <math>C_{sat}</math></li> <li>Form 3.3 – Groundwater Data Summary and Comparison to RBRGs and Solubility Limits</li> </ul>
4. Point-by-point comparison	<ul style="list-style-type: none"> <li>Point-by-point tabulation of all chemicals, sample numbers, locations, and depths and indicate any exceedance of the soil RBRG and <math>C_{sat}</math></li> <li>Point-by-point tabulation of all chemicals, sample numbers, locations, and depths and indicate any exceedance of the groundwater RBRG and solubility limits</li> </ul>	<ul style="list-style-type: none"> <li>Form 3.4 – Soil Sample Concentrations and Exceedances of RBRG and <math>C_{sat}</math></li> <li>Form 3.5 - Groundwater Sample Concentrations and Exceedances of RBRG and Solubility Limits</li> </ul>
5. Establish whether NAPL is present	<ul style="list-style-type: none"> <li>Record of field observations including visual and odour evidence of NAPL plus field instrument readings.</li> </ul>	
6. Incorporate results into CAR	<ul style="list-style-type: none"> <li>Conclusions regarding need for remediation</li> <li>Discussion of information gaps and uncertainties, if applicable</li> </ul>	<ul style="list-style-type: none"> <li>CAR</li> </ul>

Figure 3.3 – NAPL Assessment Flowchart



**Notes:**

1. If site concentration is less than both the RBRG and  $C_{sat}$  / solubility limit, only removal of NAPL is necessary.

**Standard Form 3.1 - Summary of On-Site Land Use**

Property Name \_\_\_\_\_

**Current Use**

Type of facility/business	On-site property land use	Date began <sup>1</sup>	Description of business process/primary products	Owner or Occupier	Approximate size of on-site property	Off-site property affected? Yes No

**Past Use**

Are past uses different from current uses? \_\_\_ Yes \_\_\_ No If Yes, complete this section.

Complete this table with each different operation, use, or status of the on-site property. Include all operations back to pre-commercial or pre-industrial time if this information is necessary to characterize the site. Specify the status of the property at each stage, including times it may have been vacant. Start with the most recent use and list in chronological order backwards through time.

Type of facility/business	On-site property land use	Date began <sup>2</sup>	Date ended <sup>3</sup>	Description of business process/primary products	Owner or Occupier	Approximate size of on-site property (if different from current size)	Off-site property affected? Yes No

**Future Use**

Are future uses different from current uses? \_\_\_ Yes \_\_\_ No If Yes, complete this section.

Type of facility/business	On-site property land use <sup>4</sup>	Description of business process/primary products	Owner or Occupier	Approximate size of on-site property

<sup>1</sup> Specify the approximate year in which the current use of the on-site property began.

<sup>2</sup> Specify the approximate year in which the past use of the on-site property began.

<sup>3</sup> Specify the approximate year in which the past use of the on-site property ended.

<sup>4</sup> Specify all applicable land use including urban residential, rural residential, industrial or public parks

**Standard Form 3.2  
Soil Data Summary and Comparison to RBRGs and C<sub>Sat</sub>**

Chemical	Frequency of Detection <sup>(1)</sup> (x/y)	Range of Detected Concentration <sup>(2)</sup>	Range of Method Reporting Limit <sup>(3)</sup>	Analytical Method	Relevant Land Use Categories	Lowest RBRG(s) (mg/kg)	C <sub>Sat</sub> (mg/kg)	Maximum Detected Concentration Exceeds (check if applicable) RBRG C <sub>Sat</sub>
<b>Volatile Organic Chemicals</b> (List)								
<b>Semi-Volatile Organic Chemicals</b> (List)								
<b>Metals</b> (List)								
<b>Dioxins/PCBs</b> (List)								
<b>Petroleum Carbon Ranges</b> (List)								
<b>Other Inorganic Compounds</b> (List)								
<b>Organometallics</b> (List)								

- x = number of samples in which chemical was found above the method reporting limit
  - y = number of samples analyzed for chemical
  - Give minimum and maximum detected values
- Give minimum and maximum method reporting limits

**Standard Form 3.3  
Groundwater Data Summary and Comparison to RBRGs and Solubility Limits**

Chemical	Frequency of Detection <sup>(1)</sup> (x/y)	Range of Detected Concentration <sup>(2)</sup>	Range of Method Reporting Limit <sup>(3)</sup>	Analytical Method	Relevant Land Use Categories	Lowest RBRG(s) (mg/L)	Solubility Limit (mg/L)	Maximum Detected Concentration Exceeds RBRG (check if applicable) RBRG Solubility
<b>Volatile Organic Chemicals</b> (List)								
<b>Semi-Volatile Organic Chemicals</b> (List)								
<b>Metals</b> (List)								
<b>Dioxins/PCBs</b> (List)								
<b>Petroleum Carbon Ranges</b> (List)								
<b>Other Inorganic Compounds</b> (List)								
<b>Organometallics</b> (List)								

