Vedanta Resources Plc

Sustainability Governance System

Guidance Note GN15

Contaminated Site Management

GUIDANCE NOTE – CONTAMINATED SITE MANAGEMENT

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1 INTRODUCTION

Vedanta subsidiaries, operations and managed sites, if not managed properly, may impact land, water and air on-site and off-site. It is important to implement international best practices for Contaminated Site Management (CSM) to minimize potential impacts to human health and environment.

Contamination may occur as a result of existing activities at the site or as a result of previous activities by an unrelated organization (before acquisition) or from an off-Site source. Contamination may affect soil quality, water quality, human health or other ecological receptors. Contamination may be in solid, liquid or gas form in the ground or in buildings and structures.

Vedanta Companies shall conduct CSM activities:

- To identify risks due to contamination from past, current and future industrial activities at the site , implement environmental management measures and to take mitigation measures to prevent or minimize impact to the environment or people;
- In response to public/ NGO activism around an off-site groundwater issue and/ or human health risk which could potentially lead to public interest litigations;
- To evaluate risks during greenfield and/ or brownfield acquisition or divestment; and,
- To comply with the regulatory requirements.

1.1 WHAT IS THE AIM OF THIS GUIDANCE NOTE?

The aim of this GN is to outline the company requirements which Vedanta implements in order to ensure that risks associated with contaminated sites are eliminated or minimised.

1.2 WHO IS THIS GUIDANCE NOTE AIMED AT?

This Guidance Note (GN) is aimed at all Vedanta Companies and subsidiaries, managed sites, new projects; merged and acquired entities as well as those planned for divestment. This GN is applicable to the entire operation lifecycle (including exploration and planning, evaluation, operation and closure).

1.3 WHAT ISSUES DOES THIS GUIDANCE NOTE ADDRESS?

This GN presents the framework for CSM within Vedanta operations. The focus of the GN is on the provision of preferred methods and outcomes rather than prescriptions whilst at the same time representing a practical "how to" guide for all Vedanta operators. In this sense, the GN is not designed to be a definitive text, nor is it designed to provide prescriptive methods and procedures for undertaking tasks.

1.4 *HOW SHALL THIS GUIDANCE NOTE BE USED?*

This GN is intended to reflect good practice and provide the basis for continual improvement of sustainability issues across the Vedanta business. However, where this GN is not used, operations will need to demonstrate (and document) how an equivalent process is in place and how this ensures that CSM is carried out to Vedanta expectations. In most cases there will also be national and/or local regulatory requirements governing CSM activities – operations must ensure that these requirements are identified and complied with.

The GN focuses on general principles of CSM. It does not go into extensive detail on all aspects. It is imperative that CSM activities are only undertaken by trained and competent persons - extensive guidance on these and other topics is available from national regulatory bodies and industry associations, and there are also numerous technical standards and specifications published by national and international standards bodies (some of the latter are listed at the end of this document). Users shall always check the latest versions in force.

2 STEPS IN CSM

Lack of appropriate industrial and waste management practices may lead to contamination of natural resources, the soil, surface water and groundwater. Contamination may be in solid, liquid or gas form. This can cause environmental and health impacts that if not managed properly can have large implications on aspects such as soil quality, water quality, human health or other ecological receptors. A "Contaminated Site" is defied as "Sites with confirmed presence of contaminants or substances caused by human at the concentrations that either pose a significant risk and/or impact to human health or keeping in view regard to present or future land use plan" (Development of National Programme for Rehabilitation of Polluted Sites, "Final Report on Task - 1 Review of Current Systems and Task – 2 Overview of International Practices" January 2013) **

** Notes:
I. Confirmed presence of contaminates shall be done through scientific studies/approved globally harmonized methodologies.
II. Natural contaminants are not treated as contaminants or substances, which basically are anthropogenic.
III. Land would not be considered contaminated merely due to presence of hazardous substances in, on or under the land. The level of contaminants should be above risk level. Land may be contaminated even if it was contaminated partly or entirely by the migration of contaminants into, onto or under the land from other land.
IV. The risk may be considered based on human health and/or the environment; and may be accessed on the basis of present or planned future land use as well as use of ground water and surface water.
V. The risk approach may also be used with a combination of contaminants [interaction between contaminants] or certain quantities of contaminants, wherever applicable.

CSM activities can be broadly divided into Preliminary Assessment, Site Characterization, Risk Assessment, and Remediation. The progression of the decision for conducting CSM shall in line with flowcharts and conditions defined in Figure 1 of CSM Technical Standards (TS). The Figure 2.1 outlines the key activities in the steps of CSM.

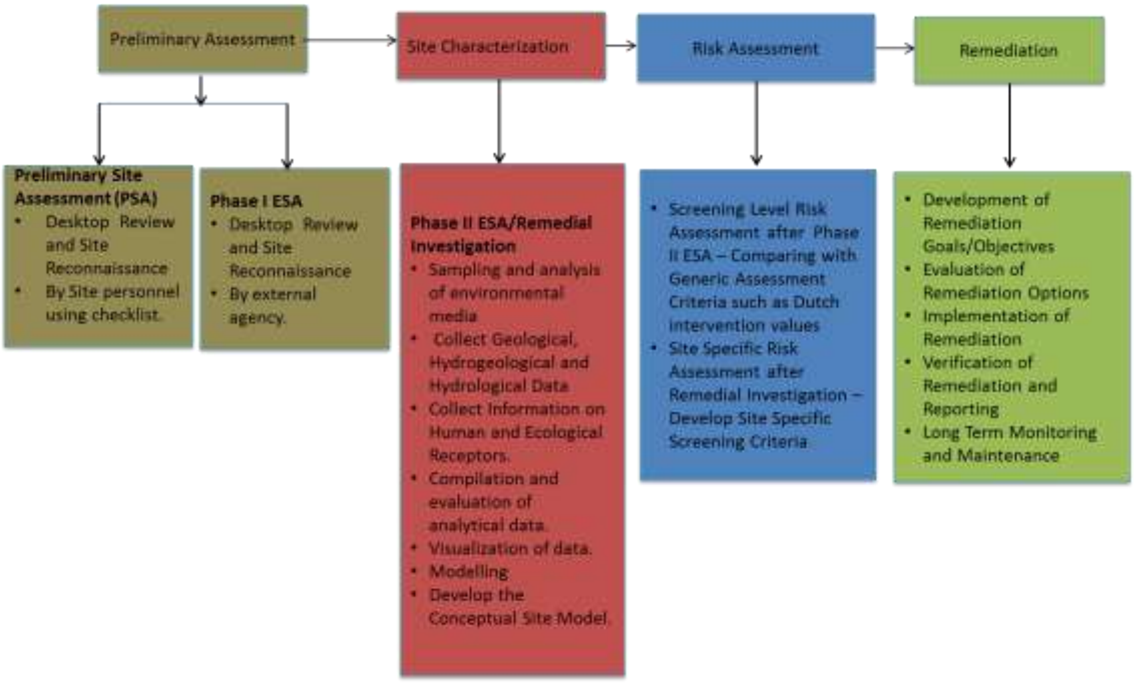

Figure 2.1- Steps in CSM

2.1 *CONDUCTING PRELIMINARY ASSESSMENT*

Preliminary Assessment activities such as Preliminary Site Assessment (PSA) and Phase I Environmental Site Assessment (ESA) primarily involve review of available information and field visits to identify potential contamination. During the Preliminary Assessment, information is gathered by the following activities:

- Reviewing existing information like maps, records and literature specific to the site location and surrounding area. This information are usually collected from various documents and records available at the site, aerial photographs, general published data about area, geology, hydrogeology, etc. Additional current and historic information is gathered by conducting field visits, site reconnaissance and through discussion with various government agencies and other stakeholders, as required.
- It includes a thorough site walk-through, discussions with site staff and management regarding current and former operations and processes, waste storage dumps, any historical leakage or spillage of chemicals, disposal of hazardous waste, current and historic storage of hazardous material (including petroleum products) and hazardous waste, usage of fertilizer, herbicides, pesticides, etc.
- An evaluation of surrounding land use is conducted to identify neighbouring activities which may present a potential risk to the

environmental quality of the site or may act as a sensitive or vulnerable receptor of environmental impacts associated with site activities.

2.1.1 *Preliminary Site Assessment (PSA)*

- Sites shall undertake a self-assessment to confirm the need to conduct site characterization and remedial activities. A self-assessment checklist is provided in ***Annex A1*** that may be used by Vedanta Companies in conducting an initial in-house screening exercise.
- Sites shall identify and designate in-house staffs to carry out the PSA. Sites shall ensure that personnel conducting the PSA screening exercise are certified environmental auditors and have about 5 years of experience in working in similar industries and conducting of environmental audits.
- Site shall conduct PSA annually. The PSA checklist along with the recommendations shall be recorded and maintained for future reference. The PSA report shall be reviewed and approved by the EHS head.
- The Site management shall review PSA findings and undertake corrective actions for improving environmental management systems effectiveness to mitigate identified current and potential future risks and liabilities.
- If PSA indicates potential risks impacting receptors, an ESA (Phase I and/or Phase II) shall be initiated to collect additional information, as applicable.

2.1.2 *Phase I ESA*

- Site shall conduct Phase I ESA if:
  - PSA indicates a requirement of further investigation due to potential of contamination at the site;
  - Any greenfield and/ or Brownfield acquisition/ divestment activity is planned (may be covered under the part of ESIA);
  - At a minimum, once every Four (4) years.
- Phase I ESA can be skipped to proceed directly to Phase II ESA, if PSA indicates clear information of sources of potential contamination and/or imminent risk to potential receptors.
- Standard practice for conducting Phase I ESA follows American Society for Testing and Materials (ASTM) standards, ASTM E 1527-13 and updates. Variation in the methodology prescribed by ASTM is allowable if certain requirements of the ASTM process are not available in the country/region of activity.
- Phase I ESA shall be conducted by a competent external agency with relevant experience. The findings and conclusions of a Phase I ESA shall be summarized in a Phase I ESA report. An example of scope or work for

conducting Phase I ESA along with proposed experience of the consultant is presented in ***Annex A2***.

- EHS head of the business shall review the Phase I ESA report and take future actions based on the recommendations.

2.2 *CONDUCTING SITE CHARACTERIZATION AND RISK ASSESSMENT*

The methodologies for conducting Site Characterization and Risk Assessment are presented in this section. Based on the findings of Preliminary Assessment, the high risk sites shall be identified for conducting Site Characterization and Risk Assessment.

Site Characterization and Risk Assessment involves the following activities:

- Site Characterization
  - Phase II ESA; and
  - Remedial Investigation
- Risk Assessment
  - Screening Level Risk Assessment
  - Site Specific (Quantitative) Risk Assessment

2.2.1 *Phase II ESA & Remedial Investigation*

Phase II ESA is conducted if the PSA and/or Phase I ESA identify the presence or likely presence of areas of contamination at a site. A Phase II ESA is conducted first, followed by a Remedial Investigation, if required. Even though the activities in Phase II ESA and Remedial Investigation are similar, the scale of field investigation differs between the two. An example of scope or work for conducting Phase II ESA/Remedial Investigation is presented in ***Annex A3***.

In the absence of local, regional and national regulatory requirements for conducting Phase II ESA, it shall be conducted consistent with ASTM International Phase II ESA Practices (ASTM 1903-11 or updates). Pre-determined numbers of samples are collected during Phase II ESA to obtain enough information to confirm the presence or absence of contamination. In Phase II ESA, the results of the environmental samples are compared against generic screening levels risk assessment criteria based on local, regional or national or international screening criteria such as Dutch Intervention Values or US EPA Regional Screening Levels. A site specific (quantitative) risk assessment may also be conducted if sufficient data is collected during a detailed Phase II ESA.

A Remedial Investigation is conducted if the Phase II ESA indicates the requirement for further investigation for delineation and collection of additional information for developing plans for remediation. The number of samples for laboratory analysis collected during the Remedial Investigation is typically greater than that collected during a Phase II ESA.

The results of additional data collected during Remedial Investigation shall be compared against selected screening level risk assessment criteria or site specific (quantitative) risk assessment criteria used to refine the conceptual site model and risk assessment if required. The results of Remedial Investigation shall be used to develop the extent of remediation and remedial designs. Various activities conducted during the Site Characterization are presented in the ***Figure* 2.2** below and discussed in subsequent sections.

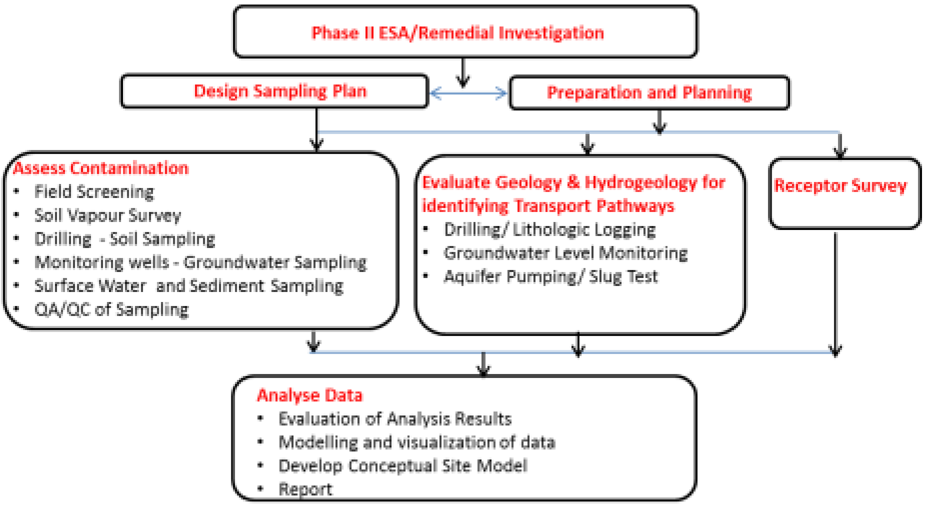

Figure 2.2- Methodologies for conducting Site Characterization

2.2.2 *Data Collection*

Data collection includes the following:

- Based on the information collected during the Preliminary Assessment, a Sampling and Analysis Plan (S&AP) should be developed for conducting field investigations.
- Field screening is used to collect real time data. Field screening and sampling complement each other to optimise the selection of samples and sampling locations. Examples of various instruments used in field screening and characterization of soil, groundwater, surface water and sediment are presented in ***Annex A4***.
- Chemical characteristics of environmental media such as soil groundwater, surface water, sediments, soil gas etc are evaluated by sampling and analysis. Details of sampling methodologies are presented in ***Annex A5.*** Sampling methods vary based on the site conditions, parameters of concern and availability of technologies. Common analysis methods are presented in ***Annex A6***.

