GUIDELINE ON ENVIRONMENTAL BASELINE STUDY

(2019 EDITION)

(This version 6 edited August 2022)

SUMMARY OF AMENDMENTS

Version 6	
Section 2.3	Revised the NEA's website on the list of third party specialist consultants
Section 7.2	Added requirement on remediation proposal
Version 5	
Section 2.3	Revised the NEA's website on the list of third party specialist consultants
Section 5.2.2	Updated to adopt the EBS data information excel template (Dutch Standard 2013)
Section 5.2.3	Added requirement on EBS BH location
Section 7.1	Added requirement for entry and exit EBS
Section 7.2	Added requirement on establishment of extent of contamination
Section 7.3	Revised requirement on certification of remediated sites
APPENDIX A.1.	Updated the link for EBS data information excel template (Dutch Standard 2013)
Version 4	
Section 2.3	Revised the NEA's website on the list of third party specialist consultants
APPENDIX A.1.	Revised contact list Added in definition for change of use
Version 3	
Section 6.4.3	Added in no use of glue requirement for groundwater monitoring well installations
Section 7.2	Added in remediation procedure
Version 2	
Section 2.3	Revised the NEA's website on the list of third party specialist consultants

Contents

1.0 Introduction

An Environmental Baseline Study (EBS) is an intrusive soil and groundwater investigation conducted to establish the baseline level of potential contaminants in soils and groundwater beneath a concerned site and to assess the extent of contamination of the site.

The EBS efforts shall determine the environmental setting and hydro-geological condition of the site at the time of site assessment. Basically, the study shall provide an overall picture of the existing soil and groundwater conditions in the context of subsurface contamination. Each study is to be planned as part of the continual monitoring program through which changes in conditions at the site can be documented, assessed and updated.

This Guideline is developed to provide the responsible parties necessary guidance for conducting EBS for assessing contamination of a site. This Guideline shall be read in conjunction with Section 7, Control of land pollution and remediation of contaminated sites, of Code of Practice on Pollution Control.

2.0 Recommended EBS procedure

2.1 The six-step EBS procedure

An environmental baseline study may include the following six steps:

<u>Step 1 Development of Work Plan</u>

- Investigation Documents (Work Plan, Health, Safety and Environment Plan)

<u>Step 2 Preliminary investigation</u>

- Objectives
- Scope of work (Desktop Investigation, site reconnaissance, development of Conceptual Site Model (CSM))

<u>Step 3 Development of investigation strategy</u>

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- Sample Handling and Documentation
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Step 5 Selection of soil and groundwater quality standards or screening level

- Standards of Assessment
- Remediation
- Certification of Remediated Site

Step 6 Reporting

- Report submission
- Self-Declaration checklist **(in Appendix A.1.)**

2.2 Acquisition of data or information

The data or information needed to conduct an EBS can be acquired from the following sources, but not limited to:

- Clients: building plans, permits and licences, manufacturing processes, historical use etc.
- SLA: land title records
- MINDEF: aerial photographs, topography maps, and road maps
- Other government departments and statutory boards, e.g. PCD of NEA.

EBS data or information acquisition is generally an iterative process. Adequacy of data or information should be constantly reviewed and evaluated. When data or information is lacking or missing, additional data or information acquisition shall be considered.

2.3 Engagement of a qualified consultant

An EBS shall be carried out by the responsible parties who may appoint a qualified consultant to undertake the EBS on their behalf. The responsible parties should check that their consultants are qualified and have proven capability and experience in the site assessment work (including EBS) or other relevant works. The qualified consultants shall be responsible for providing technical support and supervision throughout the progress of the work. The responsible parties or their consultants shall also ensure that only accredited laboratory is to be engaged for the analyses. A list of third party specialist consultants is provided by the NEA and can be found at https://www.nea.gov.sg/our-services/development-control(site assessment and site remediation)

3.0 Step 1 Development of Work Plan

3.1 Investigation Documents

For documentation purposes, the EBS Consultant shall prepare (i) a Work Plan, and (ii) a Health, Safety and Environment Plan (H&S Plan). Findings from the preliminary investigation will feed into the H&S plans and refine the Work Plan. These plans are live documents and should be updated after the findings of the preliminary investigation.

3.1.1 Work Plan

The Work Plan is a document that details how the EBS Consultant proposes to carry out the EBS. The EBS Consultant shall prepare an initial Work Plan that includes but not be limited to the following:

a. Overall EBS objectives;
b. Specific field investigation objectives (after preliminary investigation);
c. Background information and site history;
d. Breakdown of project-related tasks;
e. Equipment to be used;
f. EBS team organization including the EBS Consultant's key personnel's roles and responsibilities, selected laboratory, environmental drilling contractors and other personnel/contractors involved in the EBS;
g. Existing/previous layout plan and description on land use; and
h. Schedule or timeline for completion.

The Work Plan will also include quality control and quality assurance procedures such as:

a. Sampling strategy;
b. The type and quantity of data needed;
c. How and where the data will be obtained;
d. How the acquired data will be analysed;
e. Quality assurance and quality control activities to assess the quality performance criteria; and
f. A declaration that the consultant had adopted the standard procedures in accordance to this set of guidelines.

The Work Plan shall be attached as an Appendix to the EBS report(s).

3.1.2 Health, Safety and Environment Plan

A Health, Safety and Environment Plan (H&S Plan) is a document that details how the EBS Consultant will identify and manage site-specific health, safety and environment hazards associated with the proposed EBS. The H&S Plan shall include but not be limited to the following:

a. Risk Assessment
A site-specific health and safety risk assessment should detail all the job tasks to be carried out during the EBS as well as the associated hazards and the additional controls that must be in place to eliminate or minimise the hazards.

b. Health and Safety Measures
Details of safe work practices and control measures used to reduce or eliminate general potential hazards should be provided in this section. These safe practices and controls should cover general practices and housekeeping, hazard communication, dangerous chemicals, manual lifting, fire prevention, heights and falls, electrical hazards, biological hazards, etc.

c. Pollution Control Measures
Preventive measures to address noise, odour, dust, air and water pollution

should be provided in this section to ensure field work to be conducted in compliance with the standard of the relevant authorities.

d. Personal Protective Equipment (PPE)
The list of general hazards and the appropriate PPE required should be provided in this section. Standard PPE should be worn by all personnel in the field at all times, in compliance with the Workplace Safety and Health Act (Cap. 354A) or other relevant Ministry of Manpower (MOM) requirements.

e. Emergency Response Plan
The emergency response plan should identify the location of on-site first aid and telecommunication available, provide a list of emergency telephone numbers, indicate the evacuation routes, assembly areas and route to hospital, etc.

4.0 Step 2 Preliminary Investigation

The Preliminary Investigation (PI) forms the initial phase of all investigations. It involves a desktop investigation and site reconnaissance. This is a largely non-intrusive survey that provides data from which a preliminary Conceptual Site Model (CSM) can be developed.

4.1 Objectives

The objectives of conducting a PI are:

a. To develop a preliminary CSM for the site;
b. To identify potential sources of contamination and recognised environmental conditions(RECs) in connection with the historical and current site activities;
c. To identify the potential on-site and off-site human and environmental receptors;
d. To identify potential migration pathways, transport mechanisms and exposure pathways of the soil and groundwater contamination;
e. To identify the potential impacts of contamination to on-site and off-site receptors;
f. To gather information useful for developing the sampling program for the EBS; and
g. To identify the probability of potential off-site sources of contamination that could affect the environmental condition of the site.

4.2 Scope of Work

4.2.1 Desktop Investigation

The minimum information that must be obtained during the desktop investigation is as follows:

a. Site identification – site name, address or lot number/postal code, land/property ownership;
b. Site location – site boundaries, surrounding land uses, land use zoning, presence of surface water bodies and groundwater extraction wells, sensitive receptors (schools, child care centres, etc.) within 500 metre (m) radius, and underground services or structures in the site vicinity;
c. Historical and current land use(s), the types of industry, activities, unit operation and chemical used, previous EBS, environmental incidents and potential existing soil/groundwater risks;

d. Future intended land use; and
e. Regional and site geological/hydrogeological information.

