Tauw

Guidelines for the Sustainable Management of Contaminated Sites in the former Yugoslav Republic of Macedonia

Part 1: Assessing Contaminated Sites

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Responsibility

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Contents

List of Abbreviations

Countries and Government institutions / structures

FAO	Food and Agriculture Organization of the United Nations
UNIDO	United Nations Industrial Development Organization
USEPA	United States Environmental Protection Agency
MEPP	Ministry of Environment and Physical Planning of the Republic of Macedonia

Other abbreviations

AST	Aboveground Storage Tank
CoC	Chemicals of Concern
CSM	Conceptual Site Model
CSS	Composite Soil Sample
EMP	Environmental Management Plan
EMTK	Environmental Management Toolkit
EOX	Extractable Organic Halogen
GPS	Global Positioning System
HCH	Hexachlorocyclohexane
H&S	Health and Safety
ID	Identification
ICSM	Initial Conceptual Site Model
LNAPL	Light Non-Aqueous Phase Liquid
m bgl	meters below ground level
mg / kg d.m.	Milligram per kilogram dry matter
n.a.	Non applicable
OHIS	Organic Chemical Industry of Skopje, OHIS AD
PPE	Personal Protective Equipment
POPs	Persistent Organic Pollutants
RA	Risk Assessment
RBCA	Risk-Based Corrective Action Toolkit

RPE	Respiratory Protective Equipment
SOPs	Standard Operating Procedures
UST	Underground Storage Tank
µg / l	Microgram per litre

Definitions[1]

Benzene hexachloride	Hexachlorocyclohexane, often incorrectly used for Lindane (γ-HCH)
Conceptual Site Model	A representation of the characteristics in graphical or pictorial forms that is used to present identified potential nature and sources of contamination, their likely spatial distribution in soil (or other environmental media), routes of exposure (pathways), and the potential effects of the contaminants on the site and on adjacent sites and other receptors
Contaminant	Any hazardous substance that does not occur naturally, or occurs at greater levels than natural background and has the potential to cause significant harm to relevant receptors
Contamination / pollution	Direct or indirect introduction of materials, substances, or heat into the air, water or land, which may be harmful to human health or to the quality of aquatic or terrestrial ecosystems, which may result in damage to material property, or which impair the status of natural resources
Decision making process	A sum of activities of the council, including defining and determining issues that should be resolved, proposals and solutions, reviewing and adoption of regulations and measures
Desktop study	Interpretation of historical and current information in order to establish knowledge on presence of potentially polluting activities and to understand the environmental setting of the site in terms of pathways and receptors
DNAPL	Dense Non-Aqueous Phase Liquid - Chemicals that are more dense than water, insoluble or only slightly soluble in water that exists as a separate liquid phase in environmental media
Environmentally harmful substance	A biological or physical agent, or phenomenon/ state, the presence of which in the environment may induce direct or postponed threat to or pollution of one or more environmental media or areas, as well as other irritant, inflammable and explosive matters which exhibit such properties when of certain quantity, concentration or intensity
Environmental media	Water, air and soil
Environmental monitoring	Systematized measuring, monitoring and documenting of the conditions, quality and changes in the environmental media of a site

[1] The definitions for certain terms used in this Guidelines are in accordance with the legal regulations of the Republic of Macedonia, ie: Article 5 of the Law on Environment, Article 4 of the Law on Chemicals and Article 3 of the Law on Safety and Health at Work. The references are given in section 4

Hazardous substance / waste	Any substance, or a preparation containing one or more hazardous substances, the properties of which pollute and damage the environment and are hazardous to human life and health, with proven acute, chronical, toxic and other harmful effects
Hexachlorobenzene	Hexachlorocyclohexane, often incorrectly used for Lindane (γ-HCH)
Lindane	Gamma-hexachlorocyclohexane (γ-HCH)
LNAPL	Light Non-Aqueous Phase Liquid - Chemicals that are less dense than water, insoluble or only slightly soluble in water that exists as a separate liquid phase in environmental media
Long-term	Longer than three years after decision is taken to remediate
Mid-term	Within max two/ three year after decision is taken to remediate
Monitoring Plan	Plan that describes the monitoring of the implementation of short- and mid-term remediation measurers
Monitoring and Aftercare Plan	Plan that describes the monitoring and aftercare of the implementation of the long-term remediation measures
Natural background	The concentration of hazardous substance consistently present in the environment that has not been influenced by localized human activities
Pathway	A route by which a receptor is or might be affected by contaminant
Permit for project implementation	The decision of the competent authority granting a consent to the investor/ applicant for approval of proceeding with the project implementation
Personal Protective Equipment (PPE)	Any equipment that the worker wears, holds and uses at work, in order to be protected simultaneously from one or more dangers that could endanger his or her safety and health at work
Preliminary Site Assessment	A non-intrusive investigative research conducted to obtain as much detailed site history and contamination information as possible without having to collect, sample or analyse environmental media
Preventive measures	All measures that are taken or planned at all levels of work, for preventing or reducing the risks to occupational safety and health
Polluter	Any legal or natural person the activity of which causes, directly or indirectly, pollution of the environment
Pollution / contamination	Direct or indirect introduction of materials, substances, or heat into the air, water or land, which may be harmful to human health or to the quality of aquatic or terrestrial ecosystems, which may result in damage to material property, or which impair the status of natural resources

Receptor	Organisms or resources that could be adversely affected by a contaminant, for example humans, animals, ecosystems, properties, or controlled waters
Register of Polluting Matters	A catalogue classifying waste, hazardous and harmful matters and substances, by their chemical composition and by the extent of their hazard
Remediation	Any action undertaken for eliminating, reducing, controlling or mitigating the risks resulting from contamination
Remediation Assessment	Remediation Assessment comprises the conceptual design of at least three feasible remedial options, the selection of the best remedial option and the preliminary design of the best remedial option.
Remediation Closure	The completion of remediation, after the predetermined remediation objectives have been met
Risk	The probability that a hazardous substance, when released into the environment, will cause an adverse effect in exposed humans or other living organisms. In Macedonian Law on Environment, risk is defined as the likelihood of occurrence of a specific effect on the environment within a specified period or under specified circumstances
Risk Assessment	An analysis of the potential for adverse effects on receptors caused by chemical(s) of concern from a site
Site Assessment	An intrusive investigation and assessment of a site in order to identify and determine the presence, nature and extent of potential subsurface contamination
Site Component	The most common site components of a contaminated site are storage areas for hazardous substances; contaminated building(s) and infrastructure(s); buried hazardous waste; and contaminated soil and groundwater. Components are always site specific and therefore, identifying other site components are possible as well
Short-term	Within a year after decision is taken to remediate
Storage	Presence of a certain quantity of hazardous substances for the purpose of warehousing, depositing in safe custody or keeping in stock
Substance	A chemical element or its compounds in the natural state or obtained by means of a production process, including the additives necessary to preserve their stability and impurities deriving from the manufacturing process, with the exception of solvents which can be separated without affecting the stability of the substance or the change in its composition

1 Introduction

Disclaimer

These Technical Guidelines are a part of the Guidelines for the Sustainable Management of Contaminated Sites and are made to assist the Ministry of Environment and Physical Planning of the Republic of Macedonia (MoEPP) and UNIDO in implementing the removal of technical and economic barriers for initiating the clean-up activities for Alpha-HCH, Beta-HCH and Lindane contaminated sites at OHIS in Skopje, Macedonia.