- Understanding of the Site condition including geology and hydrogeology is important in evaluating the transport mechanism of contaminants. Permeable geology such as sand will allow downward movement of contaminants. Geology with limited permeability such as clay will restrict the movement of contaminants. If the groundwater is shallow, the vulnerability will increase and the velocity of groundwater transport will increase with the permeability of the geology. The direction of groundwater flow will determine impact to potential receptors. The geology is evaluated by visual observation, during the drilling, using geophysical methods, estimating particle size distribution etc. The hydrogeology is evaluated by installing groundwater monitoring wells/piezometers, groundwater level measurements, geophysical /pump/slug tests, tracer tests, groundwater modelling etc.
- The quality control (QC)and quality assurance (QA)for the data collection includes the following:
  - Submittal of samples to the laboratory within specified holding times;
  - Use of appropriate forms, identification of samples using an individual and unique alphanumeric code.
  - The Chain of Custody is intended to trace and control each of the samples collected in the field to the laboratory.
  - The QA/QC procedure for sample management would include sampling and analysis of field duplicate samples. The duplicate samples are sent to the laboratory with tags treating them to be another sample. Typically 10% of the samples will be collected as duplicate.
- An ecological survey shall be conducted to identify potential threat to biodiversity, especially to any endangered species from impacts originating from the site or during the remediation activities.
- Receptor survey is conducted to identify potential pathways and receptors for groundwater contamination originating from the site. A template for Receptor Survey is presented in ***Annex A7***.

2.2.3 Conceptual Site Model

A Conceptual Site Model is a qualitative description of the plausible mechanisms ('pathways') by which humans or sensitive environmental areas ('receptors') may be exposed to contamination ('sources'). A '**Source-Pathway-Receptor**' (SPR) exposure mechanism referred to as a 'SPR linkage' is established to evaluate human health or ecological risk. To develop a Conceptual Site Model, the following information shall be available:

1. The characterization of the 'sources' by identification and quantification of the COCs (identified in this context as part of the sampling and analysis);

2. The identification of potential 'receptors' (identified in this context as part of the Receptor Survey), and
3. The identification of potential 'pathways' between the 'sources' and 'receptors' (identified in this context as part of the geological and hydrogeological investigations).

At each step, the conceptual site model shall identify and address data gaps until a valid model is generated in which no significant data gaps remain. The final Conceptual Site Model should provide an understanding and description of the following:

- Nature of the contaminants, including solubility, volatility, degradability, and breakdown products;
- Contaminant transport mechanisms through air, surface water and subsurface, such as dispersion, advection, diffusion, gravity-driven flow of Non Aqueous Phase Liquids (NAPL), and cross-media transfer;
- Exposure Pathways through, air (inhalation), water (ingestion, or direct contact) and soil (ingestion, or direct contact); and
- Receptors, including humans, supply wells, hand-pump, sensitive flora and fauna, groundwater, surface water, sediment and existing structures.

An example of conceptual site model is presented in ***Annex A8***.

2.2.4 *Risk Assessment*

Detection of chemical constituents does not mean that there is a risk to humans or environment. A consistent and methodical decision-making process such as Risk-Based Corrective Action (RBCA) can be used to assess actual or likely human and/or environmental risk of exposure to a chemical release and determine appropriate remedial actions in response to such releases. Risk Assessment shall be undertaken as mentioned below:

- ***Screening Levels Risk Assessment*** - Risk assessment is carried out after Phase II ESA using generic screening levels based on local, regional or national screening criteria, international criteria such as Dutch Intervention Values or US EPA Regional Screening Levels. Dutch Intervention Values are presented in ***Annex A9***.
- ***Site Specific (Quantitative) Risk Assessment***– Site-specific (Quantitative) risk assessment criteria will be developed to evaluate site specific potential threat to human health and the environment and need for remediation. Typically Site Specific (Quantitative) Risk Assessment is less conservative than generic Screening Levels Risk Assessment.

If the level of contamination is less than risk criteria, remediation is not required. However, appropriate measures shall be taken to prevent any future contamination. If level of contamination is greater than risk criteria, remediation is required.

The major components of Risk Assessment are presented in ***Figure 2.3*** and summarized below:

Figure 2.3- Components of Risk assessment

Contaminants (Source) –The first step in the Risk Assessment is to identify the type and concentration of contaminant of concerns present at the site / beyond the site perimeter as the level of risk posed by COCs is a function of type of contaminants, their impact on human health and environment, toxicity and their concentration at a site.

Receptors – The sensitive receptors to which the contamination at the site / beyond the site perimeter can reach are identified through receptor survey. Examples of receptors considered in the risk assessment include people (local residents, industrial employee, agricultural worker etc.), animals (cattle), properties (school, hospital etc.), water bodies (groundwater, surface water, etc.).

Exposure Pathways – The various pathways through which the contamination at the site / beyond the site perimeter can reach the identified sensitive receptors are determined though developing the Conceptual Site Model.

The Risk Assessment process is specific to pathway and receptor and will provide focus for what manner of remedial action (if required) is likely to be effective. The human health risk assessment (HHRA) can be subdivided into the following stages:

- Conceptual Site Model;
- Calculation of exposure point concentrations;
- Human dose estimation;
- Effects (toxicity) assessment;

- Risk estimation;
- Risk evaluation; and
- Risk characterization.

A brief summary of the methodology of risk assessment is presented in ***Annex A8.***

2.3 CONDUCTING SITE REMEDIATION

Remediation is a corrective action undertaken to address the unacceptable risks to human health and environment. The actions which ensure the protection of human health and environment may involve the following:

- Reduction of hazardous substance concentrations in-situ;
- Complete removal or destruction of hazardous substance from the site;
- Prevention of exposure of hazardous substance through implementation of engineering or institutional control measures; or
- A combination of any of the above.

The sequence of key activities presented in Figure 2.1 shows that remediation comes after Risk Assessment, i.e., only if risk to environment and humans is identified at unacceptable levels. The method of remediation for mitigating the risk will require the following steps.

2.3.1 *Development of Remediation Objectives and Criteria*

Development of Remediation Objectives and Criteria is the first step in the option appraisal process. Typical objectives of remediation include:

- Compliance with regulatory requirements.
- Mitigation of the existing risk and protection of the receptors;

Remediation criteria provide a measure (usually expressed in quantitative terms) against which compliance with remediation objectives can be measured. Remediation criteria shall be developed in consultation with the relevant regulatory authorities and other stakeholders, as required. Examples of quantitative remediation criteria include:

- Guideline values published by regulatory authorities (e.g., soil guideline values, drinking water standards);
- Site-specific assessment criteria developed from site-specific Quantitative Risk Assessment (Site Specific Risk Assessment);

2.3.2 *Remediation Options Evaluation*

Remediation options appraisal is the next essential step in the overall process of remediating the contaminated site. The primary objective of this step is to select a cost- effective sustainable remediation option from a range of available approaches and technologies and provide the basis for the selection. The remediation options can be developed to address specific media (e.g., treatment of contaminated soil and/or groundwater) or the site as a whole (e.g., capping and access restriction).

All remediation options have advantages and limitations that make them more or less applicable in a given situation, with a wide range of site-specific technical factors that determine which remediation options are most appropriate.

Some of these factors relate to the following:

- Degree to which health and environmental risks are reduced for the protection of receptors.
- Technical complexity and ability of execution for addressing the risks.
- Cost of implementation.
- Sustainability e.g. energy efficiency, water consumption, waste generation, social acceptance of the remediation.
- Timeframe for achieving the remediation objective.
- Compliance with regulatory requirements.

At the end of the appraisal any remediation option selected must protect human health and environment; comply with regulatory and social requirements; and be cost-effective. Common remediation technologies are presented in ***Annex A10***. Elements of costing are presented in ***Annex A11***.

2.3.3 Implementation of Remediation

The implementation of the selected remediation option consists of a number of activities, including the design of remediation system, development of a Remediation Action Plan (RAP) and implementation activities. Details of these activities are provided below.

Design of Remediation System

This activity follows the remediation options appraisal and precedes the actual implementation of the selected remediation option. The design documentation may vary based on regulatory requirements as required; however, a typical design document includes design basis, expected removal or treatment efficiencies (concentration and volume), design drawings, design calculations, specifications and bid documents, schedule, performance monitoring/evaluation methods and long-term operation and monitoring requirements.

The preliminary design shall be reviewed internally and by other stakeholders, such as regulatory authorities, as required. The final design shall then be prepared to address any stakeholder requirements.

Development of Remediation Action Plan

A Remediation Action Plan (RAP) shall be prepared after the final remediation design is approved. The report summarizes the remediation option selected for the site and the typical activities to be undertaken as part of the implementation and operating of the remediation options. It shall also include plans such as such as Construction Quality Assurance Plan, Health and Safety Plan (HASP), Emergency Preparedness and Response Pan (EPRP), etc.

These plans shall be prepared by the remediation expert and/or remediation contractor. Other planning activities include obtaining regulatory permits for installation and operation of remediation systems, discharge permits for air and treated water, waste management permits, groundwater extraction permits and engaging with stakeholders as applicable.

Field Activities during Implementation of Remediation Activities

Field activities vary depending on remediation option and site conditions. Typical field activities involved in the implementation of the remediation option may include:

- Subsurface/utility clearance;
- Mobilization of equipment;
- Clearance of the area of remediation;
- Soil boring and installation of monitoring wells;
- Shoring, excavation and backfilling;
- Installation of piping and mechanical equipment;
- Installation of electrical control panels, wiring, etc.;
- Remediation technology specific activities such as injection of chemicals, installation of extraction wells, vapour extraction, etc.;
- Ambient air monitoring;
- Maintaining daily field logs and preparing progress report; and
- Equipment start-up activity and continued O&M activities.

Monitoring of Implementation of Remediation

The tasks and frequency of activity is presented in ***Annex A12***.

2.3.4 *Verification, Long term Monitoring, Operation & Maintenance and Reporting*

Verification of the success of remediation in meeting the established remediation objectives and addressing/managing the identified risks shall be conducted towards the end, or after the completion of, remediation activities.

The primary evidence used for the verification in most cases is the demonstration of reduction in contaminant concentrations through Long Term Monitoring by sampling and laboratory analysis of environmental media.

The parameters for analysis depend on the CoC. The monitoring frequencies can be monthly, quarterly or semi-annual depending on the monitoring objective. The duration of monitoring/sampling depends on the technology and site conditions. In some cases, where technologies such as monitored natural attenuation, containment, pump and treat systems are being used, sampling/monitoring may need to be extended over a long period of 5-30 years to demonstrate that long-term remediation objectives are achieved.

Continuous or periodical operation and maintenance support is required for remediation options such as groundwater pump and treatment. Operation and maintenance shall continue until it is demonstrated that all the remediation objectives have been met and the pollutant linkages have been permanently broken and any harm or pollution caused has been mitigated.

After completion of remediation, a Remediation Completion Report shall be prepared. Stakeholder feedback on the remediation works and outcomes shall be obtained and documented in the Remediation Completion report , as applicable.

3 IMPLEMENTATION OF CSM

3.1 ROLES AND RESPONSIBILITIES OF STAKEHOLDERS

Role and responsibilities are presented in ***Annex A13***.

3.2 TRAINING

Sites shall ensure that all personnel (management, workers and contractors) working in the organization are competent enough and have received appropriate training to perform tasks related to their functional area specific for CSM.

This GN may form the basis for developing appropriate CSM training and communications. The training shall be provided through classroom training as well as hands-on training. Recommended training topics include:

- Environmental Management (As per TS 11)
- Relevant regulatory requirement and mitigation actions
- Preliminary Assessment
- Site Characterization
- Risk Assessment
- Remediation options appraisal
- Verification and monitoring of remediation

4 MONITORING & REPORTING

4.1 INSPECTION & AUDITING

Inspection & audit to be conducted by Vedanta at a frequency presented in the table below:

Activity	Frequency	Reference
Preliminary Site Screening	Annually	***Annex A1***
Status Update on Site Characterization and Risk Assessment	Periodically as applicable	Not applicable
Remediation Monitoring	Periodically as applicable	***Annex A12***
Long Term Monitoring	Periodically as applicable	Not applicable

4.2 REPORTING & FORMATS FOR REPORTING

Various reports and their typical table of contents are presented in annexures as presented below.

Report Title	**Annex ID**
Typical Content of Phase I ESA Report	A14
Site Characterization Report	A15
Remediation Design Report	A16
Remediation Action Plan	A17
Remediation Completion Report	A18

4.3 RELATED VEDANTA TECHNICAL STANDARDS

Vedanta companies shall endeavour to comply with the relevant Vedanta's technical standards listed in ***Annex A19***.

4.4 REFERENCES

National and international guidance associated with CSM activities and relevant web links of references are presented in ***Annex A20***.

ANNEXURES

A.1 PRELIMINARY SITE ASSESSMENT CHECKLIST

General Information

Site Name	
Area / Location Address	
Contact Person & Phone Number	
Date and time of site / location visit	
Site / location Investigation conducted by	
Spoken with	
Weather conditions during visit	

Records/Data Requirement

Data Requirement	Status (Yes/No)
Summary of the history of the site	
Site Layout Plan	
Planning permissions/operating permits, approved plan, completion / occupation certificate/	
Details of permits, agreements and licences for effluent discharges, air emissions and waste disposal	
Topography and hydrogeological reports	
Environmental monitoring	
Integrity testing (underground tanks monitoring report, if applicable)	
Soil and groundwater testing	
Records of scrap and wastes removed by contractors	
Storage of dangerous goods	
Copy of environmental impact assessment (EIA) report	
Correspondence with authorities including response regulatory actions.	

Inventory and annual quantities used/generated of chemicals, solvents, oils, and waste materials etc.	
Details of groundwater extraction and monitoring wells on the site	
Surveys/usage records of lead based paints, PCBs and asbestos in the premises	
Details and outcome of public complaints if any (including correspondence).	
Details of water usage including sources, water treatment, analysis reports, uses of water.	