- x = number of samples in which chemical was found above the method reporting limit
  - y = number of samples analyzed for chemical
  - Give minimum and maximum detected values
- Give minimum and maximum method reporting limits

**Standard Form 3.4  
Soil Sample Concentrations and Exceedances of RBRGs and C<sub>sat</sub>**

Chemical	List Samples		Concentration	Check if RBRG Exceeded	Check if C <sub>sat</sub> Exceeded	Approximate size of Affected Area
	Sample Number	Sample Depth				
<b>Volatlie Organic Chemicals</b> (List)						
<b>Semi-Volatlie Organic Chemicals</b> (List)						
<b>Metals</b> (List)						
<b>Dioxins/PCBs</b> (List)						
<b>Petroleum Carbon Ranges</b> (List)						
<b>Other Inorganic Compounds</b> (List)						
<b>Organometallics</b> (List)						

**Standard Form 3.5  
Groundwater Sample Concentrations and Exceedances of RBRGs and Solubility Limits**

Chemical	List Samples		Concentration	Check if RBRG Exceeded	Check if Solubility Limit Exceeded	Approximate size of Affected Area
	Sample Number	Sample Depth				
<b>Volatlie Organic Chemicals</b> (List)						
<b>Semi-Volatlie Organic Chemicals</b> (List)						
<b>Metals</b> (List)						
<b>Dioxins/PCBs</b> (List)						
<b>Petroleum Carbon Ranges</b> (List)						
<b>Other Inorganic Compounds</b> (List)						
<b>Organometallics</b> (List)						



## Section 4 RECORD KEEPING AND REPORTING

As a final step in the assessment process, the user should record in the CAR all the results mentioned in Section 3 for EPD's approval.

Standard Forms 3.1 through 3.5 are provided as templates for summarizing the information necessary to complete the contamination assessment. Reproduced copies of these forms, or similar forms containing the same information, are to be included in the CAR along with a narrative to describe their contents. The following Standard Forms have been included in this manual:

- Standard Form 3.1 – Summary of On-Site Land-use
- Standard Form 3.2 – Soil Data Summary and Comparison to RBRGs and  $C_{sat}$
- Standard Form 3.3 – Groundwater Data Summary and Comparison to RBRGs and Solubility Limits
- Standard Form 3.4 – Soil Sample Concentrations and Exceedances of RBRG and  $C_{sat}$
- Standard Form 3.5 – Groundwater Sample Concentrations and Exceedances of RBRG and Solubility Limits

Instructions for completing these forms are provided in Section 3. This information is to be submitted as part of the CAR, along with conclusions regarding the need for further action, or a determination of "no further action".

The following support documentation must be maintained by the project proponents and should be submitted to EPD when required:

- Field and Laboratory Data Package – Copies of field records and laboratory analytical reports for all media samples.
- Chain-of-custody documentation.
- Quality assurance/quality control documentation.

Laboratory reports must include the following information: name and address of the laboratory, name and address of client, project name, sample results, method reporting limits, sample ID number, lab ID number, sample matrix, date and time of sample collection, date of receipt of sample, date of sample preparation and extraction, date of analysis, preparation and analytical method numbers, method quantitation limits, analytical results, signature of laboratory personnel and issue date.

Chain-of-custody documentation must include: affected property name, address, and regulatory identification number, name of person who collected the samples, date of sample collection, type of analyses requested, sample matrix, sample ID number and sampling location, sample preservation method(s), date(s) and time(s) of transfer to other person, date and time received by the laboratory, signatures of collectors, the laboratory, and any intermediary persons, laboratory-assigned job number and sample numbers, and any other pertinent log-in information.

Quality control documentation should include any other information necessary to convey the results

of the analyses and a brief summary to document that the data meet the project objectives. The project data quality objectives (DQOs) for media samples should be included in an appendix of the support documentation.

The DQO process defines the type, quantity and quality of data needed from site investigation or remediation. DQOs provide a systematic approach for defining the criteria that a data collection design should satisfy, including when, where and how to collect samples or measurements; determination of tolerable decision error rates; the number of samples or measurements that should be collected and the method reporting limits that should be achieved.

The US Environmental Protection Agency (USEPA) describes the DQO process as a stepped iterative planning approach used to prepare plans for environmental data collection. USEPA (2000) documents guidance for the DQO process and the DQO process for hazardous waste site investigations.

## Section 5 GENERAL REFERENCE

ASTM, 1995. *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. American Society for Testing and Materials (November, 1995).

ASTM, 2000. *Standard Guide for Risk-Based Corrective Action*. American Society for Testing and Materials (ASTM, November 2000).