4.2.2 Site Reconnaissance

The purpose of site reconnaissance is to obtain information indicating the likelihood of identifying RECs in conjunction with the site activities. The site reconnaissance shall consist of:

a. A walkover inspection of the site and within a 250 m radius from the site boundaries. On-site inspection shall include identification of potential areas and chemicals of concerns (such as chemical storage areas and underground/aboveground tanks), condition of site covering (such as surface material and condition, effect on the potential for contaminant ingress), site topography, surface staining, stressed vegetation, and location of aboveground as well as underground utilities/piping;
b. Interviews with relevant facility or site personnel to gather relevant current and historical site information;
c. Review of the site's general operations process flow and process waste handling;
d. Identification of potentially sensitive receptors; and
e. Collection of photographs of areas of potential concern, neighbouring land uses and other relevant observations related to potential land contamination.

Additional guidance for desktop investigation and site reconnaissance can be found in American Society for Testing and Materials (ASTM) E-1527-13 (Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process), or the latest version, to the extent practicable in Singapore.

4.2.3 Development of Conceptual Site Model (CSM)

A CSM shall be generated based on the information obtained from the desktop investigation and site reconnaissance. Basic components of a CSM are as follows:

a. General setting of the site within a local and regional context (land use, topography, geology/hydrogeology, etc.);
b. Potential sources of contamination and release mechanisms;
c. Potential migration pathways;
d. Potential exposure pathways; and
e. Potential sensitive receptors.

The CSM should be consistent with the complexity of the site and identified issues. Additional guidance for CSM development can be found in ASTM E1689-95 (Developing Conceptual Site Models).

5.0 Step 3 Development of Investigation Strategy

5.1 Field Investigation Objectives

For baseline EBS, the objective of the intrusive field investigation is to collect representative and reliable soil and groundwater data (or other media, where applicable) at the suitable locations to confirm and refine the CSM developed during the preliminary investigation. The information gathered during intrusive field investigations are used to provide technically justified conclusions on site contamination.

Site investigations for other purposes (such as spill and leak investigation or additional EBS to close out identified data gaps) may require more specific objectives and therefore a different sampling/investigation strategy.

5.2 Sampling Strategies

Based on the preliminary investigation findings, the locations, quantity and types of samples to be collected should be identified. The EBS consultant should take a conservative approach to manage uncertainties and ensure the EBS is robust and defensible.

5.2.1 Determining Sampling Media

As a minimum, soil and groundwater samples shall be collected at the site for baseline EBS. Additional/supplementary investigation may require sampling of other media such as soil vapour, surface water, sediments, and biological media, as necessary or where applicable.

5.2.2 Determining Analytes

For the EBS purpose, contaminants of concern (COCs) are typically identified on the basis of a site inspection, review of available information, and a site history review. Given that the investigation required is an environmental baseline study, analytes covering known future or expected chemicals to be used on the site (not necessarily used on the site in the past or at the time of the EBS investigation) should also be included in the analytical regime, where possible.

Appendix A.2 lists the possible COCs of some typical industries in Singapore, including refineries, electronics, shipbuilding, wood-based furnishing, petrol stations, electro-plating, and waste treatment factories. It is worth to note that the listed COCs are not exhaustive. In the cases where the industries or manufacturing-specific chemicals are not listed in this Guideline, the responsible parties and their qualified consultants shall determine the COCs based on their best professional judgement.

As a minimum for baseline EBS, the analytes to be tested shall be the full suite of analytes as referenced in the most recent version of the Dutch Environmental Guidelines Soil Remediation Circular (Dutch Guidelines). Please refer to APPENDIX A.1 for further information.

Analysis of other media, other analytes (e.g. asbestos, dioxin/furan, radioactive materials, perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), etc.), or other test methods (e.g. Toxicity Characteristics and Leaching Procedure (TCLP), Synthetic Precipitation Leaching Procedure (SPLP), etc.) shall be based on the current and historic land use of the site and the purpose of the investigation.

5.2.3 Sampling Locations and Number

Sampling locations should focus on the areas which have been identified as areas of potential concern in the preliminary investigation, such as confirmed RECs, chemicals or petroleum products storage areas, waste oil storage and disposal areas, areas with visual/written evidence of potential leakage or spillage of chemicals or petroleum product, waste or sludge burial areas, etc.

For sites located near the sea or water sources, down gradient and site boundary sampling locations should be considered. This will be useful in providing information

about contaminants migration to the water bodies.
The number of boreholes for soil sampling should be based on a site area and type of land use. Additional locations should be selected in identified areas of concern.
A guide is given below for the **minimum** number of boreholes (**Table 1**) for a baseline EBS.

Table 1 – Minimum Borehole for EBS

Area (m^2)			
≤10,000	**10,001 – 50,000**	**50,001 – 100,000**	**>100,000**
5	8	11	20

EBS consultant shall be required to submit a location plan showing the potential area/s and chemical/s of concerns from Section 4.2.2. The location plan shall indicate the location of EBS boreholes. EBS consultant shall be required to provide rationale for siting of boreholes in relation to the potential area/s and chemical of concerns. If the EBS Consultant fails to select representative sampling location without any valid explanation, JTC reserve the right to request for additional EBS borehole at appropriate location/s during the review of EBS report.

Based on the site-specific conditions and sampling objectives, the EBS Consultant may not require converting all boreholes into monitoring wells. However, at least 60% of the boreholes or a minimum of three (3), whichever is higher, must be converted into monitoring wells in order to generate groundwater elevation contours for estimation of groundwater flow direction.

5.3 Sampling of Other Media

Sampling strategy for other media such as soil vapour, surface water, sediments or biological media shall be proposed by the EBS Consultant based on internationally recognised practices, guidelines, or standards such as the ASTM.

Likely scenarios that would require sampling of other media include but are not limited to:

a. Surface water sampling – observable presence or indication of contamination originating from the site in adjacent or down gradient surface water (areas used or intended to be used for drainage purposes and water areas such as reservoirs, ponds, rivers and other water channels);
b. Soil vapour/gas sampling – presence of volatile contaminants in soil or groundwater that may pose risks of vapour intrusion into buildings or vapour inhalation (indoor or outdoor) by human receptors. Ambient indoor air monitoring may be conducted in conjunction with soil vapour sampling;
c. Sediment sampling – typically considered only for foreshore sites or when the site is at close proximity to natural or unlined water bodies. Collection of shallow (less than 0.25 m below ground surface (bgs)) sediment material samples from intertidal zones or shallow water bodies to assess potential presence of contaminants or provide characterisation of sediment conditions;
d. Biota sampling – when evaluating how contaminants are accumulated in the food chain or looking for evidence of short or long range transport of the said contaminants. Risk assessment to be based on known ecological report of the contaminant.

5.4 Further investigation

A baseline EBS may lead to additional or supplementary investigations if the overall EBS objectives are not met, or if the findings recommend further actions. Further investigations may need an updated or new set of investigation strategies.

5.5 Quality Assurance/Quality Control

To achieve quality fieldwork, including all actions, procedures, checks and decisions undertaken to ensure the representativeness and integrity of samples and worksite safety, the EBS Consultant is required to provide full-time site supervision during the whole period of soil, groundwater or other media sampling.

It is recommended that quality assurance and quality control (QA/QC) samples should include:

a. Trip Blank – a trip blank ratio of one (1) trip blank per shipment;
b. Equipment Blank – one (1) equipment blank per day of sampling. Equipment blanks should be collected from final rinse water after equipment decontamination is completed as it is poured over the equipment being decontaminated;
c. Duplicate Sample - A minimum of 1 duplicate soil per 20 samples and 1 duplicate groundwater per 10 samples are to be collected. For large scale and complex projects involving more than one laboratory, inter-laboratory duplicates should be considered to ensure data from primary laboratory is checked for quality; and
d. Field Blank – One (1) daily field blank for projects is recommended where applicable (e.g. at sites where high volatile organic compound (VOC) concentration in the atmosphere is suspected).

For QA/QC purpose, the laboratory should be independent from the parties involved in the sample collections. The EBS Consultant or drilling subcontractor should not be associated to the laboratory conducting the analysis of the samples. Laboratories are required to have relevant SAC-SINGLAS accreditation to ensure quality of the analytical results.

Field QA/QC samples should be named/labelled without reference to the type of QA/QC samples and to the corresponding duplicate samples.

The Chain of Custody document must be prepared and submitted to the laboratory by the EBS Consultant. The CoC document should include sampling date, sample identification, matrix type, container information, sampler, project name and location, and shipping details. A copy of the signed Chain of Custody documentation must be provided as an attachment or appendix to the EBS report.