Site / location Information

Question		
Total Area		**m^2**
Built-up area (m^2 or percentage of total)		**m^2**
Paved area (m^2 or percentage of total)		**m^2**
Is the site a green field or brownfield		
What is the land use?		
What was the former land use?		
What is the type of industry?		
What are the site processes and what type of chemicals are used?		
How many on-Site workers?		
What is the geology and hydrogeology?		
What are the drainage patterns?		
In which direction is the flow of groundwater, surface water, etc.?		

Questions on On-Site Conditions

Question	Yes/ No	Additional Information	Comment
Who is responsible for environmental health and safety matters?			
Are there any environmental management systems, certifications, policies or procedures at the site (e.g., ISO 14001)?			
Have the environmental management personnel received environmental training or obtained relevant certifications?			
Does the Company maintain Health & Safety certifications (e.g., ISO/OHSAS 18001)?			
Describe the company's history (names the company has operated under, related acquisitions, mergers, or divestitures)			
Are there previously operated locations, which are no longer occupied by the company? If Yes, complete next table (other company locations)			
What are the primary products manufactured by the site?			
What was on the site before the current building(s) was constructed?			
Please describe any changes in operations since the Company began operating at the Site? Include a discussion of processes or products that have been discontinued, movement of equipment, tanks, or chemical storage areas.			

Have there been any significant changes in chemical usage/ storage at the site (products that used to be used, but are no longer; or new products that weren't previously yes)?				
If yes	Describe and explain the reason for the change.			

Questions on Potential sources

Question		Yes/ No	Prevention measures / controls and monitoring measures	Comment
Are there indications of stressed vegetation on-site?				If yes, possibility of contamination, further investigation required.
Have chlorinated solvents historically been used at the Site?				
If yes	Describe types of solvents used, operations used in, location(s) of use and of storage, quantities used and stored, waste handling/disposal practices.			
Information on historical dumping of contaminants including raw material, product or waste materials on-site?				
Are there any features like wastewater pits, sumps,				

Question		Yes/ No	Prevention measures / controls and monitoring measures	Comment
lagoons, septic tanks or soakaways on-site?				
If yes	Are they lined?			If no, possibility of contamination, further investigation required.
If yes	Was there any leak, overflow that contaminated the soil?			If yes, possibility of contamination, further investigation required.
Are there dumping of raw materials, products or waste present on-site in open without secondary containment?				If yes, possibility of contamination, further investigation required.
If yes	Describe the details			
Is any kind of fuel or chemical been stored in above ground or underground storage tanks on site which may cause contamination?				
If yes	Was there a leak or spillage of the said material from the storage units?			If yes, possibility of contamination, further investigation required.
If yes	Details of status, capacity, construction material and content of the tanks.			

Question		Yes/ No	Prevention measures / controls and monitoring measures	Comment
	How is the material delivered to/transferred from the UST(s) or AST(s)?			
Is there any landfill on-site?				
If yes	Is it engineered landfill with lined bottom?			If No, possibility of contamination, further investigation required.
If Yes	Is there any data confirming the landfill being leak proof.			If no, possibility of contamination, further investigation required.
Is there any kind of effluent/sludge generated by processes on site?				
If yes	Is the discharge/disposal of these waste materials done in compliance to required environmental regulations?			If no, possibility of contamination, further investigation required.
Is there any visual evidence of contamination like stained soil, vegetation, pavement, etc.?				If yes, possibility of contamination, further investigation required.
Are the buildings visibly contaminated? low / medium / high impact/ NA				If yes, possibility of contamination, further

Question		Yes/ No	Prevention measures / controls and monitoring measures	Comment
				investigation required.
Does the site have below the ground piping carrying potential contaminants which are suspected to be leaking?				If yes, possibility of contamination, further investigation required.
If yes	Describe the details			
Is there a presence of Ozone-depleting substances (refrigerants) used at the site?				
If yes	Describe refrigerant used, container size, equipment used in, and quantity of refrigerant.			
Is there presence of hazardous material like Polycyclic biphenyl (PCB) containing materials (transformer oil) on site?				If yes, possibility of contamination, further investigation required.
Has any sampling for PCB’s been conducted?				
Has Asbestos been used as a process material? If yes, describe.				
Is there presence of hazardous material like asbestos present on site?				If yes, possibility of contamination, further investigation required.

Question		Yes/ No	Prevention measures / controls and monitoring measures	Comment
If yes	Has an asbestos repair or abatement been conducted?			
If Yes	Doe the site have an Asbestos Operations & Maintenance Plan?			

Questions on Pathways

Question		Yes/ No	Prevention measures /controls and monitoring measures	Comment
On- Site				
Is there excavation or any other activity that may result in dermal contact with impacted waste, soil or groundwater?				
Are there risks of vapour inhalation from impacted waste, soil or groundwater (eg. Vapour intrusion in to manufacturing area through cracks on the floor)				
Are there indications of groundwater pollution; e.g. smelling wells.				If yes, possibility of contamination, further investigation required.
If yes	If yes, what is the level (intensity) of			

Question	Yes/ No	Prevention measures /controls and monitoring measures	Comment
groundwater contamination			
Is there surface water at the site? Is the surface water visible contaminated?			If yes, possibility of contamination, further investigation required.
Is the impacted groundwater for cleaning, washing, air cooling systems, process?			
Is the impacted groundwater used for consumption?			
Off- Site			
Is there risk of ingestion of impacted waste, soil by people?			If yes, immediate intervention is required.
Is there excavation or any other activity that may result in dermal contact with impacted waste, soil or groundwater by people?			If yes, immediate intervention is required.
Are there risks of vapour inhalation from impacted waste, soil or groundwater (eg. Vapour intrusion in to populated areas such as homes, commercial buildings)			If yes, immediate intervention is required.
Is there agriculture cultivation/fisheries and consumption of produces happening in contaminated land or			If yes, immediate intervention is required.

Question	Yes/ No	Prevention measures /controls and monitoring measures	Comment
using contaminated groundwater.			
Are there indications of groundwater pollution; e.g. smelling wells.			If yes, possibility of contamination, further investigation required.
If yes	If yes, what is the level (intensity) of groundwater contamination		
Is there surface water at the site? Is the surface water visible contaminated?			If yes, possibility of contamination, further investigation required.
Is the impacted groundwater used for domestic purposes or by other off-Site commercial/industrial establishments?			If yes, immediate intervention is required.
Is the impacted groundwater used for consumption?			If yes, immediate intervention is required.

Question on Receptors

Question	Yes/ No	Prevention measures / controls and monitoring measures	Comment
On-Site Receptors			
Are there employees handling the impacted waste, soil or groundwater?			If yes, immediate intervention is required.
Is the impacted groundwater used for consumption?			If yes, immediate intervention is required.
Are there employees working area where vapour intrusion is happening?			If yes, immediate intervention is required.
Off-Site Receptors			
What is the land use next to the site?			
Is there inhabitation next to the site?			
What is the distance to other sensitive activities e.g. Schools, nursery, religious centers (m)			
Are there groundwater wells present? If so what use (consumption / domestic / industrial?			
Is there any visible sign of impact from the site on the surroundings?			
If yes: Describe the details			If yes, the possibility of contamination, further investigation required.
Are there any potential or known impact issues to			If yes, possibility of contamination,

Question		Yes/ No	Prevention measures / controls and monitoring measures	Comment
nearby community from the operation of the Site?				further investigation required.
If yes	Describe			

Question on Actions by Regulators or NGOs

Question		Yes/ No	Additional Information	Comment
Is there any regulatory action or Public Interest Litigation against the Site due to on-site off-site contamination?				
If yes	List any other pending complaints, claims, and liabilities, non-compliances conversations with site personnel or neighbours and other relevant matters related to soil and groundwater pollution aspects.			

REPORT TEMPLATE

Findings	Location	Criticality of the Findings	Prevention measures/ controls and monitoring measures	Corrective Actions
MATERIAL STORAGE AREAS				

STORAGE TANKS (UNDERGROUND & ABOVE GROUND)				
DRUM STORAGE AREA				
WASTE MANAGEMENT (HAZARDOUS & NON HAZARDOUS)				
WASTEWATER MANAGEMENT (DOMESTIC & INDUSTRIAL)				
PCB CONTAINING MATERIALS				
ASBESTOS				
RADIOACTIVE MATERIALS				
OZONE DEPLETING SUBSTANCES				
PRIOR ENVIRONMENTAL EVENTS				
ENVIRONMENTAL COMPLIANCE				

AREA OF POTENTIAL CONCERN	RISK RATING	RATIONALE

Area of concern to be classified based on the field observation and interview to understand the imminent risk. The risk rating is based on the following Criteria:

High Risk-
- Impact to sensitive off-site or on-site receptors currently or in future.
- Potential for regulatory action or environmental activism.

Medium Risk-
- Impact is contained within the boundary of the site based on engineering controls (eg. engineered landfill) or natural controls (low permeable geology).
- This may be elevated to High Risk or low risk based on additional data.

Low Risk-
- Impact is localised with no pathway or receptors.
- Impact is small enough to pose any risks.

<u>EXAMPLES OF PSA FINDING AND MANAGEMENT OF RISK</u>

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Wrong Practice	Right Practice
	
Drum storage without Secondary containment	Drum storage with Secondary containment

	
Unlined Wastewater structures	Lined Wastewater structures
	
Unorganized Waste Storage	Waste Stored in Designated Area
	
Spill/Leak from Process	Tidy process area

A.2 SCOPE OF WORK - PSA/PHASE I ESA

OBJECTIVES

- Undertake a PSA/Phase I ESA at the Site, to identify issues, concerns and potential environmental risks and/or liabilities associated with the past or current use of the Site and activities at neighbouring properties;
- Undertake an assessment of current environmental compliance status and future local and national compliance requirements; and
- Based on the above findings, prepare a report for the Site presenting the assessment findings, compliance requirements, baseline environmental conditions and any recommendations for further course of action (if required).

SCOPE OF WORK

The Scope of work shall include site visit for interviews and on-site observation and document review to collect following information:

- Surrounding land use, site topography, locations of the nearest residential communities and other sensitive areas and identification of major industries present in the area, proximity to site, industries located upwind to the site
- Geology, hydrology and hydro-geology of the site
- History of the site such as historical land use and former operations and processes at the site.
- General assessment of formal and informal environmental management systems, policies and procedures including organization, staffing, training and data quality including details of regulatory authority inspections, voluntary audits and any current or pending regulatory enforcement actions
- Water management, wastewater management, material storage and handling, waste management, environmental noise, polychlorinated biphenyls (PCB), radioactive materials, asbestos, ozone depleting substances (ODS).
- Summary of any past (within five years) notices or pending environment prosecutions & actions;
- Risk of Soil and Groundwater Contamination

REPORTING

Following completion of the above task, the consultant shall produce a written report presenting the findings and associated implications.

EXPERTISE REQUIRED

- The consultant/organization shall national or international reputation in the ESA field.
- The consultant/organization shall have experience in conducting ESA as per ASTM standards or modified, if certain requirements of the ASTM process are not available in the country/region of activity.
- The consultant/organization shall have experience in conducting ESA in varied sectors such as mining, oil and gas, smelters, power and manufacturing.
- The consultant staff shall have experience in conducting ESAs.
- The consultant staff shall have a Post Graduate degree in Environmental / Civil/Chemical Engineering /Science or relevant discipline AND demonstrated experience of similar work in the region or local geography.

A.3 SCOPE OF WORK - PHASE II ESA / REMEDIAL INVESTIGATION

OBJECTIVES

- To evaluate soil environmental quality within the identified Areas of Concern (AoC).
- To characterize site specific geology and hydrogeology.
- To evaluate groundwater environmental quality at the Site wells.
- Based on the above findings, prepare a report presenting prevailing environmental conditions (baseline), laboratory analysis results, the assessment findings, and recommendations regarding further course of action required.
- Risk Assessment identification of potential liabilities around any adverse impacts to soil , groundwater , surface water quality at the Site.

SCOPE OF WORK

- Drilling of sampling bore-holes/excavation for test pits/installation of groundwater monitoring well/passive and active soil vapour sampling, in and around contaminated sites in consultation with the site team.
- Collection of samples and analysis of soil/surface water/ground water/sediments for comprehensive analysis of major ions and heavy metals, organic constituents, pesticides and other relevant parameters related to the contaminated site as per national / international accredited testing procedures as required for the site characterization.
- Collect data on Geological, hydrogeological and hydrological features of the contaminated site.
- Identification of Benchmark /Background samples.
- Use of rapid assessment tools / methods (for Field screening of samples)
- Conduct Top of Casing survey and preparation of groundwater level contour maps w.r.t. MSL; ascertaining groundwater flow direction.
- Conduct hydro geological modelling to evaluate contaminant transport processes and visualize the contaminant plume in groundwater. Outlining the extent of contaminant plume through Surfer maps or similar tools.
- Comparison of analytical data against risk assessment criteria and identify locations in a map that exceed the risk levels.
- Development of conceptual site plan/model.

- Assess the potential environmental/ecological/health impacts on population, flora and fauna due to contact and/or consumption of contaminated soil, ground water, surface water etc.

REPORTING

Following completion of the above task, the consultant shall produce a written report presenting the findings and associated implications.

EXPERTISE REQUIRED

- The consultant/organization shall national or international reputation in the ESA field.
- The consultant/organization shall have experience in conducting ESA – Phase 2 as per ASTM standards or modified, if certain requirements of the ASTM process are not available in the country/region of activity.
- The consultant/organization shall have experience in conducting ESA in varied sectors such as mining, oil and gas, smelters, power and manufacturing.
- The consultant staff shall have experience in conducting ESAs.
- The consultant staff shall have a Post Graduate degree in Environmental / Civil/Chemical Engineering /Science or relevant discipline AND demonstrated experience of similar work in the region or local geography.

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A.4 TYPICAL FIELD SCREENING EQUIPMENT

Equipment	General Description	Representative Illustration
PID	Photoionization Detectors (PID) for the measurement of Volatile Organic Compounds (VOC) and other gases from sub ppb to 10,000 ppm. Produce instantaneous readings.	
Confined Space Entry Monitor	One-to-four sensor confined space gas detector. Allows Combustible, Oxygen, Hydrogen Sulfide, Carbon Monoxide, etc. measurement.	
Handheld XRF	X-Ray Fluorescence instrument, proven technique for detecting trace concentration for heavy metals. Measures all the 26 elements defined in EPA method 6200.	
UVF analyzer (TPH/PAHs)	Portable field analysers using Ultraviolet Fluorescence Technology; a very selective detection method useful for measuring many types of petroleum contaminants in soil, sediment and water.	
TPF field screening.	On-site test kit for analysis of Total Petroleum Hydrocarbon (TPH) in Soil. Quantifies all fuels, oils, and greases as total hydrocarbons.	
Odour meter	Handheld tool for odour analysis. Measuring and Finding odour source at factories, incinerator plants, etc. Measures odour source such as Ethanol, Acetone, Hydrogen, etc.	
Geiger counter	Compact precision instrument for measuring α-, β- and γ-radiation.	