CCME, 1996. *A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*. Canadian Council of Ministers of the Environment (March 1996).

CCME, 2000. *Canada-Wide Standards for Petroleum Hydrocarbons (PHCs) in Soil: Scientific Rationale - Supporting Technical Document*. Canadian Council of Ministers of the Environment (CCME, December 2000).

US EPA, 1992. *Estimating Potential for Occurrence of DNAPL at Superfund Sites*. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, R.S. Kerr Environmental Research Laboratory, Houston, Texas, USA (1992).

US EPA, 1998. Guidelines for Ecological Risk Assessment. United States Environmental Protection Agency, April 1998, EPA/630/R-95/002F. USEPA Risk Assessment Forum, Washington DC

USEPA 2000, Data Quality Objectives Process for Hazardous Waste Site Investigations, EPA QA/G-4HW Final, Washington DC

Annex B

## Site Layout Plan and Site Photographs

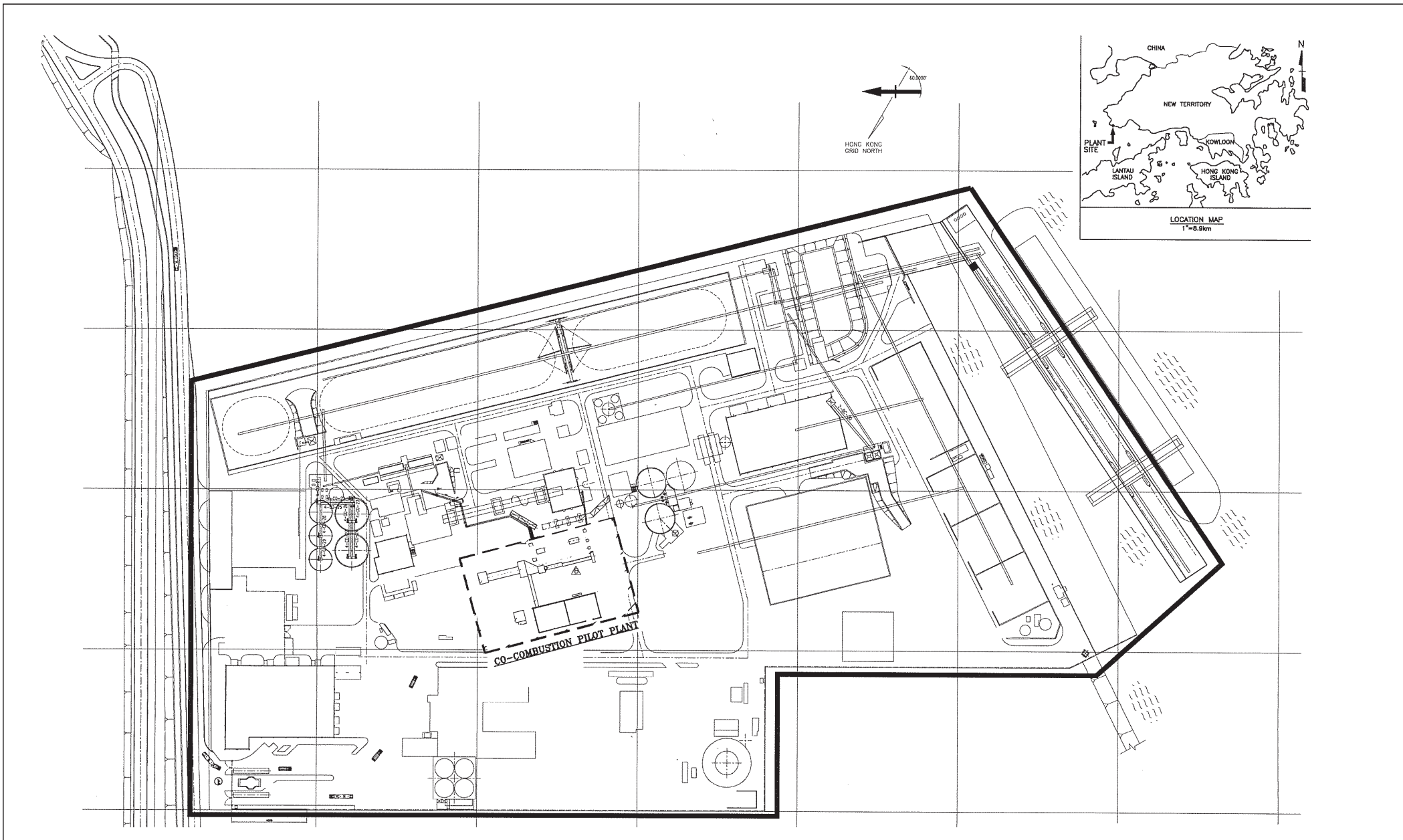


Figure B1

Site Layout Plan

FILE: 0071019a  
DATE: 07/09/2007

Environmental  
Resources  
Management



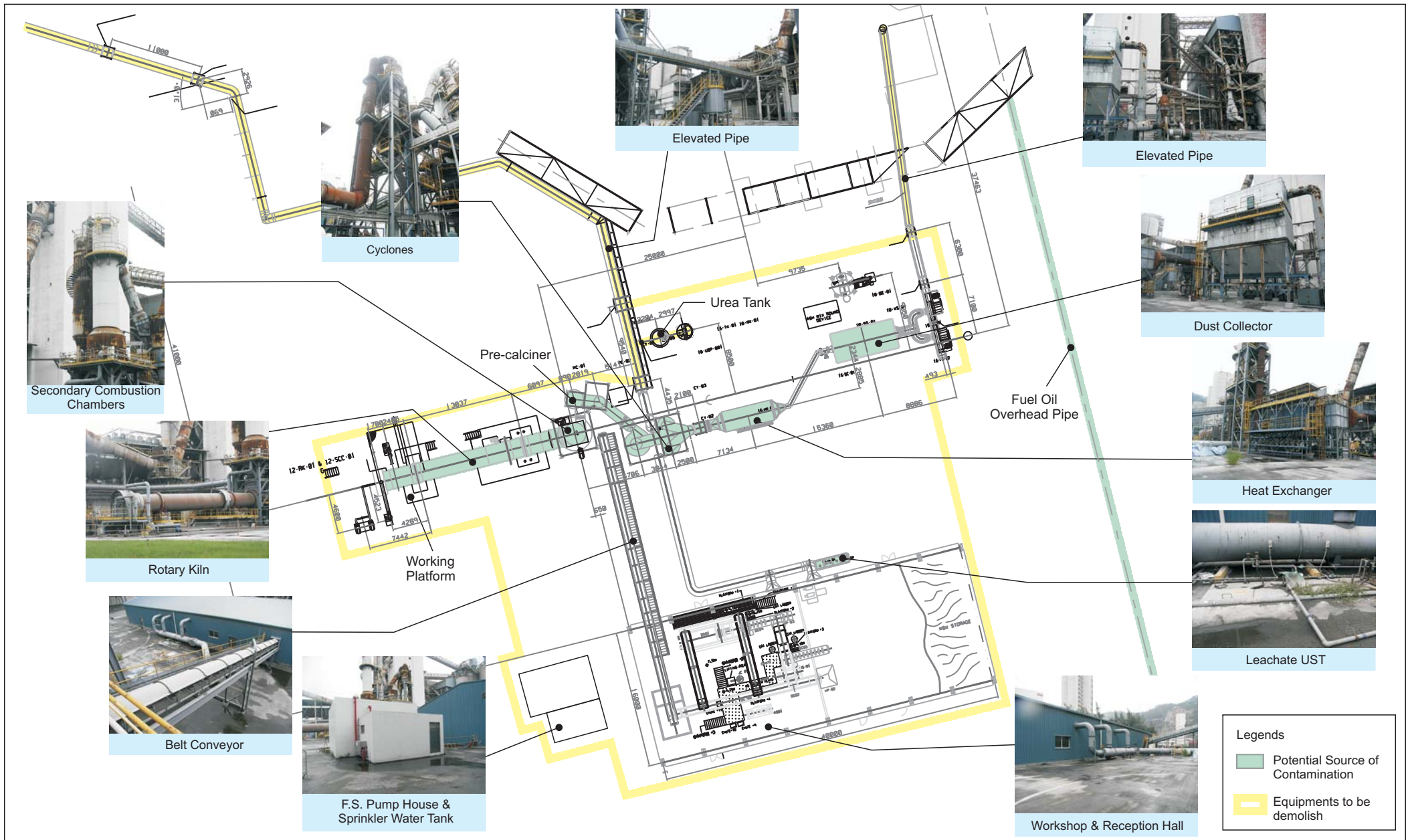


Figure B2 Location of Potential Sources of Contamination





Photo 1 – CCPP



Photo 2 – CCPP



Photo 3 – Material recovery building



Photo 4 – Conveyor belt connecting the CCPP unit with the material recovery building