6.0 Step 4 Field Investigation

6.1 Permitting/H&S Consideration

All field activities must be conducted in compliance with MOM's safety regulations and other statutory requirements. All necessary documents or permits such as site access, valid permits (where applicable) must be obtained prior to any intrusive site works.

A copy of the H&S Plan should be maintained at the site at all times during the field work. The EBS Consultant and all workers are expected to observe and follow appropriate health and safety procedures as stated in the H&S Plan. The H&S Plan should be communicated to all workers on-site prior to start of any work through a safety briefing.

6.2 Detection and Protection of Utility Infrastructure

Prior to sampling, the EBS Consultant should carry out all necessary works to detect and protect existing transport and utilities infrastructure, such as railway, pipes, cables, wires, apparatuses, appliances, equipment, installations, fittings and fixtures that provide transportation, water, electricity, telecommunications network, gas or carry water-borne sewerage. This includes purchasing relevant plans from the relevant authorities or utilities service providers. However, the EBS Consultant should note that some underground utilities infrastructure existing at the sites may not be shown on the purchased plans. Notwithstanding this, the EBS Consultant is responsible for conducting a thorough check by using appropriate equipment, carrying out trial pits or carrying out other necessary steps to ensure that their works will not damage any existing utilities infrastructure.

All relevant codes of practice, rules and regulations pertaining to transport infrastructures and utilities must be complied with. Additionally, the EBS Consultant should liaise with the relevant authorities and utilities service providers to obtain requisite approvals prior to carry out any sampling works in the vicinity of any utilities infrastructure, and comply with all conditions and requirements which may be imposed by such authorities and utilities service providers. Additionally, the EBS Consultant should carry out all the drilling works in accordance with the requirement set out by LTA/BCA. Preconsultation with LTA/BCA shall be made if clarification is required.

6.3 Techniques and Soil Sampling Methods

6.3.1 General

The drilling methods should be selected in the context of the EBS objectives, Singapore regulations, guidelines, sub-surface conditions, local equipment availability and access constraints. In general, dry drilling capable of obtaining undisturbed samples is preferred. Drilling fluids will not be permitted during drilling operations as drilling fluids lead to soluble contaminant losses and drilling air leads to volatile losses.

At least 1.5 m of the borehole must be advanced using manual drilling or non-destructive drilling techniques such as use of hand auger, air knife or vacuum excavation to confirm the absence of underground services at the borehole location. Mechanical drilling, such as hollow-stem auger (with split spoon sampler), direct push or solid-stem auger, may be used to advance the borehole from 1.5 m up to the terminal depth.

Borehole diameters should be specified in the Work Plan with justification for subsequent well annulus spacing.

6.3.2 Sampling Depths and Intervals

Sampling interval shall be decided on the basis of hydro-geological characteristics of the subsurface strata. The sampling depths, intervals, and testing should be sufficient to enable the assessment and delineation of any potential contaminants identified. For the purpose of EBS, the following sampling scheme is recommended based on sampling practice and the knowledge of subsurface hydro-geological conditions in

Singapore.

For each borehole at all sites, the first soil sample shall be taken between 0.3 and 0.5 m below ground level (bgl). Subsequent samples in the borehole shall be taken at every 1.5 m interval (ie. 1.5 m, 3 m, 4.5 m, etc.) up to 6 m bgl or at least 2 m below groundwater level, whichever is deeper. In the event where groundwater level is deeper than 6 m, additional samples shall be taken at every 2.5 m interval until 20 m bgl or until 2 m below groundwater, whichever is shallower. For each borehole where groundwater is encountered, the borehole should be converted to a monitoring well. One groundwater sample should be collected from each monitoring well within 2 m below groundwater level for further analysis. Specific mention should be made within the sampling plan for assessing the presence of any contaminants, notably phase separated hydrocarbons (PSH) or indication of similar non-aqueous phase liquids that may float on the water table. In addition, there might be some seasonal or tidal fluctuation in the water table. This should be assessed and commented, where applicable.

Due to heterogeneity and stratified nature of subsurface geology, the exact subsurface hydro-geological conditions will only be known during drilling. The pre-determined sampling depth and sampling interval shall be adjusted if necessary as work progresses. If the baseline data obtained from the site characterisation are doubtful or disputable, additional site characterisation may be necessary.

To facilitate laboratory analysis, only part of the samples collected would be tested. For each borehole, the sampling for analysis/test shall include but not limited to:

(a) one near surface top layer soil sample (0.3 to 0.5m);

(b) one soil sample per every stratum (in addition to (a), particularly including the upper boundary of any layers of low relative permeability (eg. clay), since there is typically a higher potential for contaminants to accumulate there;

(c) one soil sample from the saturated zone near the boundary with the unsaturated (ie. the vadose zone – where the water table is first encountered), since there is a potential for contaminants which are insoluble in water (eg. phase separated hydrocarbons) to accumulate there; and

(d) one groundwater sample.

More samples shall be taken for testing as deemed necessary by the responsible parties and their qualified consultants.

For reclaimed lands, at least 40% of total boreholes should be drilled down to 2 m below the original soil to provide a better characterisation of the fill material and underlying original soil.

6.3.3 Sample Collection

It is recommended that soil samples be collected directly from the sampler (split spoon or equivalent sampling tools). Soil samples shall be collected directly from the sampler and placed into appropriate containers for headspace volatile organic compounds (VOCs) screening. When a soil sample is selected for laboratory analysis, a portion directly collected from the sampler shall be placed into a laboratory certified clean sample container. All soil samples should be properly labelled e.g. borehole ID, depth, date and project reference number.

Soil samples to be analysed for VOCs should be undisturbed. Soil samples for metals analysis should be homogenised to provide representative analysis of actual conditions.

The following QA/QC procedures should be followed during sample collection:

- All sampling equipment should be decontaminated prior to and after obtaining each sample where the sampling equipment is not disposable;
- Field personnel should wear suitable types of gloves (PVC/latex/nitrile) depending on contaminants of concern, whilst handling sampling equipment and collecting samples;
- Gloves should be replaced between the handling of each sample;
- All samples should be properly chilled in cooler boxes immediately after sample collection, prior to delivery to the accredited laboratory.

6.3.4 Screening

Field screening tools should be selected to best achieve the EBS objectives. Soil samples should be headspace screened in the field during sample collection for VOCs with a PID or similar equipment such as a flame ionisation detector (FID) to provide on-site identification of samples likely to contain high concentrations of VOCs. It should be noted that the PID/FID/hand held device should only be used for sample selection and not as an alternative for laboratory test.

Other soil/groundwater screening tools, such as heavy metals analyser, Total Petroleum Hydrocarbon (TPH) analyser, pesticide screening kit, etc., may also be utilised during field work if deemed necessary for the purpose of the EBS.

6.3.5 Sample Logging

Subsurface conditions encountered at every borehole or trial pit should be logged using the US Soil Classification System (USCS) and recorded in a boring log. Each boring log should include the following information: date, project/site name, borehole identification, borehole location, sampler's name, driller's name, drilling method, depth of groundwater level as observed during drilling, depth of monitoring well once stabilised, screened intervals, thickness of filter pack and bentonite plug. Depths should be referred to as below ground surface (bgs).

In addition to USCS descriptions, visual and general olfactory (odour) observations should be recorded in the boring log together with any other relevant information that assists development of the CSM, such as drilling resistance.

It should be noted that sample logging should not be limited to soil samples. The descriptions should be a continual process based on undisturbed cores and/or drill cuttings observations.

6.3.6 Borehole Reinstatement

Boreholes that are not to be converted into monitoring wells should be backfilled with the soil cuttings from the original borehole or with clean soil from identified sources and sealed with clean, low permeability material as such bentonite/cement grout. The borehole surface should be reinstated in line with surrounding surface conditions.

6.4 Monitoring Well Installation

6.4.1 General

Monitoring wells should be installed at the boreholes for groundwater monitoring activities. Monitoring wells should be designed such that the construction would allow the presence of sufficient groundwater for sample collection in consideration of groundwater level fluctuation. The monitoring well should also be appropriately designed such that anticipated contaminants being targeted are captured, including free phase hydrocarbons (light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquids (DNAPL)).