A.5 SAMPLING METHODS IN ENVIRONMENTAL MEDIA

Soil Sampling

The intent of soil sampling is to characterize and estimate the limits of existing soil contamination. Field-screening techniques (e.g. soil gas analysis, mobile laboratories for target compounds) can be useful for directing soil sampling into areas of greatest contamination or "hot spots." If existing information provides no basis for predicting where hot spots might occur, sampling locations can be chosen in a grid pattern of appropriate size such that investigators can be confident that areas of high concentration have been located.

Soil contamination should be documented in both vertical and horizontal directions. This approach will help to determine both areas of contamination and background concentrations. Soils to be analyzed usually can be obtained manually, allowing many samples to be taken and initially analyzed with instruments such as a photoionization detector. Results of field screening can then be used to determine which samples should be further analyzed using more rigorous methods.

Important information collected from soil sampling includes:

1. Visual observation as shown in ***Figure A.2.1*** for the evidence of the contamination in the soil;
2. Olfactory observation (e.g. smell of petroleum product) for the evidence of the contamination in the soil;
3. Results from field screening;
4. Understanding of geology as shown in ***Figure A.2.1*** (type of soil, texture); and
5. Laboratory analysis for measuring concentration of contaminants in the soil.

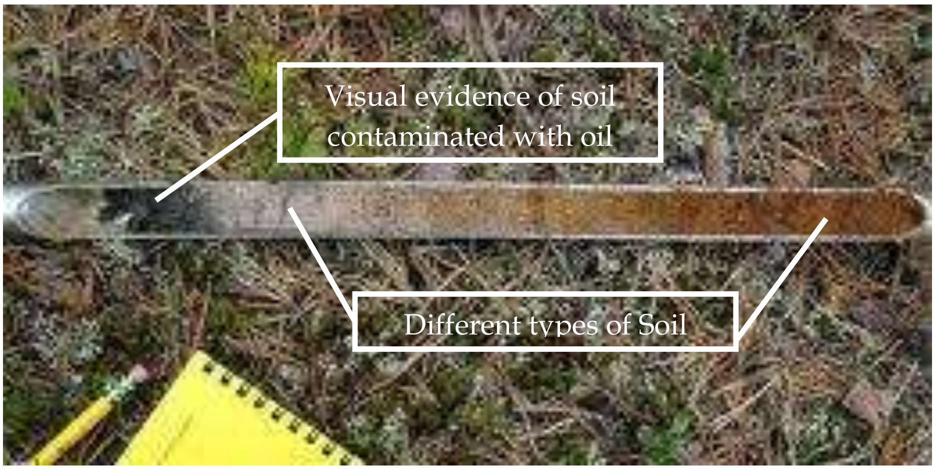


Figure A.2.1 Example of Field Evaluation of Soil Samples

Since the objective of soil sampling is to characterize the three-dimensional distribution of contaminated soil, factors for consideration during soil sampling include:

- The number and location of samples needed to delineate the contamination may be affected by the uncertainty of the location of the source of contamination. Focused sampling is appropriate when evidence for the location of contamination is available. Grid sampling is appropriate when the specifics about a potential contamination location are unknown.
- The depth at which samples are collected should be based on the depth at which the contamination is most likely to be detected.
- The methods such as manual auger, trial pits or mechanical drilling such as hollow stem auger as shown in ***Figure A.2.2*** allow sampling from discreet depth intervals. Soil samples should be undisturbed to the extent possible. Disturbance to the soil samples will cause volatile components of the contaminants to escape affecting the sample quality.
- Continuous sampling is usually necessary to understand the variation in geology and the three-dimensional distribution of the contamination in the subsurface.

Figure A.2.2 Examples of Soil Sampling Methods

<u>Soil-Gas Sampling</u>

Volatile contaminants present in the soil (pure product, dissolved phase or adsorbed to soil particle) may be present in the soil pore space in the vapour form through vaporization of liquid or adsorbed phase into gas phase. It is a low cost and rapid method which provides high yield information when applied correctly. This method can be used to:

- Identify contaminants and relative concentration.
- Identify source and the extent of contamination.
- As a guide to select soil sampling location.
- Monitor the progress of clean-up.

There two types of soil gas sampling methods. Examples of soil gas sampling methods are presented in ***Figure A.2.3*** below:

- *Active soil-gas sampling*: In this method a probe is placed in the subsurface and soil gases are pumped into a sample container (canister, vial glass bulb, gas-sample bag, syringe) or through a sorbent medium.
- *Passive soil-gas sampling*: A sorbent material is placed in the subsurface for a period of time so that the contaminants are collected through diffusion and/or adsorption to the sorbent material.

The contaminants in the sorbent material are then analyzed using the gas chromatography. Analysis can be on-site using a portable gas chromatography or the sample can be sent to the lab for analysis.

Figure A.2.3 Examples of Soil Gas Sampling Methods

<u>Groundwater Sampling</u>

The nature and extent of groundwater contamination should be evaluated both horizontally and vertically. On the basis of geologic and hydrogeologic investigations, it should be determined if contamination of an aquifer(s) is possible and if such contamination could potentially affect human or environmental receptors. Following this, a groundwater monitoring program may need to be implemented, concentrating the placement of wells in the direction of groundwater flow, in aquifers subject to contamination, and in places where they would indicate an existing or future threat to receptor populations. Sampling for background levels, and determining if there is a contribution from other sources, sampling should also be conducted in the area perceived to be upgradient from the contaminant source.

Groundwater samples are collected from permanent or temporary monitoring wells at the site to identify the groundwater impact and characterize the three-dimensional extent and distribution of contamination in groundwater as shown in ***Figure A.2.4*** below. As such the placements of monitoring wells are critical to delineate the contamination in the groundwater. Detailed knowledge of the site geology is necessary for proper construction of monitoring well. The location and the depth of monitoring well should be decided based upon the location of source of contamination and receptor, groundwater flow direction and hydrogeological characteristics of aquifer and care should be taken during design and installation to avoid the cross contamination between aquifer. In addition to wells in the contamination zone, Wells should be placed to find the groundwater contamination boundaries.

Groundwater can provide more information of potential contamination at the site than the soil samples collected from unsaturated soils. Although groundwater data do not necessarily indicate the source of contamination, it provides indirect line of evidence that contaminant release has occurred. The information collected from groundwater sampling should include:

- The depth to groundwater table.
- The groundwater chemistry (pH, conductivity, Oxidation Reduction Potential (ORP), dissolved oxygen, turbidity, TDS) which helps understand the state of contaminants in the groundwater (for example: oxidation state of metal species, evidence for the potential for biodegradation of contaminants, evidence for the presence of inorganic species which influence the efficiency of treatment technologies).
- The type and concentration of contaminants in groundwater.

Examples of groundwater sampling methods are presented in ***Table A.2.1*** below.

Table A.2.1 Groundwater Sampling Methods

Method	General Description	Representative Illustration
Low flow Sampling	Groundwater is collected using a submersible, bladder or peristaltic pump	
Grab Sampling	Collection of groundwater sample using bailers	
	Hydrasleeve: Used for sampling from discrete depths. Sleeve is placed in the monitoring well at desired depth for at least 24 hrs for equilibration and then pulled up to collect sample	

Figure A.2.4 Examples of Groundwater Sampling Methods

Some of important factors for consideration during groundwater sampling are:

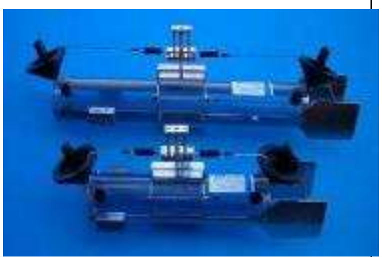
- Identifying groundwater sample location should consider location of contaminated area, existing or future potential use of groundwater and sensitive receptors in the vicinity of the site.
- Sampling points should be located at area of potential concern and/or the downgradient of the area of potential concern.
- Sampling points should be close enough to each area of potential concern to detect contaminant migration to groundwater.
- As seasonal or tidal variations may influence the migration of contaminants to the groundwater and the concentration of contaminants in the groundwater, a single groundwater sampling event may not be sufficient to determine the degree and extent of contamination.
- Sampling at several discrete depths may be required to delineate contamination vertically.

Surface Water Sampling

Surface water samples should be collected whenever potential impact to surface water is identified. The number of samples, location and depth of sampling depends on the size of the surface water body and the amount of information required to adequately characterize the degree and extent of contamination and to evaluate potential impacts to sensitive receptors.

Samples are collected by directly filling the container or decanting the water from a collection device such as stainless steel scoop. Similar to groundwater sampling, pH, conductivity, ORP, dissolved oxygen, temperature and turbidity of the collected sample should be measured on the site. The typical sampling techniques are presented in the ***Table A.2.2*** and ***Figure A.2.5.***

Table A.2.2 Surface Water Sampling Methods

Method	General Description	Representative Illustration
Dip Sampling	This technique is used for collecting samples from an outfall pipe or along a lagoon where direct access is limited. A long handle is attached to the collection device to allow access to an inaccessible location.	
Direct Method	This method is used for collecting samples from streams, lakes, rivers and other surface water. The sampler is faced toward the upstream and sample is collected without disturbing the sediments. This method is not recommended for lagoons where contact with contaminants is a concern.	
Discrete depth sampling	In this method a standard Kemmerer (top) or Van don (bottom) sampling device is used to collect sample from a specific depth.	 

Method	General Description	Representative Illustration
Peristaltic pumps	Battery powered peristaltic pumps can also be used to collect a sample from specific depth as in the case of low-flow groundwater sampling from monitoring well.	

Figure A.2.5 Examples of Surface water Sampling

Sediment Sampling

Sediment samples should be collected whenever potential impact to sediment is identified or sediment contains eroded contaminated soil. The samples collected should be sufficient to adequately characterize the degree and extent of contamination and to evaluate potential impacts to sensitive receptors.

The sediments samples are collected either as a grab sample or core sample. The grab sample is collected using samplers such as the Van Veen Grab and Ponar Grab sampler. Van Veen is the most commonly used tool for grab sampling. The core sampling method should be used when there is a need to collect samples from subsurface or when there is a need to understand the change in the lithology and chemical composition with the depth. The advantage of the core sampling method is that the recovered sample is undisturbed. The common tools used for sediment sampling are presented in the ***Table A.2.3.***

Table A.2.3 Tools Commonly Used for the Sediment Sampling

Method	General Description	Representative Illustration

Grab Sampling	Van Veen	
	Ponar	
Core sampling	Barrel corer: It is a gravity corer with a cylindrical barrel for collecting the sample. The corer free-falls and penetrates the surface by gravity. The corer penetrates the sediment by free fall, and sucks the sediment into the core barrel by an upward moving piston as the core is retrieved.	

A.6 LABORATORY ANALYSIS METHODS

Analytical Parameter	Method No. [1]
Volatile Organic Compounds (VOCs) • Monocyclic Aromatic Hydrocarbons • Oxygenated Compounds • Sulfonated Compounds • Fumigants • Halogenated Aliphatics • Halogenated Aromatics • Trihalomethanes	Headspace GC-MS - USEPA 8260.
Semi-Volatile Organic compounds (SVOCs) • Phenols • Polyaromatic Hydrocarbons • Phthalate Esters • Nitrosamines • Nitroaromatics and Ketones • Haloethers • Chlorinated Hydrocarbons • Anilines and Benzidines • Organochlorine Pesticides • Organophosphorus Pesticides	Headspace GC-MS - USEPA 8270
Total Petroleum Hydrocarbons (TPH) C6-C10; C10-C15; C15-C29; C29-C36	GC-FID - USEPA 8015B
Metals • Aluminium (mg/l) • Arsenic (mg/l) • Cadmium (mg/l) • Chromium (III and VI) (mg/l) • Copper (mg/l) • Iron (mg/l) • Lead (mg/l) • Manganese (mg/l) • Mercury (mg/l) • Nickel (mg/l) • Vanadium (mg/l) • Zinc (mg/l)	ICP-OES - US EPA Method 200.7

Analytical Parameter	Method No. [1]
pH,	EPA 150.1
Calcium,	ICP-OES USEPA 200.7
Magnesium,	ICP-OES USEPA 200.7
Sodium,	ICP-OES USEPA 200.7
Chloride,	BS 2690 part 7: 1968
Sulphate,	BS 2690 part 7: 1968
Nitrate,	BS 2690 part 7: 1968
Fluoride	Ion chromatography
Phosphates,	BS 2690 part 7: 1968
Total Dissolved Solids (TDS),	BS 15216
Total Suspended Solids (TSS)	BS 15216

Notes:

1. Standard Methods for the Examination of Water and Wastewater 20th Edition. Publisher: American Public Health Association; 20th Edition, 30 August 2011.