Photo 5 – Ash bags in material recovery building

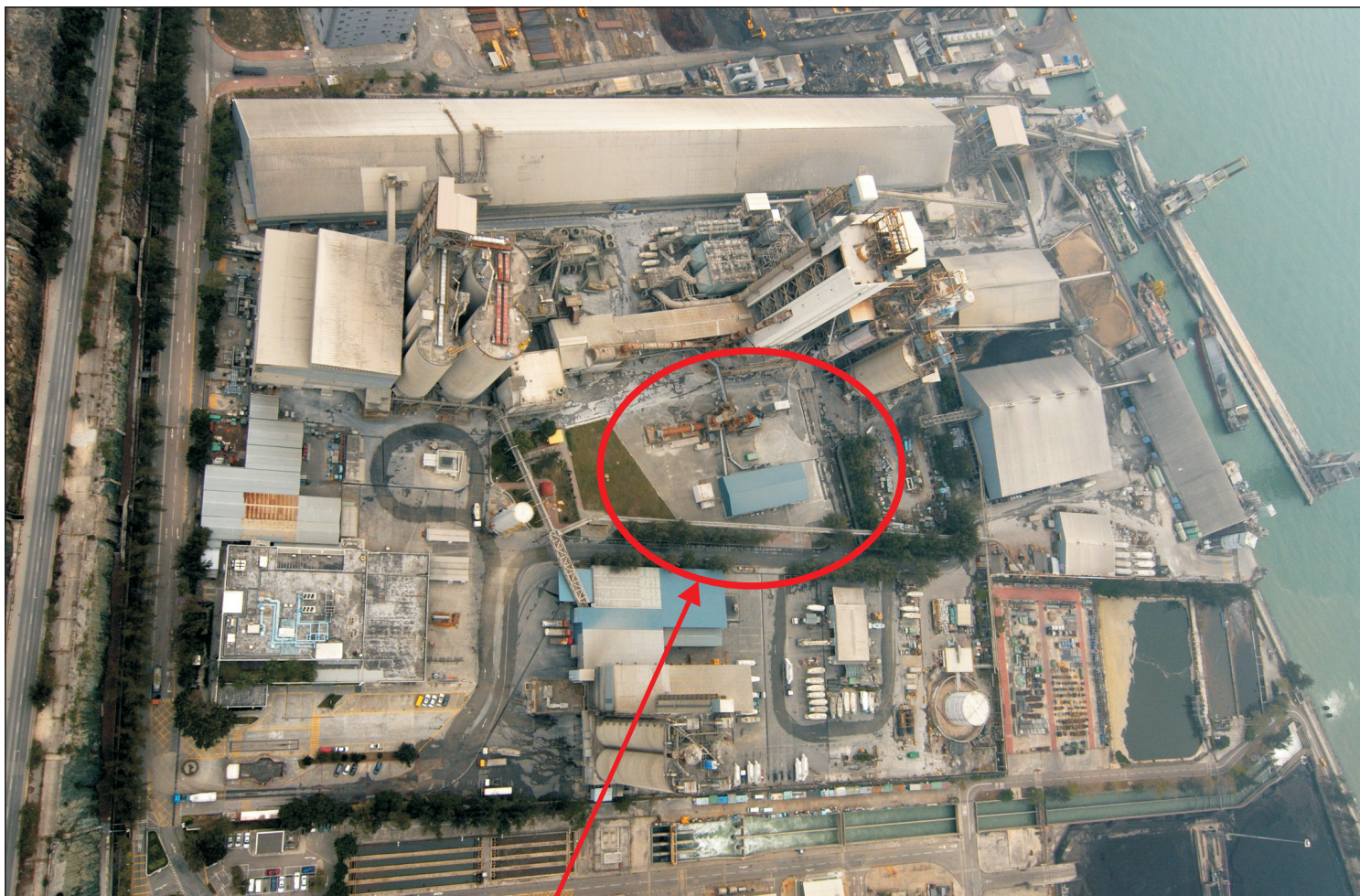


Photo 6 – Fuel USTs and dispensing station

Annex C

## Site Aerial Photograph





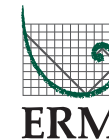
The Site

Figure C1

Aerial Photographs of the Site

FILE: 0071019b3  
DATE: 07/09/2007

Environmental  
Resources  
Management





Annex D

## Historical Photographs



FINISH GRINDING AREA – FINISH MILL FOUNDATION EXCAVATION  
DECEMBER 11, 1980.



GENERAL VIEW OF SITE LOOKING SOUTH. JANUARY 22, 1981.



CASTLE PEAK CEMENT PROJECT SITE. FEBRUARY 27, 1981



GENERAL VIEW OF SITE LOOKING SOUTH, MARCH 21, 1981.