6.4.2 Well Construction Materials

Well Casing
The monitoring well casing should be a clean, polyvinyl chloride (PVC) or similar inert material pipe, with internal diameter of 50 mm, that can withstand the corrosiveness of the anticipated chemicals present in the groundwater. The casing is composed of a slotted section (well screen) and a blank section (riser pipe).

Filter Pack
The filter pack is used to fill the annular space between the borehole and the well casing and should consist of clean graded gravel or coarse sand with a particle size range that is sufficient to allow unrestricted entry of free phase hydrocarbons.

Bentonite
Bentonite should be used to seal or plug the well annular space to prevent the infiltration of the surface water through ground surface above potentially contaminated material into the filter pack and well screen. The preferred form is in pellet form to allow ease of application and minimising penetration into the filter pack, which usually happens in liquid bentonite or slurry.

Protective Cover/Casing
Monitoring wells should have a protective metal or steel cover where they are deemed necessary. Well covers may be in the form of flush-mounted metal covers or aboveground steel risers, depending on suitability and location.

6.4.3 Installation Details

Following completion of drilling, the well casing (consisting of well screen, riser and bottom cap) is assembled and lowered into the borehole. The well casing must extend such that the screened portion is at least 2 m below the minimum expected groundwater level. The well screen must extend to at least 0.5 m above the stabilised groundwater level in consideration of groundwater fluctuation. The well casing must be centred within the borehole. Centralisers may be used particularly for deep well installations (> 8 m bgs) to ensure proper well casing position and alignment. The screen length may be adjusted accordingly for groundwater level <0.5 m bgs.

The borehole annular space is progressively filled with filter pack from the bottom until 0.5 m above the top of the screen, whenever possible, but may be adjusted accordingly for groundwater level <0.5 m bgs. To eliminate possible bridging or creation of voids, placement of the sand pack may require the use of a tremie pipe. Use of tremie pipe is generally suggested for deep water table wells and for wells which are screened some distance beneath the water table.

A layer of bentonite pellets, with a minimum of 0.5 m thickness whenever possible, is placed immediately above the filter pack. The thickness of the bentonite layer may be adjusted accordingly for groundwater level <0.5 m bgs. Care shall be taken to avoid introducing bentonite into the well casing.

For all groundwater monitoring well installations, connections between PVC slotted pipes and riser shall be made with threaded connections. No glue shall be used.

Figure 1 illustrates the typical groundwater monitoring well construction.

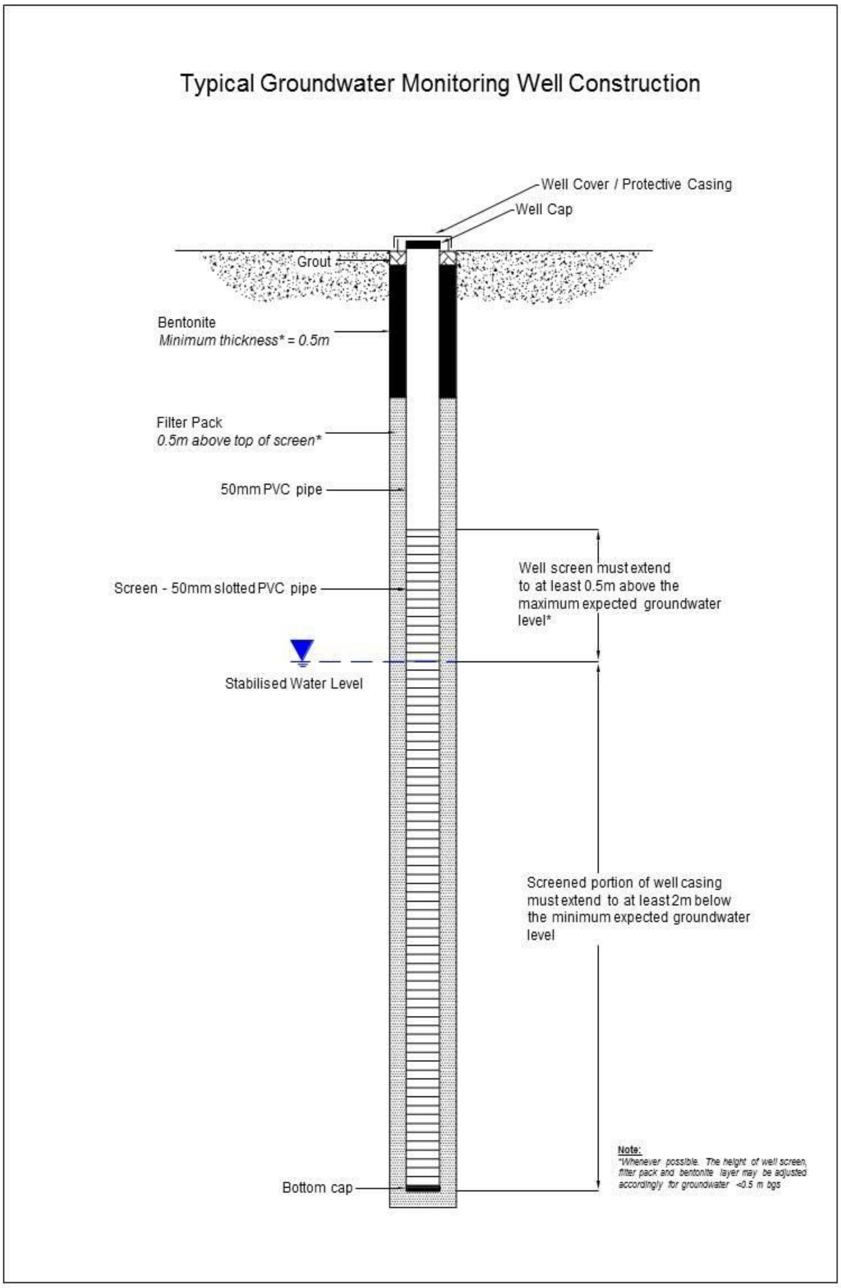

Figure 1 – Typical Groundwater Monitoring Well Construction

6.4.4 Well Completion

Following the emplacement of the bentonite seal, each permanent monitoring well should be finished by concreting either a flush mounted, metal casing/cover or galvanised monument with clear well ID label on the concrete pad surface or on the metal cover. The flush mounted cover is best suited to high traffic areas; covers should at least provide sufficient strength to withstand normal vehicular traffic. Proper well covers can provide protection for the monitoring well from the weather, tampering, vehicular movements and accidental destruction.

Each temporary monitoring well should be constructed with a protective casing to avoid external disturbance or vandalism that may cause intrusion of potential contamination into the well; temporary monitoring wells should be properly abandoned as soon as reasonably possible, refer to Section 5.5 for more details.

6.4.5 Well Development

All newly constructed monitoring wells should be developed 24 hours after installation to allow the bentonite grout to set. The aim of development is to create both backward and forward surging action in monitoring well screen and gravel pack to breakup and remove fines. Proper development of monitoring wells is essential for the collection of representative groundwater samples in the wells. During the drilling, fines are forced into the soil formation, forming a mud cake that reduces the hydraulic conductivity of the materials in the immediate area of the well bore. To allow water to freely enter the monitoring well from the soil formation being monitored, this mud cake must be broken down opposite the screened portion of the well and the fines removed from the well.

Well development involves physical purging of each monitoring well by carefully lowering the bailer into the centre of the screened portion of the monitoring well and removing groundwater from the monitoring well.

Field parameters of groundwater should be measured during well development. These include temperature, pH, redox potential, electrical conductivity (EC), and dissolved oxygen (DO). These measurements should be conducted and recorded at every well volume of the groundwater purged. Well development should be continued until 5 well volumes are removed or if the monitoring well purges dry before 5 well volumes are removed, development may be discontinued. The following information is to be recorded on the groundwater sampling field data sheet:

- Date and time;
- Water level;
- Purged volume;
- Odour;
- Colour;
- Turbidity and field parameter values;
- Monitoring well ID.