A.7 TEMPLATE FOR RECEPTOR SURVEY

	N°___ Date	N°___ Date	N°___ Date	N°___ Date
Area ID. Refer to base map grid, ex. A1, B2, etc.				
Location name Locality Village Industrial Site				
Detail on the area Near a road Agricultural field Forest Residential area Religious centres Schools Hospitals Other				
Latitude (Northing) Coordinate GPS For tracing a path (stream, river), polygon (pond, lake) or point (abstraction location)				
Longitude (Easting) Coordinate GPS For tracing a path (stream, river), polygon (pond, lake) or point (abstraction location)				
Surface water abstraction point Yes/No If not in use provide date of abandon & reason (perceived pollution/sickness/impact on cultivation)				
Abstraction point Visited/Inspected Yes/No Reason if not visited (information provided without visual reconnaissance/not accessible, etc.)				
How is the abstraction done Surface pump Other				
Usage of surface water Drinking purpose Sanitary purpose				

	N°___ Date	N°___ Date	N°___ Date	N°___ Date
Irrigation purpose (provide detail on type of cultivation) Bathing Washing Fishing				
Receptors Who is drinking/using the water Is there consumption of vegetables/cereals/other from irrigated fields, consumption of fishes				
Is surface water accessible for DTW measure Yes/No Provide Depth to Water (DTW) measure (mbgl) if possible				
Any benchmark that can be surveyed later while doing the ToC survey Longitude/Latitude/Landmark				
Organoleptic evidence of impact in the water, in immediate vicinity Yes, No Description (Colour, odour, turbidity, etc.), distressed vegetation Provide GPS coordinates of the impact if visually identified				
Is the area accessible for future Investigations For surface water sampling? For sediment sampling?				
Photo Photo number Time				
Interviewed person/Source Contact details Owner, other				

A.8 CONCEPTUAL SITE MODEL (CSM) AND RISK ASSESSMENT

CONCEPTUAL SITE MODEL (CSM)

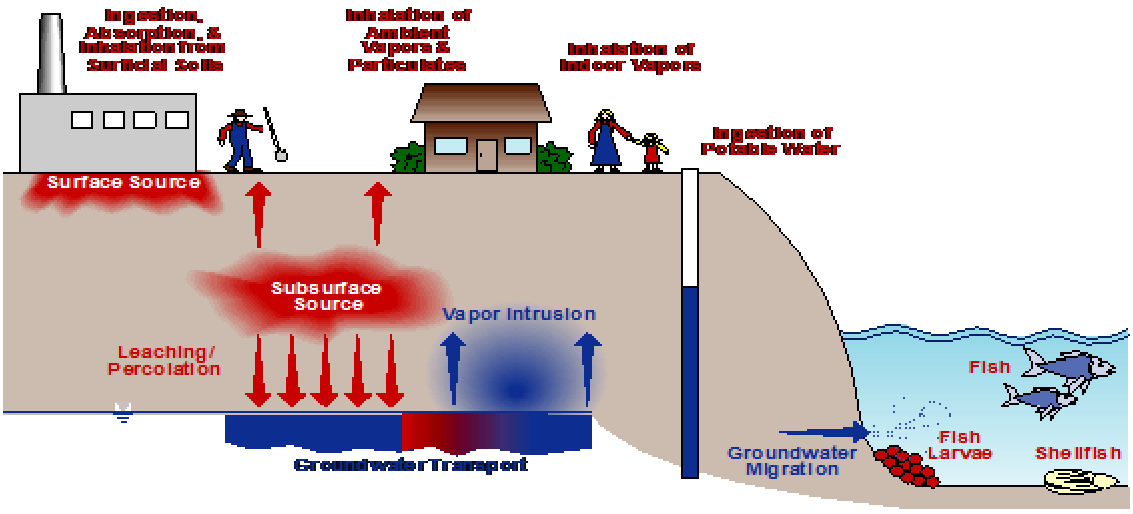


Figure A.5.1 Source–Pathway–Receptor Linkage

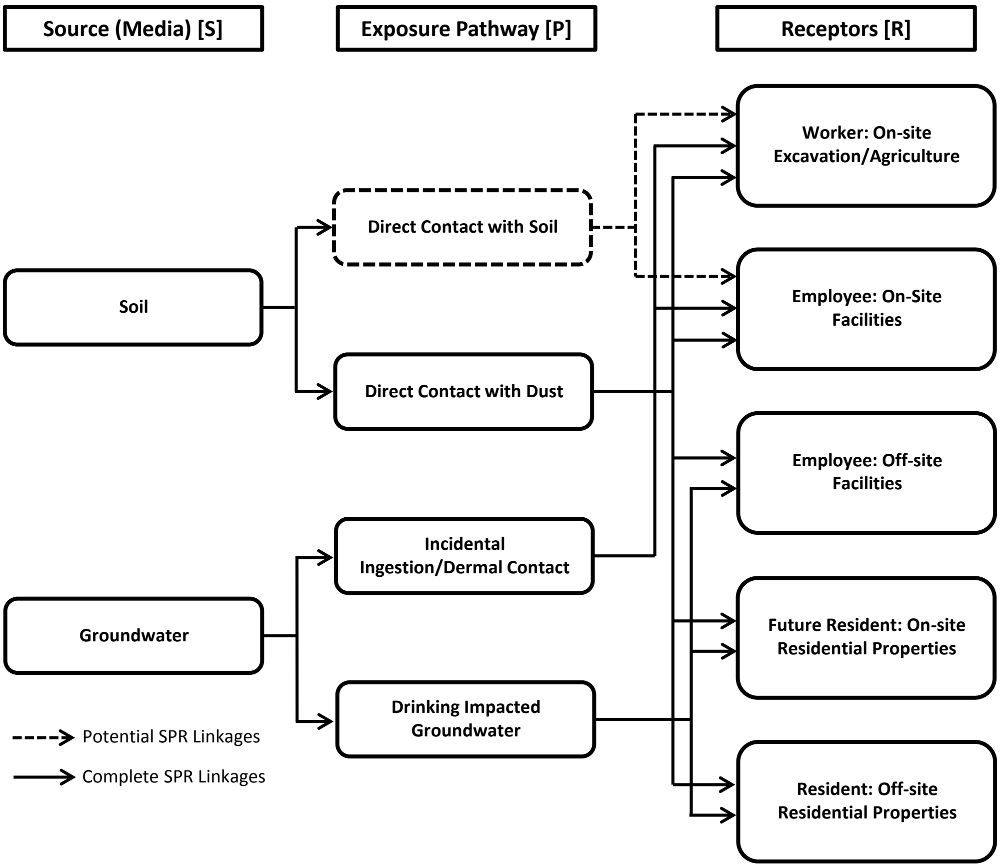


Figure A.5.2 Example of a Conceptual Site Model

METHODOLOGIES OF RISK ASSESSMENT

Exposure Point Concentrations

Exposure point concentrations are the contaminant concentrations in media to which receptors are exposed. All historical and current data collected from the site should be reviewed to choose appropriate 'input' concentrations to the HHRA model (e.g. the average, maximum, or 95th percentile concentration).

Human Dose Estimation

The human dose estimation step involves the use of assumptions regarding human physiology and behaviour to calculate the chemical dose to which each of the identified receptors could be exposed. Assumptions regarding human behaviour and physiology can be taken from a variety of sources, (e.g. ASTM 2002[1], US EPA 2008[2]), that are designed to be health conservative, referring to the likely behaviour of a hypothetical Maximally Exposed Individual (MEI).

Mathematical equations are used to calculate the dose that each of the potentially exposed receptors would receive from the exposure pathways under the assumed exposure scenarios. This dose estimate (termed a Maximum Daily Intake or MDI) is used in the calculation of risk for non-carcinogenic compounds. Carcinogens are assessed by calculation of a Chronic Daily Intake (CDI), which is the total received daily dose (calculated using the MDI and assumed exposure duration) averaged over the assumed lifetime (70 years).

Effects Assessment

In order to relate the estimated received dose to a toxicological effect, it is necessary to collate available published toxicological data. The establishment of such toxicity profiles is termed the 'effects assessment'. Published sources of toxicological data include:

a. World Health Organization (WHO) Guidelines; and

b. US EPA resources (e.g. Integrated Risk Information System on-line database).

A distinction should be made in the assessment methodology between those compounds classified as carcinogenic (genotoxic), and those that result in non-carcinogenic effects. Such non-carcinogens are considered to have a threshold mode of action, whereby exposure below the threshold dosage (termed the Tolerable Daily Intake, or TDI) is considered to result in no observable, or adverse, effect. Chemicals

[1] ASTM (2002) *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. E1739-95 (reapproved 2002).

[2] US EPA (1997) *Exposure Factors Handbook. National Center for Environmental Assessment, Office of Research and Development, Washington, DC 20460.*

considered acting by genotoxic mechanisms can potentially cause carcinogenesis at any level of exposure, with the probability of carcinogenesis increasing linearly with dosage. The multiplier relating dosage and genotoxicity is termed a 'Slope Factor' (SF).

This distinction between carcinogenic and non-carcinogenic (genotoxic and non-genotoxic) contaminants is of relevance to the Risk Estimation and Evaluation stages of the assessment. It should be noted that different effect criteria will be used for different exposure pathways, reflecting the modes of toxic action of the contaminants considered. These effects criteria are based upon the assumption that chemicals act upon the body in isolation to each other, and that the effects are not synergistic or antagonistic.

Risk Estimation

At the Risk Estimation stage, estimates of chemical dosage are combined with the effects criteria to produce numerical indices of likely health effect.

For non-carcinogens, the MDI for each exposure pathway is divided by the appropriate toxicological data (e.g. reference dose, tolerable daily intake) to produce a simple ratio, termed a Human Health Hazard Index (HHHI). The HHHIs for all exposure pathways for each contaminant are summed to produce a total HHHI.

For carcinogenic (genotoxic) chemicals, the CDI for each exposure pathway and SF is multiplied to produce pathway specific estimates of increased lifetime cancer risks. Estimates from all pathways are summed to produce a total increased lifetime cancer risk for each contaminant assessed.

Risk Evaluation

Risk estimates (hazard indices and increased lifetime cancer risks) are evaluated against acceptability criteria termed 'Maximum Acceptable Risk Levels' (MARLs). A MARL of one (1) should be used in the assessment of non-carcinogenic risks from individual contaminants. A MARL of 10^{-5} (1 in 100,000 increased lifetime risk of cancer) should be used for carcinogenic contaminants.

Risk Characterization

Risk characterization is the final step in the quantitative risk assessment process. In risk characterization, potential risks of adverse health or environmental effects for each of the exposure scenarios derived in the exposure assessment, is developed and summarized. Estimates of risks are obtained by integrating information developed during the exposure and toxicity assessments to characterize the potential or actual risk, including carcinogenic risks, non-carcinogenic risks, and environmental risks. By conducting site-specific risk assessment, the following benefits are achieved:

- Provide an evaluation of the overall quality of the assessment and the degree of confidence the risk assessors have in estimates of risk and conclusions drawn;
- Describe the risks to individuals and populations in terms of nature, extent and severity of potential adverse health effects;
- Communicate results of the risk assessment to the risk manager; and
- Provide key information for risk communication.

If, the site-specific risk assessment shows that potentially significant risks are present, a more detailed investigation and/or remediation can be specified.

A.9 DUTCH INTERVENTION VALUE

Metals - Dutch Target & Intervention Values (Soil Remediation Circular 2009-2012 Revision)								
Substance	CAS No.	Target value groundwater shallow (< 10 m –gl) (µg/l)	Target value groundwater (incl. BC) deep (> 10 m –gl) (µg/l)	**Intervention values groundwater (µg/l)**	Target value groundwater shallow (< 10 m –gl) (mg/l)	Target value groundwater (incl. BC) deep (> 10 m –gl) (mg/l)	**Intervention values groundwater (mg/l)**	**Intervention values soil (mg/kg d.s.)**
Units		***(µg/l)***	***(µg/l)***	***(µg/l)***	***(mg/l)***	***(mg/l)***	***(mg/l)***	***(mg/kg d.s.)***
1 Metals								
Antimony	7440-36-0	X	0.15	**20**	X	0.00015	**0.02**	**22**
Arsenic	7440-38-2	10	7.2	**60**	0.01	0.0072	**0.06**	**76**
Barium	7440-39-3	50	200	**625**	0.05	0.2	**0.625**	**920**
Cadmium	7440-43-9	0.4	0.06	**6**	0.0004	0.00006	**0.006**	**13**
Chromium	7440-47-3	1	2.5	**30**	0.001	0.0025	**0.03**	**X**
ChromiumIII	16065-83-1	X	X	**X**	X	X	**X**	**180**
ChromiumVI	18540-29-9	X	X	**X**	X	X	**X**	**78**
Cobalt	7440-48-4	20	0.7	**100**	0.02	0.0007	**0.1**	**190**
Copper	7440-50-8	15	1.3	**75**	0.015	0.0013	**0.075**	**190**
Mercury	7439-97-6	0.05	0.01	**0.3**	0.00005	0.00001	**0.0003**	**X**
Mercury(inorganic)	7439-97-7	X	X	**X**	X	X	**X**	**36**
Mercury(organic)	22967-92-6	X	X	**X**	X	X	**X**	**4**
Lead	7439-92-1	15	1.7	**75**	0.015	0.0017	**0.075**	**530**
Molybdenum	7439-98-7	5	3.6	**300**	0.005	0.0036	**0.3**	**190**
Nickel	7440-02-0	15	2.1	**75**	0.015	0.0021	**0.075**	**100**
Zinc	7440-66-5	65	24	**800**	0.065	0.024	**0.8**	**720**

The barium standard has been repealed because the intervention value for barium proved to be lower than the concentration naturally occurring in the soil. In the case of increased barium concentrations compared to the natural background due to an anthropogenic source, this concentration can be assessed on the basis of the former intervention value for barium of 920 mg/kg d.s. This former intervention value is substantiated in the same manner as the intervention values for most of the other metals, and for barium it includes a natural background concentration of 190 mg/kg d.s.