These Technical Guidelines are based on the experiences of the authors. In no event shall the authors, the Ministry of Environment and Physical Planning of the Republic of Macedonia (MoEPP) or UNIDO be liable for any direct, indirect, special, incidental or consequential damage arising out of, or related to, the use of these Guidelines.

It is expected that the reader(s), or person(s) using these Guidelines, have professional knowledge of the field of environmental investigation, and master the basics of chemistry and soil science. Hence, the Guidelines will not go into detail on explaining such knowledge.

1.1 General

UNIDO, in association with the Former Yugoslav Republic of Macedonia, is currently (2017) implementing a project in the scope of the National Implementation Plan (NIP) of the Stockholm Convention on Persistent Organic Pollutants (POPs) entitled '*Removal of Technical and Economic Barriers for initiating the Clean-up Activities for Alpha-HCH, Beta-HCH and Lindane Contaminated Sites at OHIS'*. Due to the addition of Lindane (γ-HCH) and its isomers to the Stockholm Convention as POPs in 2009, the OHIS site in Skopje is now recognized as POPs contaminated site. One of the key priority challenges (no. 8) of the National Implementation Plan (NIP) of Macedonia is to clean up and remediate this site.

This set of Guidelines for the Sustainable Management of Contaminated Sites covers all internationally recognized five phases of sustainable management of contaminated sites. The Guidelines have been divided in the following documents:

- Part 1: Assessing Contaminated Sites;
  - Phase 1: Preliminary Site Assessment
  - Phase 2: Site Assessment
- Part 2: Remediation of Contaminated Sites;
  - Phase 3: Remediation Assessment
  - Phase 4: Remediation Management
  - Phase 5: Monitoring and Aftercare

- Part 3: Standard Operating Procedures (SOPs)

1.2 Objectives of the Guidelines

These Guidelines provide an easy-reference manual for the standardized phases of sustainable management of contaminated sites. These Guidelines are intended to assist Governmental Authorities and the Private Sector that are responsible for the enforcement, remediation, implementation and maintenance of the sustainable management of contaminated sites during the full process from preliminary assessment until final reporting on maintenance and aftercare of contaminated sites. Easy to use templates to report each Phase, are provided at the end of the individual sections.

Risk based approach is the leading principle in these Guidelines. This means that all decisions on contaminated land management should be based on protection of human health, the ecosystem and preventing contaminants to migrate. Moreover, the Site Assessment should focus on collecting relevant information required to determine the likely health impacts, the likely impact on the ecosystem and the likely migration of contaminants associated with the site. Since the resources available for contaminated site management are limited, the resources should be allocated based on the risks to human health, the ecosystem and migration.

1.3 Organization of the Guidelines

The sustainable management of contaminated sites is a stepwise process, with five phases the approach and the steps described in these Guidelines are based on international best practice.

Technical and methodological instructions for the following Sections in this Part 1 of the Guidelines are described in detail:

- Phase 1: Preliminary Site Assessment (Section 2) is a systematic approach for identifying any potential presence of (human health and ecosystem) environmental impacts. It typically involves a desktop study, interview(s) and a site visit
- Phase 2: Site Assessment (Section 3) is a soil and groundwater investigation process that aims to determine if the environmental media are impacted. A Site Assessment is generally carried out if the findings of the Preliminary Site Assessment suggest that the site is potentially contaminated by on-site or off-site activities

Please refer to the Part 3 – Standard Operating Procedures (SOPs) of these Guidelines for supplementary information on the procedures. It is strongly advised to follow the technical procedures presented in these Guidelines as much as possible, in order to meet the required quality and to obtain reliable results in contaminated site management.

For more information on the Macedonian national legislation and policies, please refer to Annex 1 of Report summarizing the results of the reviews and outlining the literature and legal acts and practices for the development of the national regulatory acts (Stefanoni and Pejcinovska-Andonova, 2015).
Reference is also made to the Tauw project report *Task 2 - Reporting Inventory of International Standard* with the reference R002-1251431BFF-los-V03-N, date 18 October 2017, providing all relevant documents consulted in the scope of the writing of these Guidelines. Section 4 of this part of the Guidelines provides all reference documents.

2 Phase 1: Premilinary Site Assessment

2.1 Objectives and Tasks

The aim of the Preliminary Site Assessment (Phase 1) is to gather sufficient information in order to estimate the likelihood of contamination present at the site. All data and site information gathered during this phase will be used as input for the following phases of the contaminated site management.

The objectives of the Preliminary Site Assessment are to gain a comprehensive overview of the site contamination in relation to hazardous substances, by identifying possible source areas, (source – receptor) receptor pathways and receptors of a contamination at a site. The factual contamination and exposure levels are not determined during this phase, but are investigated later by field investigations in Phase 2 (Site Assessment). If the results of the Preliminary Site Assessment suggest risks regarding human health, ecosystem and/ or contaminant migration, the results are used for planning and implementing the Phase 2, Site Assessment (described in Section 3).

The procedure of the Preliminary Site Assessment includes the following tasks:
1. Collecting information through Desktop Study (Section 2.2)
2. Executing a Site Visit (Section 2.3) and a Site Reconnaissance Survey (2.3.5)
3. Drafting an Initial Conceptual Site Model (Section 2.4)
4. Conducting a Preliminary (Tier 1) Risk Assessment (Section 2.5)
5. Collating all data and Reporting in the preferred format (Section 2.6)

During the Desktop Study and the Site Visit(s), data on the following topics will be collected:
- General site information
- Current site layout with potentially contaminated site components such as storage areas for hazardous substances; contaminated building(s) and infrastructure(s); buried hazardous waste; and contaminated soil and groundwater
- Site soil composition, local geology and geohydrology
- Past site use and past use of the site surroundings, identifying past soil threatening activities
- Current site use and current use of the site surroundings, identifying current soil threatening activities
- Future intended site use and future intended use of the site surroundings, assessing the sensitivity of the future site and site surroundings
- Legal and financial aspects, recovering the site ownership and the site responsibilities

This information serves as input for the Initial Conceptual Site Model (ICSM) that will be part of the Preliminary Site Assessment Report. The process for effectively carrying out the Phase 1 Preliminary Site Assessment is visualized in Figure 2.1.