6.5 Well Decommissioning

Monitoring wells may be decommissioned when: (1) they are no longer needed in the site’s monitoring program, or (2) the well’s integrity is suspect or compromised. Similar terms for ‘decommissioning’ include ‘abandonment’, ‘plugging’ or ‘grouting’. The aim of decommissioning is to permanently seal the well to prevent the entry of fluids or contaminants from the surface and the mixing of fluids or pressures between aquifers. Decommissioning by fully grouting from top to bottom is the preferred method and is discussed here. However, as this is not always the most practical method, other options may also be employed, including grouting from screen to surface, grouting in-place followed by case pulling, and over-drilling. The EBS Consultant should review bore logs or well construction details and historic gauging data to determine the suitability of the method. The EBS Consultant shall provide records that decommissioning of the monitoring wells has been accomplished in accordance with the EBS guidelines.

6.5.1 Grouting from Bottom to Top

Fully grouting from top to bottom is the simplest and most commonly used method for grouting shallow monitoring wells and the only acceptable method where there is a possibility the well is screened across multiple aquifers. This involves completely filling the well with a cement/bentonite grout. Suggested ratio of cement to bentonite is 3-5% bentonite by dry weight. Options for different cement/bentonite mix may be used depending on suitability, provided that the mix contains sufficient bentonite to make it impermeable to water but not too viscous to pump or pour into the well. The well cover/protective casing should be removed, including the stick up riser and concrete pad, if present.

For shallow wells (< 4 m), the PVC well casing may be pulled out prior to filling in with grout. If not possible, the PVC well casing should be cut off at a level below the surrounding concrete slab (if present). Pour or pump the grout into the well until filled. Surface completion should be done to reinstate the ground in line with surrounding surface conditions.

6.6 Groundwater Sampling Methods

6.61 General

Groundwater sample shall be collected from the monitoring well installed after the completion of drilling and well development. Groundwater sampling methods available include use of bailers, low flow sampling, no-purge sampling or other sampling technologies following the ASTM guidelines. The selected method and rationale should be clearly outlined in the Work Plan by the EBS Consultant.

6.7 Equipment Decontamination

The drilling/sampling tools must be cleaned prior to each use, and when transferring to a new location. This is to avoid cross contamination between locations and samples (soil, groundwater, sediment, etc.).
This can be conducted by:

- Washing and scrubbing the tools with phosphate free detergent followed by a tap water rinse; and subsequently
- Air drying.

6.8 Elevation and Coordinates Survey

Newly-installed monitoring wells shall be surveyed for well and ground elevations based on a known or temporary bench mark. GPS coordinates in SVY21 system must also be recorded for each well.

6.9 Sample Handling and Documentation

The samples should be collected into the appropriate containers cleaned and supplied by the accredited laboratory. Samples should be placed into a cooler box and be properly chilled before being received by the laboratory.

Information such as project identification, sample identifications, sample matrix, sampler, dates of sampling, dates and times of sample relinquishments and receipts, types of analysis required, and other relevant information should be documented and signed off on the Chain of Custody forms. The proper Chain of Custody procedures have to be complied during sample shipments.

Field QA/QC samples should be named/labelled without reference to the type of QA/QC samples and corresponding duplicate samples.

6.10 Methods of Analysis

The recommended methods of analysis for various analytes are shown in **Appendix A.3**. If listed methods are not available, appropriate methods may be selected from the list of approved analytical methods publishing organizations provided at the end of table.

The laboratory's levels/limits of reporting (LORs) should be lower than the soil and groundwater quality standards or screening levels. If these LORs are not achievable by the available analytical technologies in Singapore, then analysis should be performed by a qualified international laboratory.

6.11 Waste Management

6. 11.1 Disposal of Wastes

Waste management controls should be anticipated prior to field investigation and detailed in the Work Plan. The EBS Consultant should ensure field-derived wastes are disposed of in an appropriate manner. Waste segregation should be considered based on anticipated waste types: (1) those that require licensed transportation and disposal; and (2) those that can be recycled or disposed of as general waste.

For proper disposal of contaminated soils and liquids, please refer to NEA's list of licensed toxic industrial waste collectors.

6. 11.2 Spill Control and Management

Control and management of spills should be detailed in the Work Plan and/or H&S Plan. Corrective actions shall be dependent upon the size, location, type of material in the spill (contaminated soil/water, etc.) and risks of environmental harm, fire or other emergency situations. For small-scale spills, the spill should be contained through the use of absorbents. In the event of a large spill, where there is a potential for risk of injury to personnel, environmental harm and/or fire, the area must be evacuated and emergency services must be notified such as the Fire Station (nearest) or Police Station (nearest). Following any spill incident, JTC must be immediately notified and an Incident Report is to be submitted to JTC as soon as possible.

7.0 Step 5 Selection of Soil and Groundwater Quality Standards or Screening Level

7.1 Standard of Assessment

Entry EBS[1]

Standard values are needed whereby the chemical compound levels found in the soil and groundwater can be matched. The comparison between the actual levels found

[1] Entry EBS is conducted to set the first baseline set for the site.

and the standard values will determine the level and extent of contamination of the site and the appropriate remedial actions to take.

For the EBS purpose, the latest Dutch Standards are adopted for assessing land contamination and remediation. The Dutch Standards specify two sets of limits for heavy metals, inorganic compounds, aromatic compounds, hydrocarbons, pesticides and other pollutants in both soils and groundwater

For entry EBS assessment, with contaminants above Dutch intervention value, the site is considered contaminated. The EBS consultant shall provide assessment on the potential source of contamination and risk assessment study is required to resolve uncertainties with respect to the possible pollution and its associated risks to determine the need to carry out a clean up. The risk assessment shall cover the risk of contamination both during construction and targeted operations. As part of the risk assessment, mitigating measure shall also be explored to overcome the associated risks. The methodology of risk assessment study shall be in accordance to Singapore Standard SS593:2013 (Code of Practice for Pollution Control).

Exit EBS[2]

In addition to the requirement of entry EBS, EBS specialist shall also make reference and compare with the entry EBS and identify the potential sources of contamination in the report for exit EBS. Comparison shall be made between entry and exit EBS. Under Polluters Pay Principle, remediation will be required when the exit EBS level indicates that the contamination level exceeds entry EBS level (First EBS level) or prevailing Dutch standards (i.e DIV).If the contamination is assessed to be caused by others, evidence shall be provided to JTC for evaluation and acceptance on case by case basis.

7.2 Remediation

If the site is found contaminated, the responsible parties involved shall be required to remediate the property under Polluters Pay Principle by restoring it to either:

- the standards required by relevant authorities or in the absence of such requirement, the prevailing Dutch Standards; or
- the first EBS level (if any) at the commencement of the original lease term,

whichever is less stringent.

However, if the original lease already contains a stipulation that decontamination back to the first EBS level at the commencement of lease is required, no option will be given to comply with whichever standard that is less stringent. Besides, it is necessary to remediate any off-site adjacent contaminated land so long as the contaminant emanated from the subject site. This principle will hold even when risk assessment has shown that the site is safe for occupants.

In order to conduct remediation, the EBS Consultant shall include but not be limited to the following steps:

(a) establish the extent of the contamination (in terms of the area and depth) to size up the scope of work. The extent of the contamination shall be proven using the accredited laboratory and agreed by JTC prior to remediation. While field-based analytics such as handheld scanner or

[2] Exit EBS is conducted as part of the conditions upon lessee exit from the site.

field test kits could be adopted for preliminary data, the extent of contamination shall be established with sampling and laboratory analysis from accredited laboratory.

(b) propose suitable remediation methods for treating contaminants to the level below DIV or first EBS level, whichever less stringent and submit to JTC for review. EBS Consultant shall highlight any incompliance to the target level/ standard for remediation of contaminated sites in the remediation proposal. Nonetheless, JTC acceptance on the proposed remediation method does not relieve EBS consultant's responsibilities and compliances to the required target level/ standard for remediation.

(c) conduct the remediation based on the proposed method. After decontamination is completed, conduct retest at the same locations of the affected boreholes to ascertain if the remediation met the standard required. When conducting retest of the affected boreholes, there is a need to retest all the contaminants instead of the exceeded contaminants only. The new EBS values will supersede the previous EBS values as the exit EBS for the site.

(d) submit the revised complete EBS report that includes but not limited to the remediation report, laboratory results and certification of remediation.

7.3 Certification of Remediated Sites

The remediated sites shall be certified by an EBS expert/specialist consultant to meet the standards required.

The certification shall contain the following:

(a) a statement that the subject site has been remediated to meet the standards required; and
(b) a statement that the certification given is a true and unbiased representation of the facts and that all reasonable professional skill, care and diligence have been taken in checking the facts

The originals or authenticated copies of the certification shall be submitted to JTC Corporation for review and approval.