Non-Metals - Dutch Target & Intervention Values (Soil Remediation Circular 2009-2012 Revision)						
Substance	CAS No.	Target value groundwater (µg/l)	**Intervention values groundwater (µg/l)**	Target value groundwater (mg/l)	**Intervention values groundwater (mg/l)**	**Intervention values soil (mg/kg d.s.)**
Units		*(µg/l)*	*(µg/l)*	*(mg/l)*	*(mg/l)*	*(mg/kg d.s.)*
2. Other inorganic substances						
Chloride	16887-00-6	100000	X	100	X	X
Cyanide(free)	57-12-5	5	1500	0.005	1.5	20
Cyanide(complex)	74-90-8	10	1500	0.01	1.5	50
Thiocyanate	302-04-5	X	1500	X	1.5	20
3. Aromatic compounds						
Benzene	71-43-2	0.2	30	0.0002	0.03	1.1
Ethylbenzene	100-41-4	4	150	0.004	0.15	110
Toluene	108-88-3	7	1000	0.007	1	32
Xylenes(sum)	95-47-6, 108-38-3, 106-42-3	0.2	70	0.0002	0.07	17
Styrene(vinylbenzene)	100-42-5	6	300	0.006	0.3	86
Phenol	108-95-2	0.2	2000	0.0002	2	14
Cresols(sum)	108-39-4, 95-48-7, 106-44-5	0.2	200	0.0002	0.2	13
4. Polycyclic Aromatic Hydrocarbons (PAHs)						
Naphthalene	91-20-3	0.01	70	0.00001	0.07	X
Phenanthrene	85-01-8	0.003	5	0.000003	0.005	X
Anthracene	120-12-7	0.0007	5	0.0000007	0.005	X
Fluoranthene	206-44-0	0.003	1	0.000003	0.001	X
Chrysene	218-01-9	0.003	0.2	0.000003	0.0002	X
Benzo(a)anthracene	56-553	0.0001	0.5	0.0000001	0.0005	X
Benzo(a)pyrene	50-32-8	0.0005	0.05	0.0000005	0.00005	X
Benzo(k)fluoranthene	207-08-9	0.0004	0.05	0.0000004	0.00005	X
Indeno(1,2,3cd)pyrene	193-39-5	0.0004	0.05	0.0000004	0.00005	X
Benzo(ghi)perylene	191-24-2	0.0003	0.05	0.0000003	0.00005	X
PAHs(total)(sum10)	Sum of above list of 10 PAHs	X	X	X	X	40

Non-Metals - Dutch Target & Intervention Values (Soil Remediation Circular 2009-2012 Revision)						
Substance	CAS No.	Target value groundwater (µg/l)	**Intervention values groundwater (µg/l)**	Target value groundwater (mg/l)	**Intervention values groundwater (mg/l)**	**Intervention values soil (mg/kg d.s.)**
Units		***(µg/l)***	***(µg/l)***	***(mg/l)***	***(mg/l)***	***(mg/kg d.s.)***
5. Chlorinated hydrocarbons						
a. (volatile) hydrocarbons						
Monochloroethene(Vinylchloride)	9002-86-2	0.01	**5**	0.00001	**0.005**	**0.1**
Dichloromethane	75-09-2	0.01	**1000**	0.00001	**1**	**3.9**
1,1-dichloroethane	75-34-3	7	**900**	0.007	**0.9**	**15**
1,2-dichloroethane	107-06-2	7	**400**	0.007	**0.4**	**6.4**
1,1-dichloroethene	75-35-4	0.01	**10**	0.00001	**0.01**	**0.3**
1,2-dichloroethene(sum)	156-59-2, 156-60-5	0.01	**20**	0.00001	**0.02**	**1**
Dichloropropanes(sum)	78-99-9, 78-87-5, 142-28-9	0.8	**80**	0.0008	**0.08**	**2**
Trichloromethane(chloroform)	67-66-3	6	**400**	0.006	**0.4**	**5.6**
1,1,1-trichloroethane	71-55-6	0.01	**300**	0.00001	**0.3**	**15**
1,1,2-trichloroethane	79-00-5	0.01	**130**	0.00001	**0.13**	**10**
Trichloroethene(Tri)	79-01-6	24	**500**	0.024	**0.5**	**2.5**
Tetrachloromethane(Tetra)	56-23-5	0.01	**10**	0.00001	**0.01**	**0.7**
Tetrachloroethene(Per)	127-18-4	0.01	**40**	0.00001	**0.04**	**8.8**
b. chlorobenzenes						
Monochlorobenzene	108-90-7	7	**180**	0.007	**0.18**	**15**
Dichlorobenzenes(sum)	95-50-1, 541-73-1, 106-46-7	3	**50**	0.003	**0.05**	**19**
Trichlorobenzenes(sum)	87-61-6, 120-82-1, 108-70-3	0.01	**10**	0.00001	**0.01**	**11**
Tetrachlorobenzenes(sum)	634-90-2, 634-66-2, 95-94-3	0.01	**2.5**	0.00001	**0.0025**	**2.2**
Pentachlorobenzene	608-93-5	0.003	**1**	0.000003	**0.001**	**6.7**
Hexachlorobenzene	118-74-1	0.00009	**0.5**	0.00000009	**0.0005**	**2**
c. chlorophenols						
Monochlorophenols(sum)	95-57-8, 108-43-0, 106-48-9	0.3	**100**	0.0003	**0.1**	**5.4**
Dichlorophenols(sum)	576-24-9, 120-83-2, 583-78-8, 87-65-0, 95-77-2, 591-35-5	0.2	**30**	0.0002	**0.03**	**22**
Trichlorophenols(sum)	15950-66-0, 933-78-8, 933-75-5, 95-95-4, 06/02/88, 609-19-8	0.03	**10**	0.00003	**0.01**	**22**

Non-Metals - Dutch Target & Intervention Values (Soil Remediation Circular 2009-2012 Revision)						
Substance	CAS No.	Target value groundwater (µg/l)	**Intervention values groundwater (µg/l)**	Target value groundwater (mg/l)	**Intervention values groundwater (mg/l)**	**Intervention values soil (mg/kg d.s.)**
Units		***(µg/l)***	***(µg/l)***	***(mg/l)***	***(mg/l)***	***(mg/kg d.s.)***
Tetrachlorophenols(sum)	4901-51-3, 58-90-2, 935-95-5	0.01	**10**	0.00001	**0.01**	**21**
Pentachlorophenol	87-86-5	0.04	**3**	0.00004	**0.003**	**12**
d. polychlorobiphenyls (PCBs)						
PCBs(sum)	7012-37-5, 35693-99-3, 37680-37-2, 35065-28-2, 35065-27-1, 35065-29-3, 31308-00-6	0.01	**0.01**	0.00001	**0.00001**	**1**
e. Other chlorinated hydrocarbons						
Monochloroanilines(sum)	95-51-2, 108-42-9, 106-47-8	X	**30**	X	**0.03**	**50**
Dioxin(sum-TEQ)	01/06/1746, 40321-76-4, 57653-85-7, 19408-74-3 , 39227-28-6 , 35822-46-9 , 3268-87-9, 51207-31-9, 57117-41-6,57117-31-4,57117-44-9 , 72918-21-9, 70648-26-9,60851-34-5 ,67562-39-4 ,55673-89-7, 39001-02-0 ,32598-13-3, 70362-50-4 , 32598-14-4, 74472-37-0, 31508-00-6, 65510-44-3,57465-28-8,38380-08-4, 69782-90-7 , 52663-72-6 , 32774-16-6, 39635-31-9	X	**X**	X	**X**	**0.00018**
Chloronaphthalene(sum)	90-13-1, 91-58-7	X	**6**	X	**0.006**	**23**
6. Pesticides						
a. organochlorine pesticides						
Chlorodane(sum)	5103-71-9 , 5103-74-2	0.00002	**0.2**	0.00000002	**0.0002**	**4**
DDT(sum)	789-02-6, 50-29-3	X	**X**	X	**X**	**1.7**
DDE(sum)	3424-82-6, 72-55-9	X	**X**	X	**X**	**2.3**
DDD(sum)	53-19-0, 72-54-8	X	**X**	X	**X**	**34**
DDT/DDE/DDD(sum)	789-02-6, 50-29-3, 3424-82-6, 72-55-9, 53-19-0, 72-54-8	0.000004	**0.01**	0.000000004	**0.00001**	**X**
Aldrin	309-00-2	0.000009	**X**	0.000000009	**X**	**0.32**
Dieldrin	60-57-1	0.0001	**X**	0.0000001	**X**	**X**
Endrin	72-20-8	0.00004	**X**	0.00000004	**X**	**X**
Drins(sum)	309-00-2, 60-57-1, 72-20-8	X	**0.1**	X	**0.0001**	**4**
α-endosulphan	959-98-8	0.0002	**5**	0.0000002	**0.005**	**4**
α-HCH	319-84-6	0.033	**X**	0.000033	**X**	**17**

Non-Metals - Dutch Target & Intervention Values (Soil Remediation Circular 2009-2012 Revision)						
Substance	CAS No.	Target value groundwater (µg/l)	**Intervention values groundwater (µg/l)**	Target value groundwater (mg/l)	**Intervention values groundwater (mg/l)**	**Intervention values soil (mg/kg d.s.)**
Units		***(µg/l)***	***(µg/l)***	***(mg/l)***	***(mg/l)***	***(mg/kg d.s.)***
β-HCH	319-85-7	0.008	**X**	0.000008	**X**	**1.6**
γ-HCH(lindane)	58-89-9	0.009	**X**	0.000009	**X**	**1.2**
HCH-compounds(sum)	319-84-6 , 319-85-7, 58-89-9, 319-86-8	0.05	**1**	0.00005	**0.001**	**X**
Heptachlor	76-44-8	0.000005	**0.3**	0.000000005	**0.0003**	**4**
Heptachlorepoxide(sum)	280044-83-9, 1024-5703	0.000005	**3**	0.000000005	**0.003**	**4**
c. organotin pesticides						
Organotincompounds(sum)	688-73-3, 892-20-6	0.00005	**0.7**	0.00000005	**0.0007**	**2.5**
d. chlorophenoxy-acetic acid herbicides						
MCPA	94-74-6	0.02	**50**	0.00002	**0.05**	**4**
e. other pesticides						
Atrazine	1912-24-9	0.029	**150**	0.000029	**0.15**	**0.71**
Carbaryl	63-25-2	0.002	**50**	0.000002	**0.05**	**0.45**
Carbofuran	1563-66-2	0.009	**100**	0.000009	**0.1**	**0.017**
7. Other substances						
Asbestos	12001-29-5	X	**X**	X	**X**	**100**
Cyclohexanone	108-94-1	0.5	**15000**	0.0005	**15**	**150**
Dimethylphthalate	131-11-3	X	**X**	X	**X**	**82**
Diethylphthalate	84-66-2	X	**X**	X	**X**	**53**
Di-isobutylphthalate	84-69-5	X	**X**	X	**X**	**17**
Dibutylphthalate	84-74-2	X	**X**	X	**X**	**36**
Butylbenzylphthalate	85-68-7	X	**X**	X	**X**	**48**
Dihexylphthalate	84-75-3	X	**X**	X	**X**	**220**
Di(2-ethylhexyl)phthalate	117-81-7	X	**X**	X	**X**	**60**
Phthalates(sum)	131-11-3, 84-66-2 , 84-69-5, 84-74-2, 85-68-7, 84-75-3, 117-81-7	0.5	**5**	0.0005	**0.005**	**X**
Mineral oil	8012-95-1	50	**600**	0.05	**0.6**	**5000**
Pyridine	110-86-1	0.5	**30**	0.0005	**0.03**	**11**
Tetrahydrofuran	109-99-9	0.5	**300**	0.0005	**0.3**	**7**

Non-Metals - Dutch Target & Intervention Values (Soil Remediation Circular 2009-2012 Revision)						
Substance	CAS No.	Target value groundwater (µg/l)	**Intervention values groundwater (µg/l)**	Target value groundwater (mg/l)	**Intervention values groundwater (mg/l)**	**Intervention values soil (mg/kg d.s.)**
Units		***(µg/l)***	***(µg/l)***	***(mg/l)***	***(mg/l)***	***(mg/kg d.s.)***
Tetrahydrothiophene	110-01-0	0.5	**5000**	0.0005	**5**	**8.8**
Tribromomethane(bromoform)	75-25-2	X	**630**	X	**0.63**	**75**

All (sum) values' constituent CAS numbers are as defined in Annex N of the Soil Quality Regulation 2011

A.10 LIST OF REMEDIATION TECHNOLOGIES

For Soil, Sediment, Bedrock and Sludge		
Technologies	**Brief Description**	**Typical Contaminants treated**
In Situ Biological Treatment - Contamination is treated in-place without removal using biological processes		
Bioventing	Involves injecting air to provide oxygen to existing soil microorganisms to stimulate the natural in situ biodegradation of aerobically degradable compounds in soil.	VOCs, SVOCs, Fuels
Enhanced Bioremediation	Nutrients, oxygen, or other amendments are supplied to enhance bioremediation by indigenous or inoculated micro-organisms (e.g. fungi, bacteria, and other microbes).	VOCs, SVOCs, hVOCs, Fuels
Phytoremediation	Plants are used to remove, transfer, stabilize, and destroy contaminants in soil and sediment through enhanced rhizosphere biodegradation, phyto-extraction (phyto-accumulation), phyto-degradation, and phyto-stabilization.	VOCs, SVOCs, hVOCs, Fuels, metals
In Situ Physical/Chemical Treatment - Contamination is treated in-place without removal using Physical/chemical processes		
Chemical Oxidation	Oxidants such as peroxide, persulfate, ozone and permanganate are applied to the contaminated soil to oxidize and destroy many toxic organic chemicals present in the soil.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels
Electrokinetic Separation	A low-density DC current is applied through the soil using ceramic electrodes to mobilize sorbed metal contaminants. The current creates an acid front at the anode and a base front at the cathode. The generation of acidic condition at anode increases the solubility of metal species adsorbed to the soil and hence mobilizing it.	VOCs, SVOCs, hVOCs, hSVOCs, metals
Soil Flushing	Contaminants from the soil are extracted by passing the extraction fluid (water or other suitable aqueous solutions) through in-place soils using an injection or infiltration process.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels, metals
Soil Vapour Extraction	A vacuum is applied to the soil to induce air flow and remove volatile and some semivolatile contaminants from unsaturated (vadose) zone of the soil.	VOCs, hVOCs, Fuels
Solidification/	In this process, contaminants are trapped or immobilized within the soil which contains them.	SVOCs, hSVOCs, metals

For Soil, Sediment, Bedrock and Sludge		
Technologies	**Brief Description**	**Typical Contaminants treated**
Stabilization	Solidification/stabilization agents are added to the soil to trap or immobilize contaminants.	
In Situ Thermal Treatment - Contamination is treated in-place without removal using Physical/chemical processes		
Thermal Treatment	Electrical resistance/electromagnetic/fibre optic/radio frequency heating or hot-air/steam injection is used to increase the volatilization rate of semi-volatile organic compounds and facilitate extraction using soil vapour extraction technology.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels
Ex Situ Biological Treatment (assuming excavation) - The contaminated media is removed from its original place (excavated) for the treatment using biological processes		
Biopiles	The excavated contaminated soil is mixed with nutrients and other amendments and placed on a treatment area that includes leachate collection systems and some form of aeration.	VOCs, SVOCs, hVOCs, Fuels
Composting	Composting is a controlled biodegradation process in which organic contaminants (e.g., PAHs) are converted by microorganisms (under aerobic and anaerobic conditions) to innocuous, stabilized by-products. Moisture content, nutrients, oxygen and temperature are closely monitored and applied as necessary to maximize the degradation rate.	
Landfarming	It is a bioremediation technology in which the contaminated media is applied into lined beds and periodically turned over or tilled to aerate the waste.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels
Slurry Phase Biological Treatment	Excavated media is mixed with predetermined quantity of water to form slurry and then treated in the bioreactor. The solids are maintained in suspension in the reactor and nutrients and oxygen are added to reactor to enhance the biodegradation rate.	VOCs, SVOCs, hVOCs, Fuels
Ex Situ Physical/Chemical Treatment (assuming excavation) - The contaminated media is removed from its original place (excavated) for the treatment using physical/chemical processes		
Chemical Extraction	Chemicals are added (acid, solvents) to the excavated environmental media to extract contamination from the media. It is different from	VOCs, SVOCs, hVOCs, hSVOCs, Fuels, metals