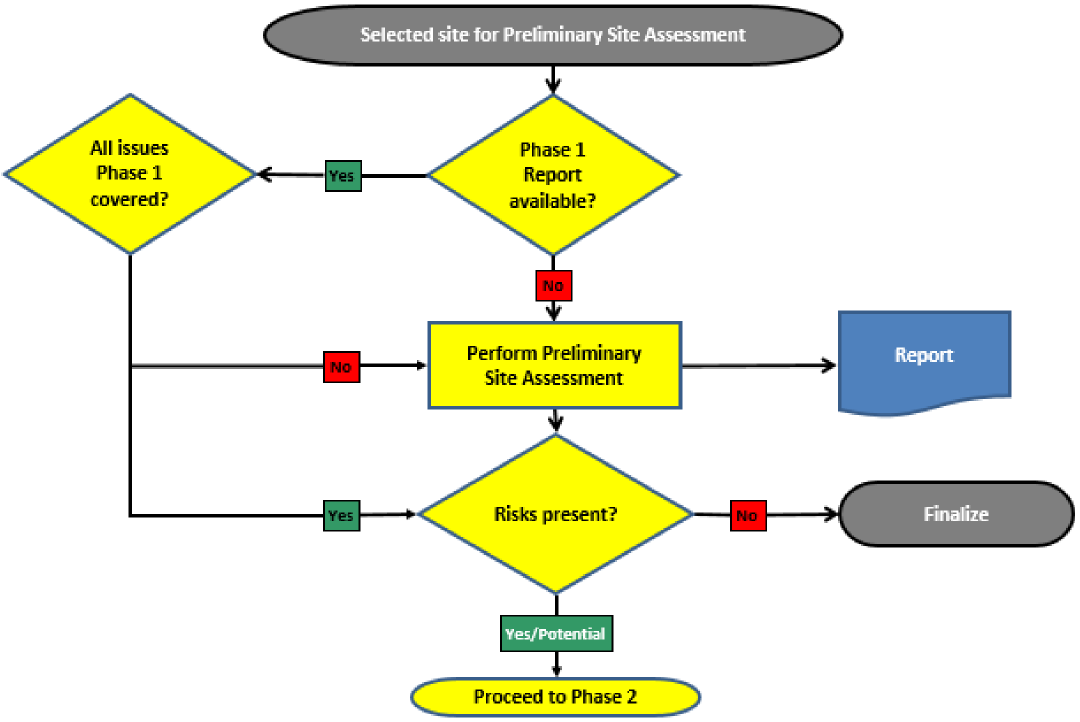

Figure 2.1 Process for the Phase 1 Preliminary Site Assessment for the sustainable management of contaminated sites (source: Tauw, 2015 a)

The following equipment and materials are advised to be used for a successful Preliminary Site Assessment:

- Satellite images available on the Internet
- Site and site surrounding information available on the internet
- Digital camera
- Suitable Personal Protective Equipment (PPE)
- Clipboard drawing and writing materials
- Site Visit Checklist (see SOP 3.2.2)

2.2 Desktop Study

The Preliminary Site Assessment always starts with the search and collection of information by means of a Desktop Study, in order to reveal the past and current site use and layout, and to identify potential sources of soil and groundwater contamination. In order to be able to carry out an effective Site Visit, the Desktop Study should reveal as much significant site information as possible. The results of the Desktop study will be verified during the Site Visit. Before starting with the Preliminary Site Assessment, please refer to SOP 4.7.2 "Site Status Classification" in order to define the current status of the site.

2.2.1 Information sources

In general, the data needed for this Desktop Study can be obtained from the following sources:

- The current and past site user(s) and owner(s)
  - Agency for real estate Cadastre (http://www.katastar.gov.mk)
- Existing site (survey) reports
  - Cadastre of waste producers, as part of the Environmental Cadastre, established and maintained by the Environmental State Administration. The data from the Cadastre is an integral part of the Environmental Information System
  - Reports of inspections performed by the Ministry of Environment and Physical Planning (MEPP)
  - Results of measurements from the National Network for Environmental Monitoring, MEPP
- Archives of relevant local, provincial and national institutions:
  - Spatial Plans of the Republic of Macedonia, General Urban Plans for towns or municipalities where the contaminated sites are found, and / or Spatial Plans for areas of special interests and protected natural sites
  - Cadastral plans in an appropriate scale, with an overview of the existing state of the land, cadastre parcels, buildings and installations (underground and aboveground)
  - Construction permits (relevant for site maps and drawings)
  - Operating permits (relevant for products used)
  - IPPC A permits (Integrated Pollution Prevention and Control), issued by the Department of Environment within the MEPP (Off. Gazette no. 4/06, 116/14, 31/16)
  - IPPC B permits issued by the Mayor of the city where the contaminated site is located (Off. Gazette no. 4/06, 116/14, 31/16)
  - Reports on Strategic Environmental Assessment (Off. Gazette no 153/07), on the basis of Article 67 paragraph 2 of the Law on Environment
  - Annex 9 Special Stud E Industrial Contaminated Sites ("hotspots"): Part of the National Waste Management Plan and Feasibility Studies- Ministry of Environment and Physical Planning (http://prtr.moepp.gov.mk/)

  - Register of discharges and transfer of pollutants, pursuant to Article 41 paragraph (2) of the Law on Environment, available and updated on the website of the Ministry of Environment and Physical planning (http://prtr.moepp.gov.mk/)
  - Environmental permits (relevant for discharge / disposal and products stored and used)
  - Regional and local geohydrology maps and reports (relevant for soil composition and characteristics)
  - Past, current and future site / land use
- Internet websites, such as online archives, publications and websites with site aerial and / or satellite images, such as Google Earth and:
  - Macedonian Soil information System http://www.maksoil.ukim.mk/masis/
  - Ministry of Environment and Physical Planning www.moepp.gov.mk
  - Ministry of Environment and Physical Planning, Macedonian informative Centre for Environment (contact@micnews.com.mk)
  - Ministry of Environment and Physical Planning, GIS Centre
  - Ministry of Environment and Physical Planning, Office for Persistent Organic Pollutants http://pops.org.mk/main_mak.html
  - European Environmental Agency, https://www.eea.europa.eu/
  - INSPIRE (Infrastructure for Spatial Information in Europe, http://inspire.ec.europa.eu/) INSPIRE Directive 2007/2/EC (INSPIRE), which is transposed in the Law on the national spatial data infrastructure of the republic of Macedonia (Off. Gazette of R.M. No. 38/2014) to determine existing land use for soil management
- Archives of local and national newspapers / media
  - Official Gazette of the Republic of Macedonia- http://www.slvesnik.com.mk/

The results of the Desktop Study will be used for the Preliminary Site Assessment report for describing the general background of the site; the site history; the current use of the site and its surroundings; the future use of the site and its surroundings; and the site characteristics. Each of these topics are described in the following sections.