8.0 Step 5 Reporting

8.1 General Structure

In general, an EBS report should include and cover the major components as listed below:

- Executive summary;
- Objectives and work scope;
- Client's business operation;
- Declaration through the declaration checklist **(in Appendix A.1)** that EBS was performed in accordance to the EBS guidelines or if not, highlight any deviations and provide corresponding justifications;
- Site background information including site history, site location and characteristics, site layout and features, site activities, surrounding land uses, topography, geology, soils, fill, hydrology and hydrogeology;

- Site Inspection including boundary conditions, surface conditions, storage tanks, other chemical use and storage, drainage, stains, odours and stressed vegetation and potential COCs and areas of Concern;
- Location plan with indication of the subject site
- Preliminary investigation findings;
- Regional geological and hydrogeological information;
- Fieldwork findings, including field observations of soil and groundwater characteristics, monitoring well construction and ground water levels (RL), visual/olfactory observations;
- Accurate coordinates of boreholes and monitoring wells
- QA/QC of field and analytical data
- Conceptual site model;
- Assumptions;
- Discussion of laboratory analytical results including determination of level of contamination and assessment of potential impact;
- Comparison of the results with the baseline (if any);
- Qualitative or Quantitative Risk Assessment, including confidence level of the assessment (e.g. 95% upper confident level);
- To indicate any areas of non-compliances with this set of guidelines;
- Conclusion including Potential contamination and impact to the site based on laboratory analytical results, site inspection and other available information, Likely nature and extent of any identified contamination and impact
- Recommendation including requirements for remediation and follow-up actions (if any)).

In conjunction with the reporting structure listed above, appropriate supporting documents/ annexures should also be included to cover the following:

- Plan showing sampling locations including all borehole, monitoring well, test pit, etc., locations and known or anticipated groundwater flow direction. Also include any pre-existing wells.
- Photographs of site, site condition, site layout plan indicating major/relevant features (e.g. buildings, surface coverings/materials, underground/aboveground storage tanks, chemical handling and storage areas, etc.) and adjacent land uses;
- Drilling methodologies;
- Soil boring logs and groundwater monitoring well construction diagrams;
- Field datasheets;
- Data of soil and groundwater analytical results;
- Original laboratory analytical report (including laboratory QA/QC reports);
- Chain of Custody documentation;
- Other relevant documents (e.g. PID Equipment Calibration Certificate).
- Inventory of chemicals used in client's operation

9.0 Conclusions

The above information is a brief guidance on conducting environmental baseline study assessment. It should be noted that the various tests and experiments conducted shall be accurate and professionally done so as to achieve a satisfactory environmental baseline study. JTC has the discretion to require further tests, experiments, assessments or investigations of similar nature, to be conducted on the Property and a subsequent report furnished (at no costs to JTC), in the event any of the tests and experiments conducted and/or information stated above is not to JTC's satisfaction.

APPENDIX A.1.

SELF-DECLARATION FORM FOR ENVIRONMENT BASELINE STUDY ("EBS")

Please complete this Form based on the outcome of the *tests carried* out in accordance with JTC's Guideline on Environmental Baseline Study (2019 Edition) ("**Guidelines**"). The completed Form must be submitted to JTC together with the following:

1. EBS Report; and
2. the EBS data information (according to Dutch Standard 2013) (in the Excel format as found at the following link):

https://www.jtc.gov.sg/get-help/managing-your-tenancy-or-lease/environmental-baseline-study

If you require any assistance completing this Form, please contact:
JTC Corporation
Technical Services Division
The JTC Summit 8 Jurong Town Hall Road
Singapore 609434

Winnie Chu (M/s)
DID: 6883 3791
Email: Winnie_CHU@jtc.gov.sg

Heng Sew Chen (M/s)
DID: 6883 3861
Email: Heng_sew_chen@jtc.gov.sg

Note: Please note that JTC collects the information contained in the completed EBS Form and may share necessary data with other Government agencies (or non-Government entities which have been authorised to carry out specific Government services), unless such sharing is prohibited by legislation.

PARTICULARS OF LESSEE/TENANT
Name of Lessee: *(as per Accounting and Corporate Regulatory Authority registry)*
Address of Site: *(Unit Number, Road Name, Allocation No. and Mukim No)*:

(A) TYPE OF SUBMISSION:

☐	☐	☐	☐	☐	☐
(a) New Allocation	(b) Land Renewal	(c) Temporary Occupation License	(d) Assignment	(e) Change of Use[2].	(e) Lease Termination

(B) PURPOSE OF ENVIRONMENTAL BASELINE REPORT:

☐	☐	☐	☐
(a) Set first baseline	(b) Set Exit Baseline with no first baseline set in lease agreement	(c) Set Exit Baseline with first baseline	(d) Others If Others, please specify:__________________

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[2] Change of use refers to introduction of pollutive activities to site

(C) CONDITIONS WHICH THE LESSEE/TENANT AND THE QUALIFIED CONSULTANT MUST COMPLY WITH:

1) The Environmental Baseline Study report submitted shall comply with the Guidelines stipulated by JTC.

Checklist Item	Does it comply with the guideline?			If No or N.A, please explain why.
Qualified Consultant listed by NEA	☐ Yes	☐ No	☐ N.A.	
Development of Work Plan	☐ Yes	☐ No	☐ N.A.	
Preliminary Investigation	☐ Yes	☐ No	☐ N.A.	
Characterization of Subsurface Conditions based on the EBS Report:				
• sampling strategies and analysis plan	☐ Yes	☐ No	☐ N.A.	
• adequate boreholes	☐ Yes	☐ No	☐ N.A.	
• representative borehole locations	☐ Yes	☐ No	☐ N.A.	
• Sampling interval and depth	☐ Yes	☐ No	☐ N.A.	
• Near surface sample	☐ Yes	☐ No	☐ N.A.	
• Soil sample per stratum	☐ Yes	☐ No	☐ N.A.	
• Soil sample near vadose zone	☐ Yes	☐ No	☐ N.A.	
• Reclaimed land sampling requirement	☐ Yes	☐ No	☐ N.A.	
• Adequate monitoring wells	☐ Yes	☐ No	☐ N.A.	
• Groundwater Samples	☐ Yes	☐ No	☐ N.A.	
• QA/QC	☐ Yes	☐ No	☐ N.A.	
• Determination of COC for sample analysis	☐ Yes	☐ No	☐ N.A.	
• Method of Analysis	☐ Yes	☐ No	☐ N.A.	
Determination of extent of subsurface contamination via reference to standards of assessment and based on the EBS Report:				
• Site location Plan	☐ Yes	☐ No	☐ N.A.	
• Site Layout Plan	☐ Yes	☐ No	☐ N.A.	
• Site Photographs	☐ Yes	☐ No	☐ N.A.	
• Sampling locations	☐ Yes	☐ No	☐ N.A.	
• Direction of Groundwater flow	☐ Yes	☐ No	☐ N.A.	
• Drilling methodologies	☐	☐	☐	

	Yes	No	N.A.	
• Soil boring logs and groundwater monitoring well construction diagrams	☐ Yes	☐ No	☐ N.A.	
• Field Documentation	☐ Yes	☐ No	☐ N.A.	
• Data of soil and groundwater analytical results	☐ Yes	☐ No	☐ N.A.	
• Laboratory analytical results	☐ Yes	☐ No	☐ N.A.	
• Chain of custody documentation	☐ Yes	☐ No	☐ N.A.	
• Inventory of chemicals used in client's operation	☐ Yes	☐ No	☐ N.A.	
• State the version of Guidelines, Dutch Standards and other standards referenced (if applicable)				

2) Result of Soil Samples
   a) Is all the contaminant level(s) within the Dutch Intervention Value (DIV) based on the latest Dutch Standard?
      ☐ Yes
      ☐ No

   b) If No, please complete the table below with a summary of the risk assessment result for both construction and targeted operation.

Chemical of Concern (exceed Dutch Intervention Value)	Dutch Intervention Value (mg/kg)	Range Detected At Site (mg/kg)	Number of samples exceeding Dutch Intervention Value	Risk Assessment (mg/kg)

3) Result of Groundwater Samples
   a) Is all the contaminant level(s) within the Dutch Intervention Value (DIV) based on the latest Dutch Standard?
      ☐ Yes
      ☐ No

   b) If No, please complete the table below with a summary of the risk assessment result for both construction and targeted operation.