Figure D1

Historical Photographs

FILE: 0071091b  
DATE: 07/09/2007

Environmental  
Resources  
Management

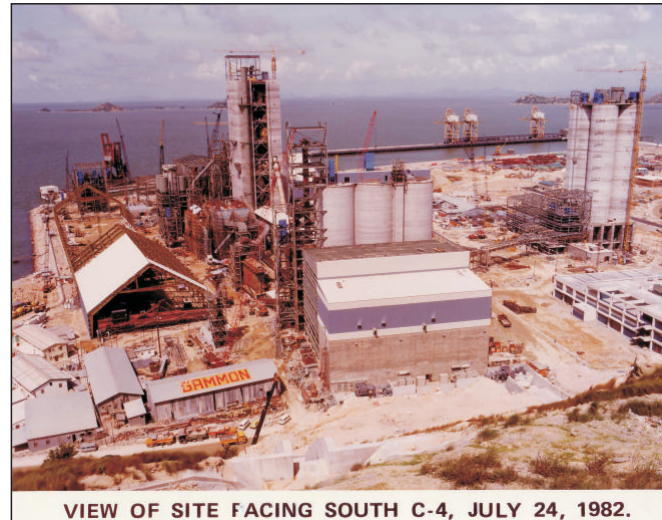




MAIN SUBSTATION GROUNDING MAT, MAY 23, 1981.



BURNING & COOLING AREA, LOOKING SOUTH. JUNE 20, 1981.



VIEW OF SITE FACING SOUTH C-4, JULY 24, 1982.

Figure D2

Historical Photographs

FILE: 0071019b1  
DATE: 07/09/2007

Environmental  
Resources  
Management







Figure D3

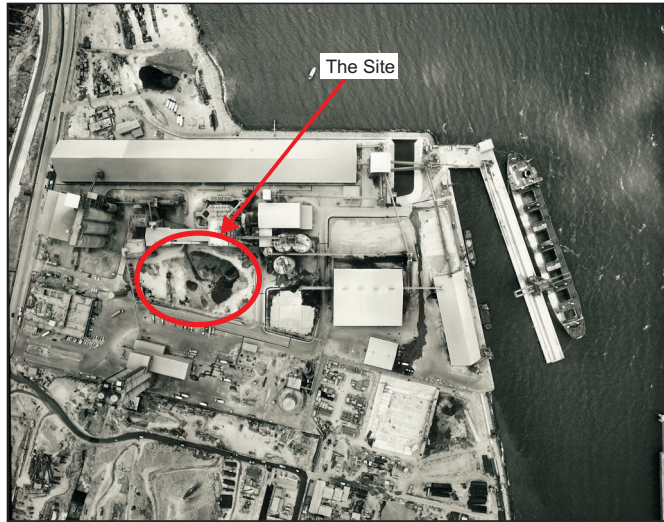
Historical Photographs (year 1981)