2.2.2 General site background

The general site background information contains at least the following items:

- Reason for the Preliminary Site Assessment
  - Identification of equipment, installations and areas where the likelihood of contamination resulting from historical or current work practices is high, including accidental spillage or leaks
- Site location data and land register information
  - Address, location within country / province, coordinates, altitude, site boundaries, size of the site, site contact person(s) and their contact details
- Maps of the site
  - Site location within the region

  - Site layout
  - Cadastre maps
  - Present zoning of the site and details of the zone categories of properties surrounding the site
- Data on regional climate and geological and hydrological conditions
  - Regional geo(hydro)logy, the extent and use of aquifers in the area
  - Estimated depth to groundwater
  - Probable direction of groundwater flow and gradient
  - Location of any springs
  - Soils and soil properties (soil type, grain size, total organic carbon, porosity and hydraulic conductivity)
  - Sources of local municipal water supply, and the location of registered private or industrial wells on-site and nearby the site
  - Tidal influence
- Data on surface waters
  - Locations of surface water bodies (e.g. lakes, streams, rivers, estuaries, wetlands), particularly where these may be adversely affected by contaminated groundwater or surface drainage from the site. Surface water bodies should be evaluated to determine environmental values, beneficial uses, sensitivity to change, and physical, chemical and biological characteristics
- Characteristics and locations of human receptors
  - Within at minimum 500 meters from the site, particularly receptors who reside at down gradient locations of the site
- Information in order to establish whether adjacent properties are, or have been, potential sources of contamination

2.2.3 Site history

The site history contains information on the past on-site activities that could have impacted the soil or the groundwater. Even though the desktop study is focused on the site itself, it is good to keep in mind that the activities in the surrounding areas might have had an impact on the site as well. Therefore, studying historical aerial photography is often useful for identifying potentially contaminating activities at the site and in the surrounding areas.

Regarding the site history, at least the following information should be gathered (if applicable):

- Historical overview of the site operations:
  - Past site owner(s), date of past site activities (from - to), complaints / issues related to the site use and use of the surrounding areas
- Description of site activities and their location:
  - Previous uses, industries, activities and processes performed

  - Storage, waste, and wastewater facilities; waste dumps; Underground Storage Tanks (USTs) and Aboveground Storage Tank (ASTs) their filling point, ventilation pipe and all the other pipes
  - Incidents and accidents involving spillage or leakage
- Products (chemicals / hazardous substances / pesticides) used / stored on the site including:
  - Type
  - Status of packaging
  - Quantity
  - Location of use
  - Location of storage
- Maps (of suitable scale, provided with North arrow), showing the locations of the above elements / the site components
- The results of any previous investigations of the site or surrounding land

2.2.4 Current Site Use

At least the following information on current on-site activities that may impact the soil and / or the groundwater should be gathered (if applicable):

- Current operation process of the site:
  - Current owner, starting date of the activities, description of the (industrial) processes, process flow diagrams, incidents and accidents involving spillage or leakage
- Lay-out of the site:
  - Location of production storage, waste and waste water facilities, USTs and ASTs and pipes, general impression on site management and maintenance
- Products (chemicals / hazardous substances / pesticides) used / stored:
  - Type, quantity, location of use, storage, and waste storage/ handling
- USTs, ASTs and piping:
  - Location, volume, condition (integrity/ pressure tests, if available) of all underground and aboveground utilities, products stored, single walled or double walled, secondary containment conditions, location of filling and aeration points, incidents and accidents involving spillage or leakage, monitoring and maintenance history
- Maps (of suitable scale, provided with North arrow), showing the locations of the above elements / site components

2.2.5 Future Site Use

In order to identify the possible future receptor(s) for on-site soil and / or groundwater contamination, it is important to investigate what is the planned future site use. At least the following information should be gathered (if applicable):

- Regional development plans for the area / site, especially future land use plans:
  - Spatial Plans of the Republic of Macedonia, the region, or the municipality
  - General Urban Plans for towns or municipalities where the contaminated sites are found

  - Spatial Plans for areas of special interests and protected natural sites (http://app.gov.mk/?tax_urbanplaning=tax_detailed_urban_plans)
- Planned changes to site lay-out or function, and to site operations / storage / production
- Maps (of suitable scale, provided with North arrow), showing the locations of the above elements / the site components

2.3 Site Visit

The most important source of information for any Preliminary Site Assessment is the Site Visit. During the Site Visit, the information on the current and past soil threatening activities obtained by Desktop Study will be verified by interviews and observations during a Site Walkover. For a successful Site Visit, make sure that you visit the site during daytime in good weather conditions, and that you have enough time for visiting the whole site.

2.3.1 General

The Site Visit consists of the following tasks, which are discussed in the following sections:

1. Site Interview(s)
2. Site Walkover
3. Preparing a Site Photo Report

Prior to the Site Visit, the following arrangements should be made:

1. Obtaining permission to visit the site
2. Contacting site owner / manager and announcing the time of arrival
3. Checking accessibility and health and safety requirements
4. Obtaining a site lay-out map and / or satellite image of the site and its surroundings

2.3.2 Site Interview

The objectives of the Site Interview(s) are to verify the Desktop Study results and to obtain additional site data in order to assess the current and past soil threatening activities. Information collected by means of interviews with the local people often proves to be very valuable in the future assessment of the contamination status.