Chemical of Concern (exceed Dutch Intervention Value)	Dutch Intervention Value (µg/L)	Range Detected At Site (µg/L)	Number of samples exceeding Dutch Intervention Value	Risk Assessment (µg/L)

4) Based on the result of the tests conducted, remediation is not required.

- ☐ Yes
- ☐ No

If No, please state the possible source of contaminants and the mitigation measures.

____

(D) DECLARATION:

I am a Qualified Consultant approved by National Environmental Agency to carry out the Environmental Baseline Study.

I confirm as follows:

1. the information stated above is correct based on tests, experiments and requirements carried out in accordance with the Guidelines;

2. I have not withheld any information or particulars required in the Form and I shall immediately notify JTC in writing in the event of any changes in the information and particulars furnished in this Form; and

I acknowledge that JTC has the discretion to require further tests, experiments, assessments or investigations of similar nature, to be conducted on the Property and a subsequent report furnished (at no costs to JTC), in the event any of the tests and experiments conducted and/or information stated above is not to JTC's satisfaction.

Signed by:

____

ENVIRONMENTAL BASELINE STUDY CONSULTANT
Name:
Designation:
Name of
Company :
Email:
Handphone No.:

APPENDIX A.2. Types of industries and their possible COCs

Types of Industry	Contaminants of Concern
Electronics	carbon tetrachloride, chloroform, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, cis-1,2-dichloroethlene, trans-1,2-dichloroethlene, trichloroethane, trichloroethylene, arsenic, cadmium, chromium, lead, nickel, zinc Other compounds not listed
Electro-Plating	1,1-dichloroethane, 1,2-dichloroethane, arsenic, chromium, cadmium, lead, copper, nickel, acids and bases Other compounds not listed
Petrol Stations	TPH, Benzene, ethyl benzene, toluene, xylene (BTEX) Polycyclic Aromatic Hydrocarbons Phenols Lead Methyl Tertiary Butyl Ether Other compounds not listed
Petrochemicals	benzene, carbon tetrachloride, chlorobenzenes, chloroform, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, cis-1,2-dichloroethlene, trans-1,2-dichloroethlene, ethyl benzene, hexachlorobenzene, hexachlorobutadiene, hexachloroethylene, phenol, styrene, tetrachloroethane, tetrachloroethyene, trichloroethane, trichloroethylene, 2,4,6-trichlorophenil, polychlorinated biphenyls, cadmium, chromium, copper, lead, mercury, nickel, zinc Other compounds not listed
Refineries	benzene, toluene, xylene, total petroleum hydrocarbons, carbon tetrachloride, 1,1-dichloroethane, 1,2-dichloroethane, phenol, polychlorinated biphenyls, cadmium, chromium, copper, lead, mercury, zinc, PAHs Other compounds not listed
Shipbuilding	Heavy metals Volatile organics (solvent/paint) Semi-volatile organics Other compounds not listed
Transformers /electrical substations	Polychlorinated biphenyls (PCBs)
Waste Disposal Site	1,1-dichloroethane, 1,2-dichloroethane, cadmium, chromium, copper, lead, nickel Other compounds not listed
Wood-based	Heavy metals PAHs Pentachorophenols Other compounds not listed

Note: The above listed chemicals are some typical contaminants of concern and are not exhaustive.

APPENDIX A.3. LABORATORY METHODS

Analytes Group	Analytes	Soil	Groundwater
Metals		EPA 3051A EPA 3052 EPA 3050B EPA 7471B APHA 3120B APHA 3125B EPA 6010D EPA 6020B EPA 7000B EPA 7010 - - -	-- - - - - - EPA 6010D EPA 6020B EPA 7000B EPA 7010 EPA 3005 EPA 7470 APHA 3125B
Inorganic Compounds	Cyanide	EPA 9010C EPA 9014 APHA-4500-CN(N)	EPA 9010C EPA 9014 APHA-4500-CN(N)
Aromatic Compounds: BTEX		EPA 5035 EPA 8260C EPA 8270D EPA 5021A - -	- EPA 8260C EPA 8270D EPA 5021A EPA 5030 EPA 3510C
Polynuclear Aromatic Hydrocarbons (PAH)		EPA 8310 EPA 8270D EPA 3545A	EPA 8310 EPA 8270D -
Chlorinated Hydrocarbons		EPA 5035 EPA 8260C EPA 8270D -	- - EPA 8270D EPA 3501C
Pesticides: Semi Volatile Organic Compounds (SVOCs)		EPA 3545A EPA 8270D -	- EPA 8270D EPA 3501C
Other Pollutants: Volatile Organic Compounds (VOCs)	Cyclohexanone Phthalates (Sum) Mineral Oils Pyridine Bromoform Tetrahydrofuran Tetrahydrothiophe ne	EPA 5035/ EPA 8260C / EPA 5021A EPA 8270D / EPA 3545A / EPA 8270D EPA 8015B EPA 5035 / EPA 8260C / EPA 3545A / EPA 8270D EPA 5035 / EPA 8260C / EPA 5021A	EPA 5021A / EPA 8260C / EPA 5030B EPA 3510C / EPA 8270D EPA 8015D EPA 5030B / EPA 8260C EPA 5021A / EPA 8260C / EPA 5030B EPA 5021A / EPA 8260C /

		EPA 8270D / EPA 5021A EPA 8270D / EPA 5021A	EPA 3510C / EPA 8270D EPA 5021A / EPA 8260C / EPA 3510C / EPA 8270D
Conventional	Organic Matter Moisture Content (dried @ 103°C) pH @ 25 deg C BOD Chemical Oxygen Demand Total Organic Carbon Fluoride as F Chloride as Cl	BS 1377-1:2016 ASTM D2974-14 BS 1377-1:2016 ASTM D2974-14 - - - - - - -	APHA 4500 H+B APHA 5210B / APHA 22nd Edition 2012 APHA 5220C / APHA 22nd Edition 2012 APHA 5310B / APHA 22nd Edition 2012 APHA 4110B / APHA 22nd Edition 2012

	Bromide as Br Sulphate as SO4 Ammonia as N Conductivity	- - - -	ASTM D1179-16 APHA 4110B / APHA 22nd Edition 2012 APHA 4110B / APHA 22nd Edition 2012 APHA 4110B / APHA 22nd Edition 2012 ASTM D516-16 APHA 4500B / APHA 4500N H / APHA 22nd Edition 2012 APHA 2510B
Total Petroleum Hydrocarbon (TPH)		EPA 5035 EPA 8015D EPA 8440 EPA 3560 EPA 3550C -	- - - - - EPA 8015C
Monocyclic Aromatic Hydrocarbons		EPA 5035 EPA 8260C -	- EPA 8260C EPA 5030B

Oxygenated Compounds		EPA 5035 EPA 8260C -	- EPA 8260C EPA 5030B
Sulfonated Compounds		EPA 5035 EPA 8260C -	- EPA 8260C EPA5030B
Fumigants		EPA 5035 EPA 8260C -	- EPA 8260C EPA5030B
Halogenated Aliphatic Compounds		EPA 5035 EPA 8260C -	- EPA 8260C EPA5030B
Halogenated Aromatic Hydrocarbons		EPA 5035 EPA 8260C -	- EPA 8260C EPA5030B
Trihalomethanes		EPA 5035 EPA 8260C -	- EPA 8260C EPA5030B
Phenolic Compounds		EPA 8270D -	EPA 8270D EPA3510C
PolyAromatic Hydrocarbons		EPA 8270D -	EPA 8270D EPA 3510C
Phthalate Esters		EPA 8270D -	EPA 8270D EPA 3510C
Nitrosamines		EPA 8270D -	EPA 8270D EPA 3510C
Nitroaromatics and Cyclic Ketones		EPA 8270D -	EPA 8270D EPA 3510C
Haloethers		EPA 8270D -	EPA 8270D EPA 3510C
Chlorinated Hydrocarbon		EPA 8270D -	EPA 8270D EPA 3510C
Anilines and Benzidines		EPA 8270D -	EPA 8270D EPA 3510C
Polychlorinated Biphenyls		EPA 8270D -	- -
Organochlorine Pesticides		EPA 8270D -	EPA 8270D EPA 3510C
Organophosphorus Pesticides		EPA 8270D -	EPA 8270D EPA 3510C
Asbestos		ASTM D7521-16 Polarized Light Microscopy	- -