For Soil, Sediment, Bedrock and Sludge		
Technologies	**Brief Description**	**Typical Contaminants treated**
	soil washing in that the soil washing uses water or water with wash enhancing additives.	
Chemical Reduction /Oxidation	Oxidising or reducing chemicals are added to the excavated media to completely destroy or convert hazardous contaminants to non-hazardous or less hazardous compounds through oxidation/reduction reactions.	
Soil Washing	The excavated contaminated soil is mixed (washed) with water or other suitable aqueous solutions to extract contaminants.	
Solidification/ Stabilization	In this process the excavated soil is mixed with solidification/stabilization agents to trap or immobilize contaminants within the soil.	SVOCs, hSVOCs, metals
Ex Situ Thermal Treatment (assuming excavation)		
Incineration	High temperatures, 870 to 1,200°C are used to volatilize and combust (in the presence of oxygen) organics in hazardous wastes.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels
Pyrolysis	Chemical decomposition is induced by heating the excavated soil 430°C or above under pressure in the absence of oxygen. The off-gases are treated in a secondary combustion chamber, flared, and partially condensed.	
Other Treatment		
Excavation, Retrieval, Off-Site Disposal	Contaminated media is removed and transported to permitted off-site treatment and/or disposal facilities.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels, metals

For Groundwater, Surface Water and Leachate		
Technologies	**Brief Description**	**Typical Contaminants treated**
In Situ Biological Treatment		
Enhanced Bioremediation	In this process the rate of natural biodegradation is enhanced by adding solubilized nutrients or other amendments to groundwater and by supplying oxygen through air sparging or by adding dilute hydrogen peroxide.	VOCs, SVOCs, Fuels, metals
Monitored Natural Attenuation	Natural processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials are allowed	VOCs, SVOCs, hVOCs, hSVOCs, Fuels

For Soil, Sediment, Bedrock and Sludge		
Technologies	**Brief Description**	**Typical Contaminants treated**
	to reduce contaminant concentrations to acceptable levels. As this option usually requires regular monitoring of contaminant concentrations in groundwater and/or modelling to predict contaminants distribution and migration with respect to time, it is not the same as the "No action".	
Phytoremediation	Uses plants to clean contamination in ground water and surface water.	
In Situ Physical/Chemical Treatment		
Air Sparging	Involves injecting air which acts as stripper to remove contaminants by volatilization and carry volatile contaminants to the unsaturated zone. Vapours from unsaturated zone are removed with the help of vapour extraction system.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels
Bioslurping	Bioslurping combines free product recovery and bioventing technologies to recover free product and bioremediate vadose zone soils simultaneously.	
Chemical Oxidation	Oxidising agents such as hydrogen peroxide, persulfate, ozone and permanganate are injected in the groundwater to completely destroy or convert hazardous contaminants to non-hazardous or less hazardous compounds through oxidation/reduction reactions.	
Dual Phase Extraction/ Multi-phase extraction/ vacuum-enhanced extraction	Uses a high vacuum system to remove various combinations of contaminated ground water, LNAPL, and hydrocarbon vapour from the subsurface. Extracted liquids and vapour are treated above ground.	
Thermal Treatment	Uses steam to force volatile and semivolatile contaminants from groundwater to the unsaturated zone. Vapours from unsaturated zone are removed with the help of vapour extraction system.	
Passive/Reactive Treatment Walls	A permeable reaction wall containing agents such as zero-valent metals, chelators, sorbents, microbes, is installed across the contaminant plume. The barrier wall allows the passage of	

For Soil, Sediment, Bedrock and Sludge		
Technologies	**Brief Description**	**Typical Contaminants treated**
	water while the agents prohibit the movement of contaminants.	
Ex Situ Biological Treatment		
Bioreactors	Suspended growth systems such as activated sludge, fluidized beds, or sequencing batch reactors or attached growth systems such as upflow fixed film bioreactors, rotating biological contactors (RBCs), and trickling filters are used to treat water. In suspended growth system microbes degrades organic matter to produce CO2, H2O, and new cells. The cells form a sludge, which is settled out in a clarifier, and is either recycled to the aeration basin or disposed. In the attach growth system, the microorganisms on the support matrix degrades organic matter.	VOCs, SVOCs, hVOCs, Fuels
Constructed Wetlands	The technology incorporates principal components of wetland ecosystems; including organic soils, microbial fauna, algae, and vascular plants. Microbial activity is responsible for most of the remediation.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels
Ex Situ Physical/Chemical Treatment (assuming pumping)		
Adsorption / Absorption	Adsorbent media such as activated carbon, activated alumina, sorption clays and synthetic resins are used to remove contaminants from water through adsorption processes.	VOCs, SVOCs, hVOCs, hSVOCs, metals
Advanced Oxidation Processes	Organic contaminants in the water are oxidized using strong oxidisers such as ozone and/or hydrogen peroxide and irradiation with UV light.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels
Air Stripping	This process is typically conducted in a packed tower or an aeration tank. Air is used to volatilise contaminants from water to air.	VOCs, hVOCs
Groundwater Pumping/Pump & Treat	The contaminated groundwater is pumped out and treated above ground using suitable treatment technology such as adsorption, oxidation, air stripping.	VOCs, SVOCs, hVOCs, Fuels, metals
Ion Exchange	Ion exchange is used to remove ions from water by the exchange of cations or anions between the contaminants and the exchange medium. The exchange medium is usually synthetic resins that	Metals

For Soil, Sediment, Bedrock and Sludge		
Technologies	**Brief Description**	**Typical Contaminants treated**
	contain ionic functional groups to which exchangeable ions are attached.	
Precipitation/Coagulation/Flocculation	It is primarily used for removing heavy metals from groundwater by precipitation. The precipitation process can generate very fine particles that are held in suspension by electrostatic surface charges. Coagulants and flocculation are used to increase particle size through aggregation to overcome the repulsive forces of the fine particles.	
Separation	Involves separating contaminants from water. Several separation processes such as distillation, filtration, freeze crystallization, membrane pervaporation and reverse osmosis are used.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels, metals
Sprinkler Irrigation	The process involves the pressurized distribution of water contaminated with volatile contaminants through sprinkler irrigation system to volatilise organic compounds.	VOCs, hVOCs
Containment		
Physical Barriers	Barriers, a vertically trench filled with a slurry, are used are used to contain/divert contaminated ground water from the drinking water intake and/or provide a barrier for the ground water treatment system. These are often used when the contaminant mass is too large for treatment and pose an imminent threat to a source of drinking water.	VOCs, SVOCs, hVOCs, hSVOCs, Fuels, metals

A.11 ELEMENTS OF COSTING

COST ELEMENTS	EXAMPLES
Project management costs	Fees for external CSM experts
Logistics	Travel, accommodation for internal and external personnel during CSM activities.
Analytical support	For investigation and verification purposes during CSM activities.
Subcontractors (labour and expenses)	Drilling, geo-physical investigation, survey, hydrogeological investigation, remediation implementation.
Site preparation	Provision of hardstanding, access roads, site security.
Regulatory approvals	Application for licenses and approvals to install and/or implement remediation.
Equipment	Procurement, transport, mobilisation, assembly, and start-up of remediation equipment and materials, calibration of equipment and other pre-operational checks.
Maintenance	Plant modification, repair and long-term performance.
Demobilisation	Disassembly of plant and equipment, decontamination measures.
Financing	Working capital, interest, depreciation, insurance, taxes, contingency.
Consumables	Sampling equipment, construction materials, replacement parts.
Utilities	Power, water, telecommunications.
Health and safety measures	Protective clothing and equipment, project-specific training, independent audits.
Environmental protection measures	Containment of dusts, vapours, noise, effluents and similar emissions and associated monitoring procedures (e.g., ambient air quality, discharge of effluents).
Waste disposal	Solid and liquid waste, pollution-control residues.
Regulatory and Social	Cost for rehabilitation, compensation, fines.

A.12 REMEDIATION MONITORING

Activity	Recommended Frequency
Making on-site observations of the work in progress, making sure the implementation proceeds in accordance with design plan and specifications and quality assurance and quality control plans are followed.	Daily
Maintaining a log of observations at the site, including meeting notes, results of tests, site visits, and questions, concerns or discussions about conformance with the approved design plans and specifications	Daily
Making sure the health and safety measures outlined in the HASP are followed during the implementation.	Daily
Reviewing change orders, work directives, and contract modifications that may be required by the constructor and reporting these changes to the Vedanta project manager	Monthly
Reviewing progress reports of the constructor and updating the Vedanta project manager with schedule and progress of work	Weekly
Making sure the perimeter monitoring is implemented when required and verifying that corrective actions are implemented when contaminants concentrations reach the trigger concentrations	As required
Reviewing certificates, operations and maintenance manuals, and other data required to be assembled and furnished by the constructor	As required
Conducting the pre-final/final inspection and reviewing the list of items requiring correction	As required
Verifying that all list items have been completed or corrected.	As required

A.13 ROLES AND RESPONSIBILITIES

S. No.	Who	Roles & Responsibilities	Experience Requirements
1.	Vedanta – Site Head	• Approval of the CSM activities and budget. • Responding to regulatory, social or media organizations if necessary.	
2.	Vedanta – Corporate HSE Head	• Approval of the CSM activities and budget. • Oversight of CSM Manager • Responding to regulatory, social or media organizations if necessary.	
3.	Vedanta - Manager for managing CSM	• Contract management for CSM implementation. • CSM implementation including review and documentation; • Managing QA/QC procedures during site characterization and remediation. • Collection of CSM regulatory requirement information and document. • Review and collation of the regulatory requirements. • Conducting Preliminary Assessment. • Oversight of CSM activities • Review of Report on CSM activities	• Experience in Environmental Health and Safety.
4.	Vedanta - Procurement Personnel	• Procurement of all third party services, such as, but not limited to: a. Analytical laboratory. b. CSM consultant. c. Remediation/O&M contractor for Remediation System.	
5.	Vedanta - Remediation Implementation Overseer	• Conduct PSA • Oversight of CSM activities.	• Experience in Environmental Health and Safety or Construction Management.

S. No.	Who	Roles & Responsibilities	Experience Requirements
6.	Vedanta - Human Resources officer	• Identification of training need in consultation with various department heads. • Arranging training through third party.	
7.	CSM Consultant	• Evaluate and interpret available data which includes environmental media and geotechnical data. • Identify data gaps. • Collect and evaluate data required for the design. • Provide complete engineering design for the construction/ implementation of the technology, including plans and specifications. • Suggest changes/ modifications to design based on site-specific requirements and to meet remediation goals. • Verify performance of remediation measures against remediation goals. • Oversee installation of remediation systems as per design specifications and desired standards. • Performance testing and verification of remediation systems as per design specifications. • Identify and obtain any permits required for the implementation of remediation option. • Update plan and specification changes during construction.	• Site Investigations • Risk Assessment • Social and Community Relations • Brownfield redevelopment/ remediation • Data Management and Visualization • Demonstrated qualification and expertise in performing the specific design services and have knowledge of governmental regulations. • Demonstrable experience in designing, construction, commissioning and O&M of remediation systems. • Demonstrated ability to complete project within the allotted time. • Professional and ethical integrity of the firm.

S. No.	Who	Roles & Responsibilities	Experience Requirements
8.	General civil, mechanical and electrical design consultant and construction contractor	• Provide/supply equipment as per design and desired standards • Install remediation systems as required by design, and desired standards • Suggest changes/modifications to design based on site-specific requirements • Start-up and commission remediation systems to verify performance per remediation goals and specifications	• Design and installation of similar equipment/structures • Should comply with all H&S regulations of the site
9.	Operation and Maintenance (O&M) Contractor	• The service provider should operate and maintain the mechanical and electrical equipment, monitor operating parameters and make adjustment to operating parameters, etc. per specified quantity and quality. • Responsibility includes adjusting the treatment system for optimization	• Operation of such systems • Should comply with all H&S regulations of the site
10.	Drilling Contractor	• The service provider should install sub-surface installations including monitoring wells, abstraction wells, etc. • It is also required that they provide other sub-surface services like collection of soil samples, installation of passive vapour samplers, etc.	• Installation of sub-surface installations • Should comply with all H&S regulations of the Site
11.	Analytical laboratory	• Physico-chemical characterization • Post-treatment physico-chemical characterization • Environmental monitoring	• Internationally/ nationally accredited laboratory service • Well-developed/ documented QA/QC protocols

S. No.	Who	Roles & Responsibilities	Experience Requirements
			• Follow internationally acceptable standards of testing
12.	Sampling equipment manufacturer	• Equipment for environmental sampling • Field screening equipment/tools	• Vendor shall be the manufacturer or authorized dealer. Vendor shall provide equipment, training and after sales service.
13.	Container / fabricator	• Customized container fabrication for hazardous waste • Customized container fabrication for installation and operation of remediation systems	• Vendor shall be the manufacturer or authorized dealer. Vendor shall provide equipment, training and after sales service.
14.	Safety equipment manufacturer	• Procurement of general and specialized Personal Protective Equipment (PPE) and safety signage • Procurement of safety devices and gadgets	• Vendor shall be the manufacturer or authorized dealer. Vendor shall provide equipment, training and after sales service.
15.	Hazardous Waste Disposal Facilities	• Identified contractor should handle and transport waste identified as hazardous produced during remediation activities as per applicable laws and regulations	• Should meet regulatory requirement to handle such waste • Should comply with all H&S regulations of the Site