In order to get relevant information, try to focus on people who have first-hand information. Interviewing 3 – 7 most relevant and reliable people is advised. Such people could be:

- People directly in charge of management, production, trading and / or storage of hazardous materials, substances and waste in the past and currently:
  - Current / former site owner(s)
  - Site manager(s)
  - Site employees (the longer they work at the site the better)

- Site neighbours: People living close to the site, people using potentially contaminated groundwater or surface water, and people owning and / or consuming livestock products from animals that regularly graze or roam in the site surrounding and / or on-site
- Local community leader(s), staff from local authorities who are familiar with the site

In determining the past and current site use in relation to potential hazards to the soil and groundwater, the interviewer needs information on the exact usage of the site over the years. As most people do not have an understanding of (past) practices leading to soil and groundwater contamination, the quality of the information being gathered will improve by taking enough time to explaining the objectives of the interview. Since the people who are interviewed might have contributed to soil and groundwater contaminated in the past, it is important to make the person feel that the past actions are not being judged.

When starting the interview, it is important to describe the site concerned in this Preliminary Site Assessment by mentioning the name of the site and showing the site Layout Map, if available. Make sure you record the name, address and other contact details of the person being interviewed, as well as their role / relationship to the site in question.

The checklist in SOP 3.2.2 can help structuring the site interview. The checklist can be appropriately modified for fitting the actual circumstances of the site and the people being interviewed. The checklist in SOP 3.2.2 is divided into five parts:
1. The person interviewed
2. Basic site information
3. The life of people living in the area
4. The current site use
5. The land use of the surrounding area

2.3.3 Site Walkover
The objectives of the Site Walkover are to verify the data from the Desktop Study and the Site Interview(s) and to obtain additional site data required to assess the current and past soil and groundwater threatening activities. The following items should be recorded, and if possible, drawn on a layout map of the site:
1. Surrounding land uses and neighbouring activities
2. Site surface cover / pavement (e.g. vegetation, asphalt, concrete, bare): location, type, age and condition
3. Site topography, vegetation and surface run-off patterns / site drainage
4. Buildings: location, type, age and quality of construction materials
5. Underground infrastructure (cables and pipes): location, type, age and condition
6. USTs and ASTs: location, type, age, size and condition

7. Location and presence of any visible contamination
8. Location and presence of excavated, backfilled, or raised areas
9. Shallow and deep groundwater wells (on-site and surrounding the site): location, depth and capacity

2.3.4 Site Photo Report

The Site Walkover is the suitable occasion for preparing of a Site Photo Report. Objectives of a Site Photo Report are to have a visual reference of site components, to provide persons who have not visited the site with a good overview of the site, and to have photographs for use in future reports. When possible, close-up photos should be taken without using the flash as the flash will strongly reflect shiny surfaces, for example water with oil contamination.

At least the following photos should be taken for a Site Photo Report:

1. General photos of the site to provide an overview of the location from **all** view directions
2. All site boundaries and adjacent properties
3. All site components such as for instance:
   - Production / storage buildings (photos from both inside and outside)
   - Storage areas
   - Contaminated (parts of the) building
   - All waste storage areas
   - Locations where hazardous waste is possibly buried
   - Any suspect locations of soil and / or groundwater contamination, with close-up photos of any visible contamination

Mark and number all photos and indicate the direction of each photo with an arrow on a map with appropriate scale as shown in Figure 2.2.

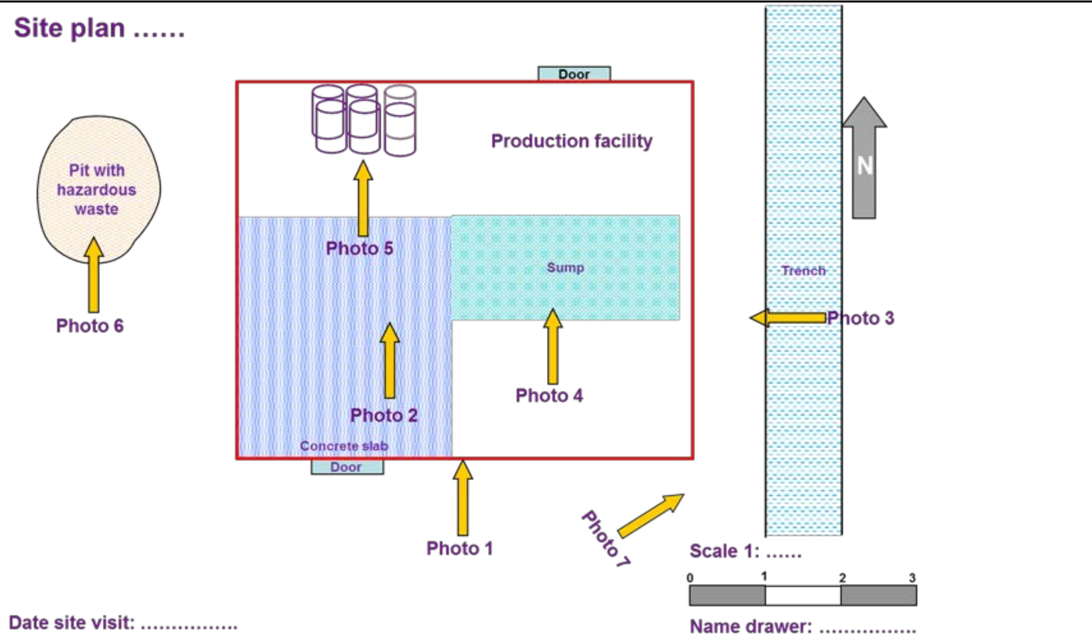

Figure 2.2 Example of a photo report map (modified from Tauw, 2015 a)

2.3.5 Site Reconnaissance Survey

A Site Reconnaissance Survey is a limited sampling campaign in order to identify hazardous waste or strongly contaminated soil at an early stage. By conducting this survey, health and safety related risks could be avoided or mitigated during the future field activities. The survey is only carried out if certain site components could be crucial for the site (human health, ecosystem, migration) environmental risk profile, the further project planning and the project budget. If this is the case, the sampling is carried out following the Site Visit and reported in the Phase 1 report. See SOP 3.2.6 for more information on Reconnaissance Field Testing.

A Site Reconnaissance Survey consists of the following steps:

- Spotting large quantities of possible hazardous waste and / or strongly contaminated soil at the site
- Making an assumption on the content of the waste and the quality of the soil
- Verifying the assumption by:
  - Representative sampling of the waste and / or the soil
  - Analysing the samples in order to establish if it is:
    - Hazardous or non-hazardous waste
    - Strongly or slightly contaminated soil

Depending on the results, the follow-up actions can be designed in a safe and sustainable way in a later phase of the contaminated site management.