		(PLM)	
Pharmaceuticals and Personal Care Products		EPA 1694	EPA 1694
Steroids and Hormones		EPA 1698	EPA 1698
Brominated Diphenyl Ethers		EPA 1614A	EPA 1614A
Pesticides		EPA 1699	EPA 1699
Cation Exchange Capacity (CEC)		EPA 9081 pH 7 Ammonium Acetate CEC BACl2 Compulsive Exchange Method	- - -
Toxicity Characterisitc Leaching Procedure (TCLP)	VOCs, SVOCs, Chlorinated Pesticides and Herbicides, and Metals	EPA 1311	EPA 1311
Synthetic Precipitation Leaching Procedure (SPLP)		EPA 1312 EPA 1313 EPA 1314 EPA 1315 EPA 1316 AS 4439	EPA 1312 - - - EPA 1316 AS 4439

Bioavailability		EPA in Vitro Bioaccessibility Assay Physiologically Based Extraction Test (PBET) Simplified Bioaccessibility Extraction Test (SBET) Relative Bioaccessibility Leaching Procedurer (RBALP) Solubility Bioaccessibility Research Consortium (SBRC) In Vitro Gastrointestinal Extraction Method (IVG) Standardised German in Vitro Assay (DIN) Dutch National Institute for Public Health and the Environment (RIVM) Bioaccessibility Research Group of Europe (BARGE UBM) Simulator of the Human Intestinal Ecosystem (SHIME) Dynamic Computer-Controlled Gastrointestinal Model (TIM)	
Hardness			ASTM D1126-12

Analytes Group	**Analytes**	**Soil**	**Groundwater**
Metals		EPA 3051A EPA 3052 EPA 3050B EPA 7471B APHA 3120B APHA 3125B EPA 6010D EPA 6020B EPA 7000B EPA 7010 - -	-- - - - - - EPA 6010D EPA 6020B EPA 7000B EPA 7010 EPA 3005 EPA 7470

		-	APHA 3125B
Inorganic Compounds	Cyanide	EPA 9010C EPA 9014 APHA-4500-CN(N)	EPA 9010C EPA 9014 APHA-4500-CN(N)
Aromatic Compounds: BTEX		EPA 5035 EPA 8260C EPA 8270D EPA 5021A - -	- EPA 8260C EPA 8270D EPA 5021A EPA 5030 EPA 3510C
Polynuclear Aromatic Hydrocarbons (PAH)		EPA 8310 EPA 8270D EPA 3545A	EPA 8310 EPA 8270D -
Chlorinated Hydrocarbons		EPA 5035 EPA 8260C EPA 8270D -	- - EPA 8270D EPA 3501C
Pesticides: Semi Volatile Organic Compounds (SVOCs)		EPA 3545A EPA 8270D -	- EPA 8270D EPA 3501C
Other Pollutants: Volatile Organic Compounds (VOCs)	Cyclohexanone Phthalates (Sum) Mineral Oils Pyridine Bromoform Tetrahydrofuran Tetrahydrothiophene	EPA 5035/ EPA 8260C / EPA 5021A EPA 8270D / EPA 3545A / EPA 8270D EPA 8015B EPA 5035 / EPA 8260C / EPA 3545A / EPA 8270D EPA 5035 / EPA 8260C / EPA 5021A EPA 8270D / EPA 5021A EPA 8270D / EPA 5021A	EPA 5021A / EPA 8260C / EPA 5030B EPA 3510C / EPA 8270D EPA 8015D EPA 5030B / EPA 8260C EPA 5021A / EPA 8260C /EPA 5030B EPA 5021A / EPA 8260C /EPA 3510C / EPA 8270D EPA 5021A / EPA 8260C /EPA 3510C / EPA 8270D

Conventional	Organic Matter Moisture Content (dried @ 103°C) pH @ 25 deg C BOD Chemical Oxygen Demand Total Organic Carbon Fluoride as F Chloride as Cl Bromide as Br Sulphate as SO4 Ammonia as N Conductivity	BS 1377-1:2016 ASTM D2974-14 BS 1377-1:2016 ASTM D2974-14 - - - - - - -	APHA 4500 H+B APHA 5210B / APHA 22nd Edition 2012 APHA 5220C / APHA 22nd Edition 2012 APHA 5310B / APHA 22nd Edition 2012 APHA 4110B / APHA 22nd Edition 2012 ASTM D1179-16 APHA 4110B / APHA 22nd Edition 2012 APHA 4110B / APHA 22nd Edition 2012 APHA 4110B / APHA 22nd Edition 2012 ASTM D516-16 APHA 4500B / APHA 4500N H / APHA 22nd Edition 2012 APHA 2510B
Total Petroleum Hydrocarbon (TPH)		EPA 5035 EPA 8015D EPA 8440 EPA 3560 EPA 3550C -	- - - - - EPA 8015C
Monocyclic Aromatic Hydrocarbons		EPA 5035 EPA 8260C -	- EPA 8260C EPA 5030B
Oxygenated Compounds		EPA 5035 EPA 8260C -	- EPA 8260C EPA 5030B
Sulfonated Compounds		EPA 5035 EPA 8260C -	- EPA 8260C EPA5030B
Fumigants		EPA 5035 EPA 8260C -	- EPA 8260C EPA5030B
Halogenated Aliphatic Compounds		EPA 5035 EPA 8260C -	- EPA 8260C EPA5030B
Halogenated Aromatic Hydrocarbons		EPA 5035 EPA 8260C -	- EPA 8260C EPA5030B
Trihalomethanes		EPA 5035 EPA 8260C -	- EPA 8260C EPA5030B
Phenolic Compounds		EPA 8270D -	EPA 8270D EPA3510C
PolyAromatic Hydrocarbons		EPA 8270D -	EPA 8270D EPA 3510C

Phthalate Esters		EPA 8270D -	EPA 8270D EPA 3510C
Nitrosamines		EPA 8270D -	EPA 8270D EPA 3510C
Nitroaromatics and Cyclic Ketones		EPA 8270D -	EPA 8270D EPA 3510C
Haloethers		EPA 8270D -	EPA 8270D EPA 3510C
Chlorinated Hydrocarbon		EPA 8270D -	EPA 8270D EPA 3510C
Anilines and Benzidines		EPA 8270D -	EPA 8270D EPA 3510C
Polychlorinated Biphenyls		EPA 8270D -	- -
Organochlorine Pesticides		EPA 8270D -	EPA 8270D EPA 3510C
Organophosphorus Pesticides		EPA 8270D -	EPA 8270D EPA 3510C
Asbestos		ASTM D7521-16 Polarized Light Microscopy (PLM)	- -
Pharmaceuticals and Personal Care Products		EPA 1694	EPA 1694
Steroids and Hormones		EPA 1698	EPA 1698
Brominated Diphenyl Ethers		EPA 1614A	EPA 1614A
Pesticides		EPA 1699	EPA 1699
Cation Exchange Capacity (CEC)		EPA 9081 pH 7 Ammonium Acetate CEC BACl2 Compulsive Exchange Method	- - -
Toxicity Characterisitc Leaching Procedure (TCLP)	VOCs, SVOCs, Chlorinated Pesticides and Herbicides, and Metals	EPA 1311	EPA 1311

Synthetic Precipitation Leaching Procedure (SPLP)		EPA 1312 EPA 1313 EPA 1314 EPA 1315 EPA 1316 AS 4439	EPA 1312 - - - EPA 1316 AS 4439
Bioavailability		EPA in Vitro Bioaccessibility Assay Physiologically Based Extraction Test (PBET) Simplified Bioaccessibility Extraction Test (SBET) Relative Bioaccessibility Leaching Procedurer (RBALP) Solubility Bioaccessibility Research Consortium (SBRC) In Vitro Gastrointestinal Extraction Method (IVG) Standardised German in Vitro Assay (DIN) Dutch National Institute for Public Health and the Environment (RIVM) Bioaccessibility Research Group of Europe (BARGE UBM) Simulator of the Human Intestinal Ecosystem (SHIME) Dynamic Computer-Controlled Gastrointestinal Model (TIM)	
Hardness			ASTM D1126-12