A.14 TYPICAL CONTENT OF PHASE I ESA REPORT

Executive Summary & Conclusions

1. Introduction and Background

1.1 Purpose and Auditors

1.2 Scope of Work

1.3 Limiting and Special Conditions

1.3.1 Limiting Conditions during the Site Visit

1.3.2 Data Gaps

1.3.3 Significant Assumptions

1.3.4 Exceptions and Deletions to the ASTM E1527-13 Standard

2. Physical Site Setting

2.1 Location

2.2 Topography and Hydrology

2.3 Geology and Hydrogeology

3. Site Description, Operations & History

3.1 General Site Descriptions

3.1.1 Real Estate Ownership Information

3.1.2 Corporate Ownership

3.1.3 Subject Property Layout

3.2 Current Site Operations

3.3 Historical Site Operations

3.3.1 Historical Summary

3.3.2 Evaluation of Historical Information Sources.

3.3.3 Discussion of Historical Environmental Issues/ Assessments/ Investigations

4. Environmental Operations & Regulatory Issues

4.1 Environmental, Health and Safety Management Systems

4.2 Hazardous Material Use and Storage

4.2.1 Underground Storage Tanks (USTs)

4.2.2 Aboveground Tanks (ASTs)

4.2.3 Chemical Reporting

4.2.4 Spill Prevention Control and Countermeasures (SPCC) Plan

4.3 Waste Management

4.3.1 Hazardous Waste

4.3.2 Non-Hazardous Waste

4.3.3 Other Regulated Waste

4.3.4 Off-Site Disposal Liabilities

4.4 Water Supply, Wastewater and Storm Water

4.4.1 Water Supply

4.4.2 Wastewater

4.4.3 Storm Water

4.5 Air Emissions

4.5.1 Risk Management Program

4.6 Ozone Depleting Substances (ODSs)

4.7 Polychlorinated Biphenyls (PCBs)

4.8 Asbestos-Containing Materials

4.9 Health & Safety Review

4.9.1 Reportable Accidents and Incidents

4.9.2 Health and Safety Citations

4.9.3 Outstanding Health and Safety Claims

4.10 Optional Additional Sections Header

5. Site Vicinity Operations & History

5.1 Summary

5.2 Current Surrounding Properties

5.3 Site Vicinity Historical Summary

5.4 Adjacent Property Agency Review

6. References

7. Limitations and Other Considerations

A.15 TYPICAL CONTENT FOR SITE CHARACTERIZATION REPORT

Executive Summary

1 Introduction

1.1 Background

1.2 Objectives

1.3 Scope of Works

1.4 Limitations

1.4.1 Use of The Report

1.5 Report Structure

2 Site Setting

2.1 Site Location

2.2 Adjacent Land Use

2.3 Geology, Hydrogeology, Hydrology

2.4 Potential Sensitive Receptors

3 Site Investigation Program

3.1 Approach & Methodology

3.1.1 Health & Safety and Contractor Management

3.1.2 Site Screening and Identification of Drilling Locations

3.1.3 Underground Service Clearance

3.1.4 Decontamination Procedures

3.1.5 Soil Investigation

3.1.6 Groundwater Investigation

3.1.7 Surface Water and Sediments Investigation

3.1.8 Sample Handling and Management

3.1.9 QA/QC Procedures for Field Sampling

3.2 Laboratory Analytical Plan

3.3 Top of Casing (Toc) Survey For Monitoring Wells

4 Field Observations

4.1 Site Geology and Hydrogeology

4.1.1 Site Geology

4.1.2 Site Hydrogeology

4.1.3 Indicative Groundwater Contour Map

4.2 Water Quality Parameters

4.3 Organoleptic Findings

5 Laboratory Analytical Results

5.1 Criteria for Assessment

5.2 Soil Analytical Results

5.3 Groundwater Analytical Results

5.4 Surface Water and Sediments Analytical Results

6 Quality of Analytical Data

7 Summary of Findings and Discussions

8 Conclusion and Recommendations

A.16 TYPICAL CONTENT OF REMEDIATION DESIGN REPORT

1.0 Introduction

1.1 Site Description

1.2 Project History

2.0 Remediation Design Criteria

2.1 Description of Remedy

2.1.1 Groundwater Extraction

2.1.2 Groundwater and Surface Water Monitoring

2.2 Remediation Action Objectives and Performance Standards

2.2.1 Objective of Groundwater Remedy

2.2.2 Groundwater Monitoring

2.2.3 Surface Water Monitoring

3.0 Background

3.1 Summary of Previous Work

3.1.1 Investigations

3.2 Operation at the site

3.2.1 Wastes and By-Products

3.2.2 Waste Management

3.2.3 Water Balance

3.3 Conceptual Site Model for Groundwater

3.3.1 Hydrogeologic Setting

3.3.3 Surface Water – Groundwater Interaction

3.3.4 Nature and Extent of Site-Derived Constituents in Groundwater

3.3.5 Fate and Transport of Site-Derived Constituents

4.0 Remediation Design

4.1 Groundwater Extraction System

4.1.1 Evaluation of the Test Groundwater Extraction System

4.1.2 Proposed Groundwater Extraction Wells

4.1.3 Extraction System Design Details

4.2 Groundwater Monitoring System

4.2.1 Evaluation of Current Groundwater Monitoring System

4.2.2 Additional Monitoring Wells

A.17 TYPICAL CONTENT OF REMEDIATION ACTION PLAN

Executive Summary

1 Introduction

1.1 Background

1.2 Objectives and Scope of Work

1.3 Subject Site Beneficial Use and Risk Assessment

1.4 Stakeholder Engagement

1.5 Remediation Goals and Objectives

1.6 Limitations of the Study

1.7 Layout of the Report

2 Summary of Environmental Investigation and Socio-Economic Baseline Assessment

2.1 Background and Approach to the Study

3 Remediation Alternatives Analysis

3.1 Evaluation

3.2 Sustainability Concepts

3.3 Remediation Alternatives Analysis Methodology

3.4 Remediation Alternatives Analysis Results

4 Remediation goal and Treatability studies

4.1 Laboratory Scale Treatability Study

4.2 Field Scale Pilot Study

4.3 Selection of Chemical Dose and Mixing Method

4.4 Geotechnical Testing for Site Restoration

5 Revision of Risk Assessment Criteria for Remediation and Final Selection of Sites for Remediation

6 Post-Remediation Long Term Monitoring Plan

6.1 Monitoring Well Drilling and Sampling

A.18 TYPICAL CONTENT OF REMEDIATION COMPLETION REPORT

Report section	Content	Comment
Background information	Reasons and objectives for the remediation Site details.	Any departure from original objectives must be documented Name, location, plan, brief history and reference to previous investigations, risk assessments and remediation actions
	Project personnel and their roles	Names, roles and contact details
Remediation	Methodology and Programme	Objectives and criteria, conceptual model, remediation methods, phasing and zoning, volume and location of materials
	Verification	Lines of evidence and their integration. Monitoring and sampling methods. Communications plan.
	Emissions control and Monitoring	Monitoring methods and links, where appropriate, to lines of evidence.
	Chemical and physical testing regime	Chemical and physical testing methods, QA/QC.
	On-going monitoring and maintenance	Results of monitoring and record of maintenance after remediation has been implemented.
Final site condition	Status at completion	Description of site conditions.
	Final extent of remediation	Documented assessment of data and record of decision. Revised conceptual model.
	Identification of post treatment Management needs	Monitoring and maintenance requirements. Access agreements and constraints on land use.
Third party contacts	Site visits by regulators	Contact details Record of inspections and meetings. Documented agreements.
	Statutory requirements	Permit compliance (planning, waste management etc.)
	Third party agreements	Documented agreements (access rights, permit compliance)
Supporting information	Plans, as-built drawings and photographs , plans, engineering drawings	
	Test results	Field and laboratory test results

Report section	Content	Comment
	Other documentation	Progress reports, Stakeholder engagement/Liaison / communications log, meeting minutes.
	Other documentation	Other documentation

A.19 RELATED VEDANTA TECHNICAL STANDARDS

Document Number	Document Title
TS 02	Employee consultation and participation
TS 03	Land and resettlement management
TS 04	Grievance Mechanisms
TS 05/POL 04	Stakeholder Engagement
TS 06/ POL 05	Suppler and Contractor Management
TS 09	Resource use and Waste Management
TS 10	Safety Management
TS 11	Environmental Management
TS 12	Occupational Health and Management
TS 13	Emergency and Crisis Management
TS 14/ POL 07	Water Management
TS 17	Site Closure
POL 6	HSE Policy
MS 02	Stakeholder Materiality and Risk Management
MS 03	New Projects, Planning Processes and Site Closure
MS 05	Objectives, Targets and Performance Improvement
MS 06	Competency Training and Awareness
MS 07	Management of Change
MS 08	Acquisitions, Divestment and Joint Venture Due Diligence
MS 10	Data Management, Performance Monitoring and Reporting

MS 11	Incident Reporting and Investigation

A.20 REFERENCES

Reference	Full Title, Brief Description and Web-links
American Society for Testing and Materials (ASTM)	ASTM E1527-13 Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process ASTM E1903 -11 Standard Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process AM-465 2014, Basic Elements of Phase I and II Environmental Site Assessments
International Organization for Standardization (ISO)	ISO 14015:2001 Environmental management – Environmental assessment of sites and organizations (EASO)
Central Pollution Control Board, India	Guidelines on Implementing Liabilities for Environmental Damages due to Handling & Disposal of Hazardous Waste and Penalty - Hazardous Waste Management Series HAZWAMS/40/2015-16 http://cpcb.nic.in/Guidelines_Environmenal_Damages_Costs_200116.pdf Protocol for Performance Evaluation and Monitoring of the Common Hazardous Waste Treatment Storage and Disposal Facilities including Common Hazardous Waste Incinerators http://cpcb.nic.in/upload/NewItems/NewItem_149_Protocol.pdf "Guidelines for Storage of Incinerable Hazardous Wastes by the Operators of Common Hazardous Waste Treatment, Storage and Disposal Facilities and Captive HW Incinerators" http://www.cpcb.nic.in/divisionsofheadoffice/hwmd/Guideline%20for%20storage%20of%20incinerable%20HW.pdf "Inventory and Mapping Of Probably Contaminated Sites in India", Ministry Of Environment and Forests, December 2015 http://envfor.nic.in/sites/default/files/ilovepdf_merged.pdf

Reference	Full Title, Brief Description and Web-links
	Development of National Programme for Rehabilitation of Polluted Sites, "Final Report on Task - 1 Review of Current Systems and Task – 2 Overview of International Practices" January 2013 http://www.moef.nic.in/sites/default/files/cbipmp/pdf/pwc/Draft-Task-1-Task-2.pdf Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India, "Options and standards for remediation of polluted sites Key output Report Task 3" January 2013 http://www.moef.nic.in/sites/default/files/cbipmp/pdf/Grontmij/Draft-Task-3.pdf
IFC - General EHS Guidelines	1.8 Contaminated Land https://www.ifc.org/wps/wcm/connect/4f4ca40048865833b49ef66a6515bb18/1-8%2BContaminated%2BLand.pdf?MOD=AJPERES
National Environment Protection (Assessment of Site Contamination) Measure - Australia	Volumes 1 – Volume 22 http://www.nepc.gov.au/nepms/assessment-site-contamination Summary of submissions http://www.nepc.gov.au/system/files/resources/3977fd72-6e23-41ba-83c9-b1d0f3b982ec/files/nepm-submissions-summary.pdf Guideline on Investigation Levels For Soil and Groundwater http://www.nepc.gov.au/system/files/resources/93ae0e77-e697-e494-656f-afaaf9fb4277/files/schedule-b1-guideline-investigation-levels-soil-and-groundwater-sep10.pdf
Office of Environment and Heritage of the Government of New	New South Wales (NSW) "Contaminated Land Management Act" of 1997 http://www.legislation.nsw.gov.au/inforcepdf/1997-140.pdf?id=3236c604-b7b9-67bc-a1b5-b89ad975f668 Guidelines for Consultants Reporting on Contaminated Sites

Reference	Full Title, Brief Description and Web-links
South Wales, Australia	http://www.epa.nsw.gov.au/resources/clm/20110650consultantsglines.pdf
Department for Environment, Food & Rural Affairs –UK (DEFRA)	Model Procedures for the Management of Land Contamination http://webarchive.nationalarchives.gov.uk/20140328084622/http://cdn.environment-agency.gov.uk/scho0804bibr-e-e.pdf Soil Guidance Value reports for specific chemicals. http://www.claire.co.uk/information-centre/water-and-land-library-wall/44-risk-assessment/178-soil-guideline-values?showall=&start=1
Dutch standards	Dutch Guidelines for Contamination Assessment of Soil http://www.esdat.com.au/Environmental%20Standards/Dutch/ENGELSE%20versie%20circulaire%20Bodemsanering%202009.pdf
US EPA	Regional Screening Levels (RSLs) - Generic Tables (May 2016) https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-may-2016 Guidance for Quality Assurance Project Plans. https://www.epa.gov/sites/production/files/2015-06/documents/g5-final.pdf USEPA's Brownfields Program http://www.epa.gov/brownfields/ Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA https://www.epa.gov/superfund/superfund-remedial-investigationfeasibility-study-site-characterization Risk assessment Portal www.epa.gov/risk_assessment/risk-characterization.htm Remedial Options Appraisals - Federal Remediation Technologies Roundtable www.frtr.gov/

Reference	Full Title, Brief Description and Web-links
	Brownfields Road Map to Understanding Options for Site Investigation and Clean-up, Fifth Edition www.brownfieldstsc.org/roadmap/pdf/RoadMapIllustration.pdf Using the Triad Approach to Streamline Brownfields Site Assessment and Clean-up www.epa.gov/tio/download/misc/triadprimer.pdf Green Remediation https://www.epa.gov/superfund/superfund-green-remediation Green Remediation Best Management Practices https://www.epa.gov/sites/production/files/2015-04/documents/gr_fact_sheet_si_12-31-2009.pdf https://clu-in.org/greenremediation/docs/GR_BMP_factsheet_overview.pdf
International Council on Mining and Metals (ICMM)	Good Practice Guidance for Mining and Biodiversity http://www.icmm.com/website/publications/pdfs/13.pdf Responsible Mining: Case Studies in Managing Social & Environmental Risks in Developed World.
International Association of Oil & Gas Producers (IOGP)	Managing Naturally Occurring Radioactive Material (NORM) in the oil and gas Industry http://www.ogp.org.uk/pubs/412.pdf
Organisation for Economic Co-operation and Development (OECD)	Environmental Performance reviews http://www.oecd.org/environment/country-reviews/

GUIDANCE NOTE – CONTAMINATED SITE