2.4 Initial Conceptual site Model (ICSM)

The ICSM is a system diagram identifying contaminant sources, receptor pathways and receptors potentially affected by the contaminants migrating through those pathways. The ICSM should be seen as the input for a further investigation and never as a final stage.

2.4.1 Introduction

The ICSM is based on the information gained during the Desktop Study the Site Visit and the Reconnaissance Survey described in the previous sections of these Guidelines (Sections 2.2, 2.3, and 2.3.5, respectively). Figure 2.3 shows how essential it is to conduct these three stages before drafting the ICSM. The knowledge on site geology and history will enable the site to be divided into separate areas regarding the ground conditions and type, form and mobility of substances likely to be present.

The objective of the ICSM is to clearly illustrate the known / potential soil and groundwater contamination situation in relation to former and current site-use. The ICSM provides an overview of:

- Potential *source area(s)* for the contamination
- Potential *pathway(s)* for the contamination (current and future)
- Potential *receptor(s)* for the contamination (current and future)

These three items are further described in the following sections.

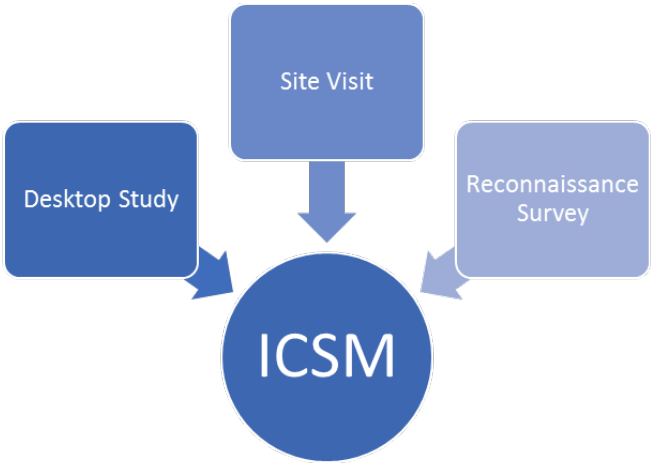

Figure 2.3 The ICSM is drafted based on the information gained during the Desktop Study, Site Visit and Reconnaissance Survey

2.4.2 Potential source areas

Potential source areas of contamination can be classified as follows:

- Areas where substance(s) that are harmful to human health, the ecosystem and having the potential to migrate, are used, handled and / or stored
- Areas where substance(s) that are harmful to human health, the ecosystem and having the potential to migrate, enter the soil, surface water and / or groundwater

Typical potential source areas are for example underground or aboveground storage places (for drums, bags, containers); USTs or ASTs and installations processing hazardous materials; production and packaging facilities; loading platforms and filling stations; hazardous waste dumps; and hazardous waste processing facilities. The potential sources should be reported in terms of the activity likely to have caused them, as well as the potential substances these areas may contain.

The potential source areas are, to a certain extent, identical at most contaminated sites. The most common source areas are:

1. Storage areas for hazardous substances
2. Contaminated buildings and infrastructures
3. Buried hazardous waste
4. Contaminated soil and groundwater

2.4.3 Potential receptors

Potential receptors for contamination are any plant, animal and / or human being that might come into direct contact or take-up the contamination. In most cases, receptors are also pathways for a contamination. The potential receptors are not necessarily in and around the site: they might be a considerable distance away, if a potential pathways are thought to exist. The receptors might also change over time. Therefore, consideration must be given to the receptors present in the future or at a certain time (for example future users and construction workers).

Typical potential receptors for soil and groundwater contamination at, near and around the contaminated site are for example humans (visitors, users, workers and general public with, if possible, specific demographics on gender and age); animals including livestock (cattle, poultry and pet animals); fish and other aquatic organisms; subsoil fauna (living organisms in the soil); vegetation (growing crops); and the ecosystem in general (soil, groundwater and/ or water bodies). During Phase 1 it is key to identify potential receptors, so that in further Phases receptors can easier be identified depending on the type and amount of contamination. The human health risks should be discussed with a qualified health expert.

2.4.4 Potential pathways

For each potential source, consideration needs to be given to whether a pathway exists, through which the contamination can migrate and spread from its original source area to the surroundings.

Typical potential pathways for soil and groundwater contamination are for example spreading through air (wind erosion); groundwater (leaching, dispersion and groundwater flow); surface run-off (water erosion); surface water (surface water flow); physical contact with the contamination (humans, domestic animals and wildlife); and uptake in the ecosystem (food chain and human body). Regarding humans, some examples of pathways are soil ingestion, inhalation of dust, uptake by food plants and direct contact with the contamination.

2.4.5 Drafting the ICSM

The ICSM should give an instant overview of the suspected contamination situation and identify the most likely Sources, Pathways and Receptors (as described in the previous sections). For drafting the ICSM, the Sources, Pathways and Receptors should first be listed. This can be done by using a schematic list (see Figure 2.4 for an example). Based on the list, it is easier to draft illustrations showing the contamination situation. One of the required illustrations for the ICSM is a site layout map. Figure 2.5 provides an example of such site layout map.

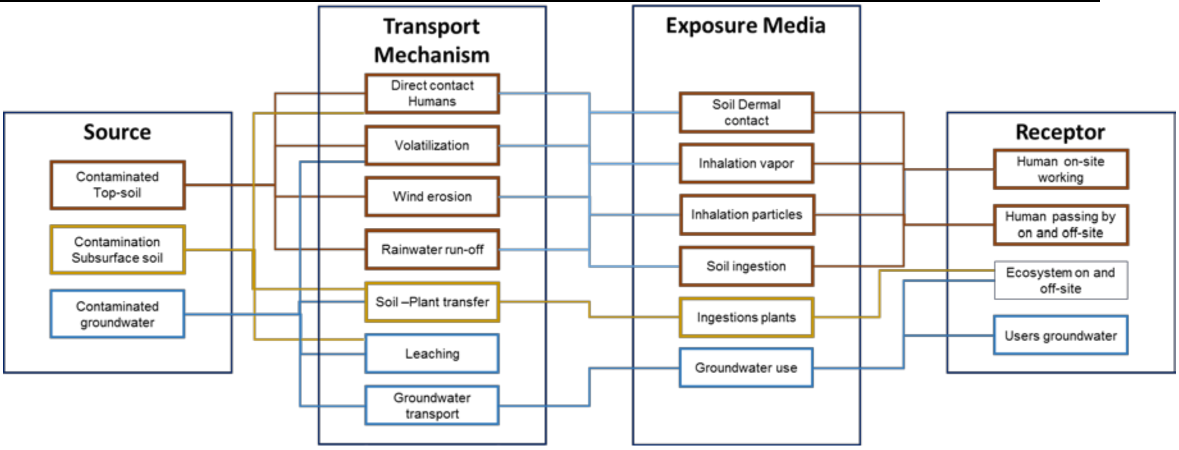

Figure 2.4 Examples of a schematic ICSM regarding of a site with contaminated op-soil subsurface soil and groundwater