FILE: 0071019b2  
DATE: 07/09/2007

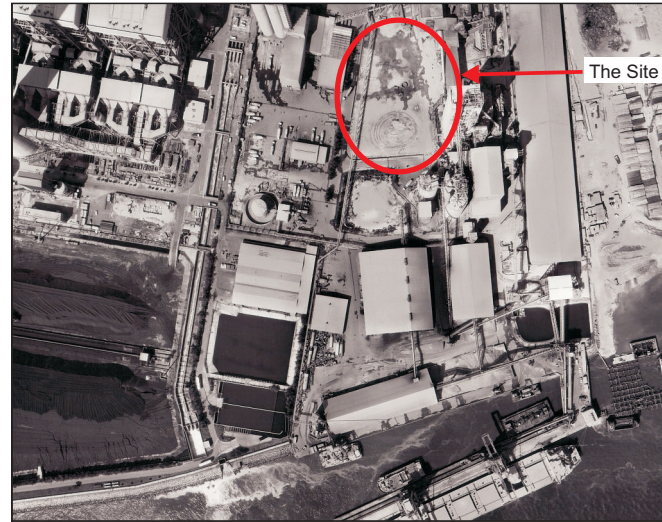
Environmental  
Resources  
Management







Year 1983



Year 1995



Year 1982

Figure D4

Historical Photographs

Annex E

## Proposed Sampling Locations

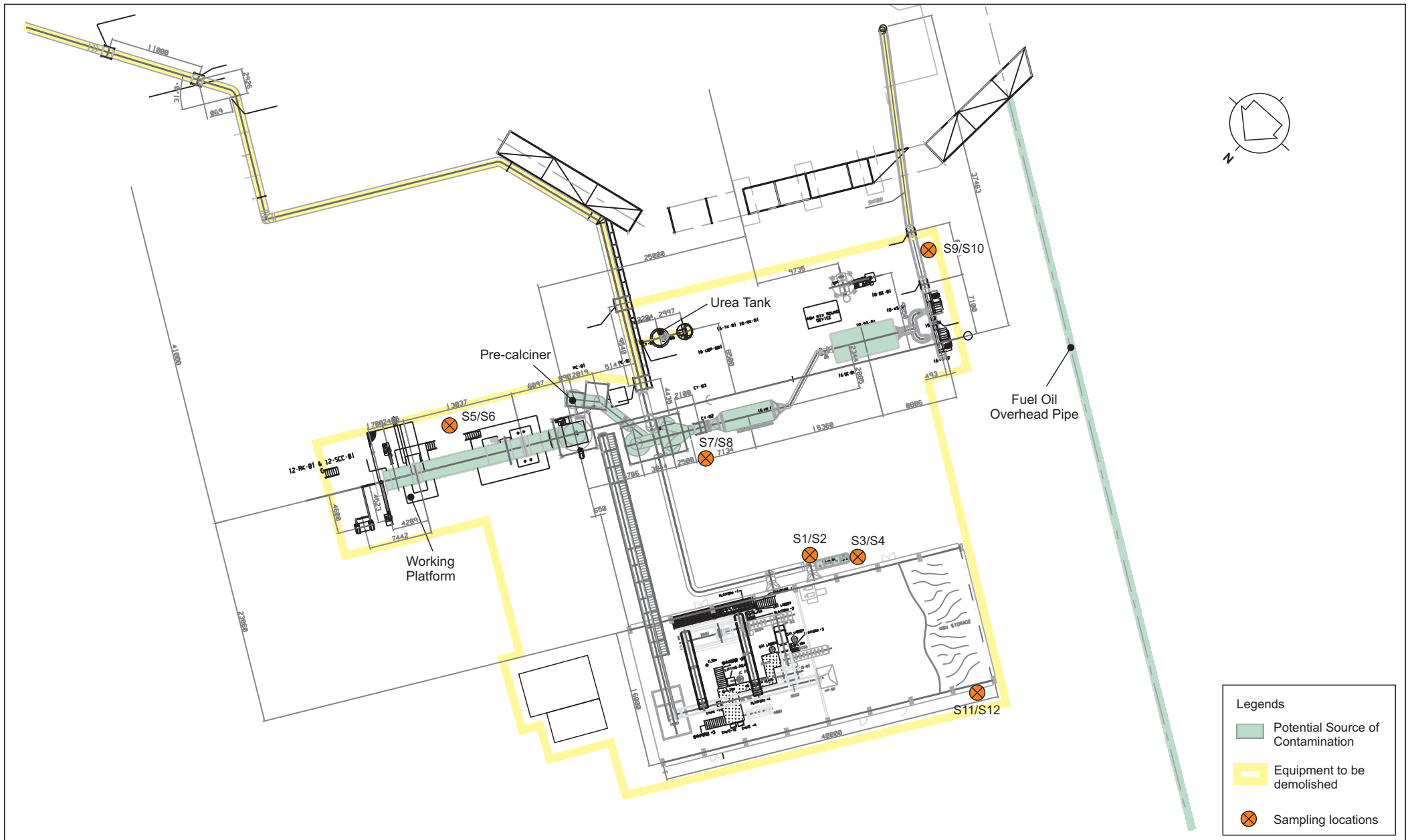


Figure E1

Proposed Soil Sampling Locations

FILE: 0071019h  
 DATE: 03/01/2008

Environmental  
 Resources  
 Management



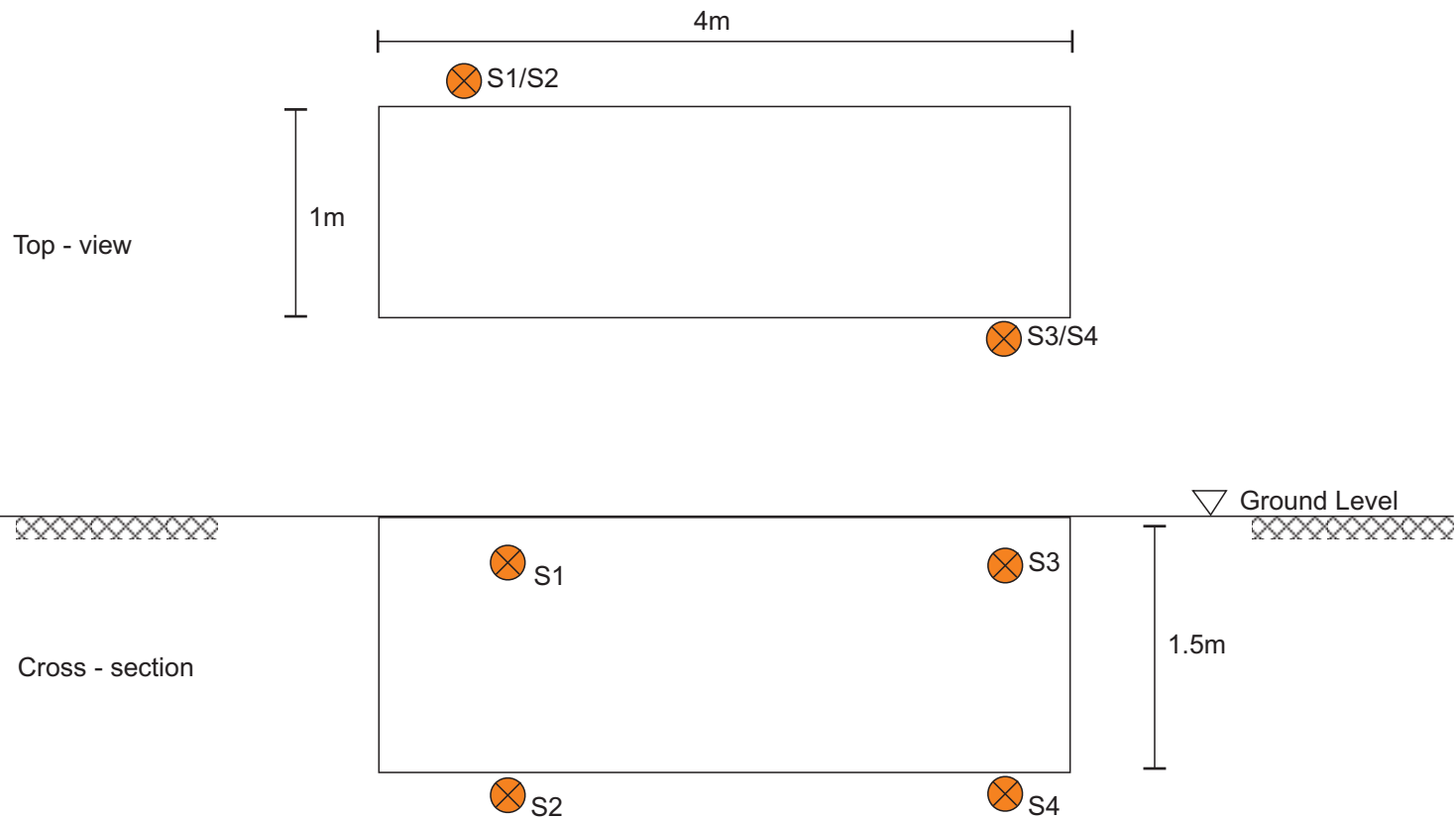


Figure E2

Proposed Soil Sampling Locations (UST)



Annex F

## Response to Comments

**RESPONSE TO COMMENTS**

**Contamination Assessment Plan for Decommissioning of the Co-Combustion Pilot Plant at Tap Shek Kok**

*H:\Team\EM\GMS Projects\0071019 EIA for Decommissioning of Co-Combustion Plant\Deliverables\annex E CAP\Submission to EPD 9 Nov 2007\Annex\0071019\_CAP\_RTC\_26102007.doc*

Ref.	Department	Reference	Comments	Consultant's Response
i.	Environmental Protection Department	() in Ax (1) to EP2/N4/PT2/80 dated 24 October 2007	1 <sup>st</sup> bullet of Off Site Sources, Section 3.2 – Please confirm whether the fuel underground storage tanks will be included in the proposed decommissioning of CCPP. If yes, a proper site investigation should be included in this CAP. If no, please state clearly in the report that it will not form part of the proposed decommissioning of CCPP.	The fuel underground fuel storage tank is not part of the decommissioning of the CCPP. Text has been elaborated to clarify this.
ii.			2 <sup>nd</sup> bullet of On Site Sources, Section 3.2 – Please state in the report what contingency measures will be provided if any evidence of past leakage and/or spillage is found during the demolition of underground storage tank for MRRF's leachate.	As discussed in Section 3.2, the UST was a steel tank. Its integrity has been checked to ensure no leakage prior to use. The tank was used for a short period of time (11 weeks) during the operations of the CCPP only and no evidence of leakage/damage was observed. Therefore the likelihood of the leachate /wastewater contaminating the soil around the tank and groundwater is considered to be very low. Moreover, the waste handled at the MRRF was municipal solid waste and the leachate generated from the operation of the MRRF was organic in nature and did not contain potential contaminants of concern such as heavy metals or persistent organic compounds.  Text has been amended accordingly.

Ref.	Department	Reference	Comments	Consultant's Response
iii.			2 <sup>nd</sup> para., Section 1.3 – Please amend “The RBRG Guidance was published on .....” to read “The RBRG Guidance Manual and associated Guidance Notes was issued by EPD on....”	Noted. Text has been amended accordingly.
iv.			5 <sup>th</sup> para., Section 2.2 – Please add “Proposed Decommissioning of CCPP” as a sub-heading for the paragraph.	Noted. Sub-heading has been added.
v.			Annex B – Please indicate clearly on Figure B2 the exact extent and parts of the CCPP to be included in the proposed decommissioning.	Noted. The exact extent and parts of the CCPP to be included in the proposed decommissioning works have been included in <i>Figure B2</i> .