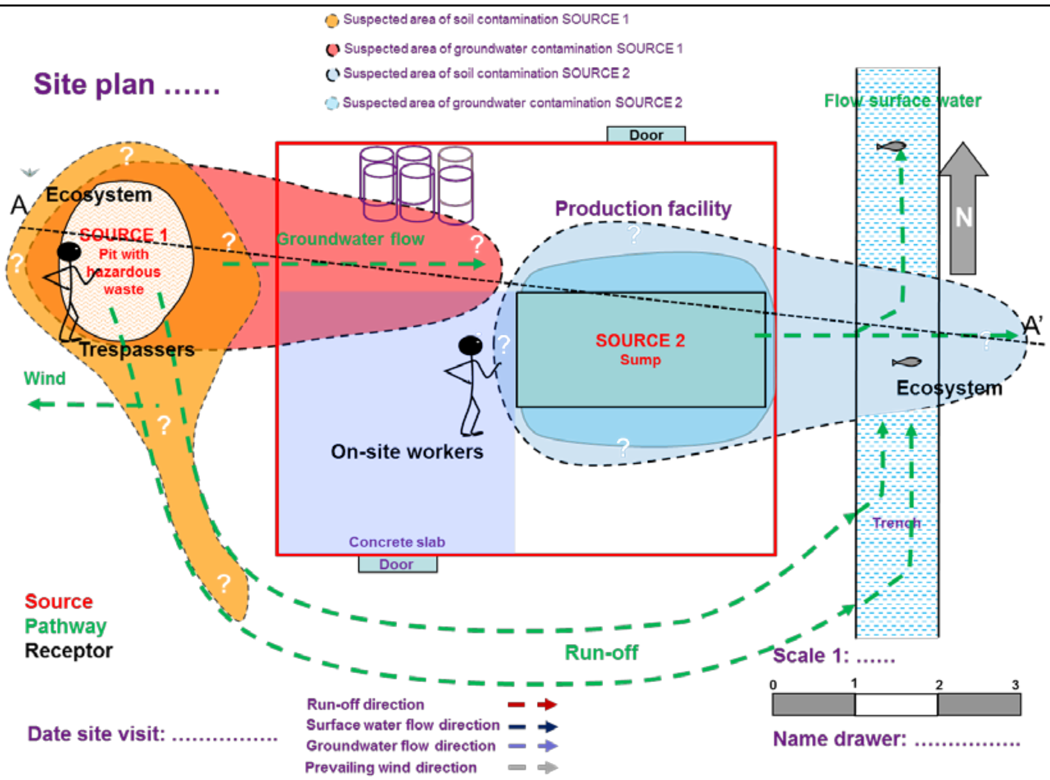

Figure 2.5 Example of a site lay-out map as a part of an ICSM

The site layout map showing the suspected contamination situation should have at least the following items:

- An appropriate scale (between 1:100 and 1:10.000), a scale bar and a North arrow
- All potential Source zones
- All potential Receptors of the contamination (including areas and routes used by workers and visitors on site)
- All potential Pathways:
  - The surface run-off directions from each individual source zone indicated with arrows pointing down gradient
  - The expected groundwater flow direction indicated with an arrow
  - The prevailing wind direction indicated with an arrow to show potential spreading when contaminants get airborne

After drafting a map with the contamination situation (see Figure 2.5), a cross-section of the site needs to be drawn in order to visualize the expected vertical and horizontal spreading of the contamination in soil, groundwater, air and surface water.
Unlike the site layout map, the cross-section does not necessarily need to be in scale. It may present a schematic view of the site, as shown in Figure 2.6.

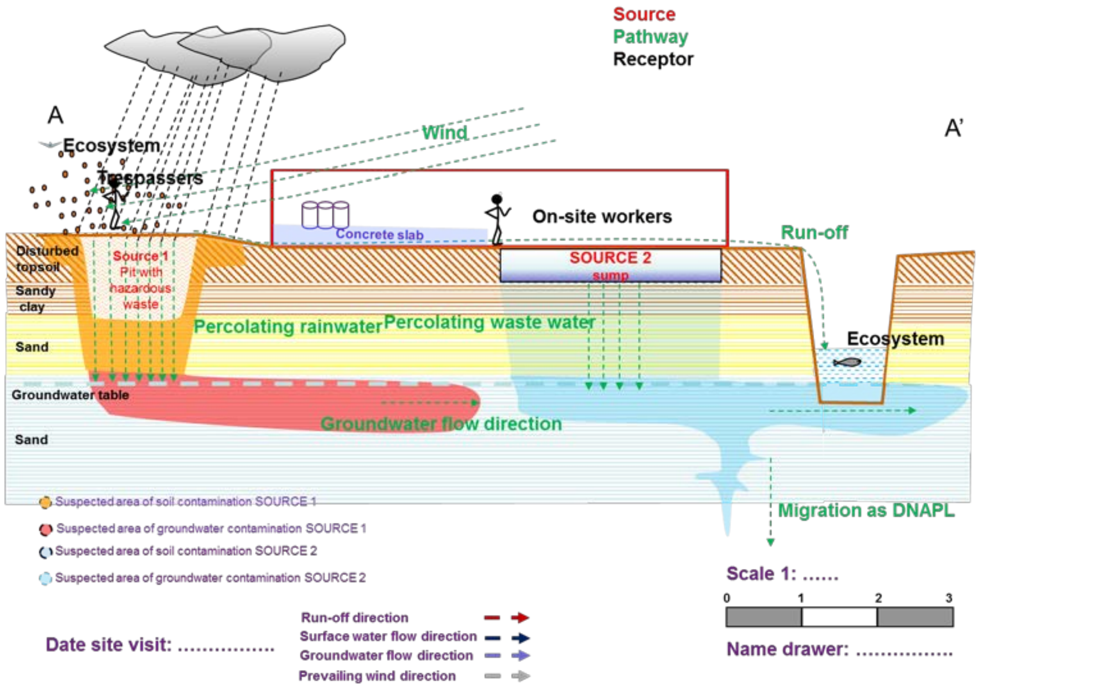

Figure 2.6 Example of a representative cross section as a part of an ICSM

For drawing a cross-section of the site, the following steps should be followed:

- Selecting an oblique line (line A – A' in Figure 2.6) across the Site Lay-out Map that contains the most important site components with the Sources, Pathways and Receptors
- Drawing the topographic surface / relief along the oblique line with an indication of the height of the various site components and site areas
- Adding the following features:
  - Buildings, constructions, underground facilities (USTs, ASTs, piping, water tanks etc.), drainage system(s)
  - Geological and soil features, groundwater level and groundwater flow direction, groundwater wells
  - Surface water bodies, agricultural fields, living quarters
  - The prevailing wind direction
  - Hazardous waste: storage building(s), buried waste, bunkers with waste

2.5 Preliminary Risk Assessment

Preliminary Risk Assessment or Tier 1 Risk Assessment is a method to obtain a site (component) risk profile with the available site (component) data. Carrying out such an assessment requires expert knowledge on Site Assessment. Based on expert judgment, the results of the Preliminary Risk Assessment can be used to prioritize contaminated sites (components) based on the potential risks for human health, ecosystem and contaminant migration. For prioritizing contaminated sites within the whole country, please refer to SOP 3.4.1 Methodology for identification and prioritization of contaminated sites in Macedonia.

Based on the risk-based prioritization, the limited resources for site remediation can be allocated on the site(s) (components) with the highest priority on adverse effects likely to occur, before they cause serious damage to humans and the ecosystem and/ or migrate. For posing a potential risk, all the three elements (Source-Pathway-Receptor) described in section 2.4 must be present.

2.5.1 General

Risk in these Guidelines is defined as the likelihood that a hazardous substance, when released into the environment, will cause an adverse effect in exposed humans and / or other living organisms (ecosystem) and or migrates. Risk Assessment is defined as estimation or calculation of the risks for a given organism or (sub)-population, when taking into account the contaminant sources, pathways and receptors.

Generally, estimating the environmental risks is called a Preliminary or Tier 1 or Qualitative Risk Assessment, whereas calculating the risks is called Tier 2 or Quantitative Risk Assessment. In these Guidelines, we use the term Preliminary Risk Assessment for estimating the risks (Tier 1) and the term Risk Assessment for calculating the risks (Tier 2).

The results of the Preliminary Risk Assessment can be used to prioritize sites (components) by comparing a site (component) risk scores with the risk scores of other sites (components). For prioritizing contaminated sites within the whole country, please refer to SOP 3.4.1 Methodology for identification and prioritization of contaminated sites in Macedonia.

When assessing a single large contaminated site, comparing the site component risk scores can help to prioritize the remediation efforts. The higher the site component risk score, the higher the urgency to remediate this site component. The mitigation / remediation measures are to be designed and implemented in the later stages of the sustainable contaminated site management.

Based on the ICSM developed in the previous section of these Guidelines, the risks for the concerned site components can be identified and preliminarily assessed. Each identified risk, source, pathway, and receptor is listed on a table (see Table 2.1 for examples of risks related to the ICSM presented in Figures 2.4 and 2.5).

Table 2.1 Identified risks (examples)

No	Risk posed by a site component	Source	Pathway	Receptor
1	Exposure to hazardous waste dumped in a pit	Dump with hazardous waste	Run-off water Direct contact	Site workers & Ecosystem
2	Exposure to strongly contaminated topsoil at the site	Strongly contaminated areas of topsoil	Run-off water Direct contact	Site workers & Ecosystem
3	Exposure to slightly contaminated soil at the site	Slightly contaminated soil	Run-off water Direct contact	Site workers & Ecosystem
4	Exposure to contaminated groundwater at the site and surroundings	Water in wells	Groundwater flow Direct contact	Villagers, cattle & Ecosystem
5	Exposure to contaminated surface water at the site	Water in trench	Surface water flow Direct contact	Villagers, cattle & Ecosystem
6	Exposure to contaminated sediment at the site	Sediments in trench	Run-off Direct contact	Villagers & Ecosystem
7	Exposure to contaminated airborne contaminated particles	Dump with hazardous waste	Direct contact	Site workers, trespassers & Ecosystem

2.5.2 Risk categories

In the next stage, the identified risks (see examples in Table 2.1) are categorized based on the likelihood of exposure to contaminants and the magnitude of impacts of the exposure, regarding the risks for human health, ecosystem and contaminant migration. In these Guidelines, the following four categories are defined:

1. **Direct risks having <u>high likelihood</u> and if occurring, have <u>high impact</u>:**
   - Humans having direct contact with the contaminant through the food chain and in their daily lives, which may severely impact their health
   - Ecosystem is in direct contact with the contaminants, having a direct negative effect on the ecosystem
   - Contaminants migrating and having a direct negative effect on the site surroundings

2. **Potential risks having <u>low to medium likelihood</u> and if occurring, have <u>high impact</u>:**
   - Humans having indirect contact with the contaminants through the surrounding ecosystem and / or contact when they visit the site, and in case of contact having severe impact on their health
   - There is no direct contact with the ecosystem but if the situation is not actively maintained, it can change to a situation with direct negative effect on the ecosystem
   - There is no migration of contaminants, but if the situation is not actively maintained, it can change to a situation with direct negative effect on the site surroundings

3. **Probable risks having <u>high likelihood</u> and if occurring, have <u>low to medium impact</u>:**
   - Humans having direct contact through the food chain with the contaminants in their daily lives, which may slightly impact their health
   - Ecosystem is in direct contact with the contaminants and if the situation is not actively maintained, it can change and minor impact to the ecosystem is expected
   - Migrating contaminants having minor impact on the surroundings

4. **Latent risks having <u>low to medium likelihood</u> and if occurring, have <u>low to medium to high impact</u>:**
   - Humans having indirect contact with the contaminants through the surrounding ecosystem and contact when visiting the site, and in case of contact, having a slight impact on their health
   - There is no direct contact with the ecosystem, but if the situation is not actively maintained, it can change and minor impact to the ecosystem is expected
   - There is no migration of contaminants, but if the situation is not actively maintained, it can change and can have minor impact on the surroundings

In order to evaluate the risks in a structured way, the identified risks are evaluated by giving a score for the likelihood and a score for the expected impact. For the classification, these Guidelines define the five classes of *likelihood* and five classes of *impact* to be used for the Preliminary Risk Assessment, as listed on Table 2.2.

Table 2.2 The classes of likelihood and impact to be used for the Preliminary Risk Assessment

Class	Likelihood	Score	Class	Impact	Score
1	Not likely	> 1 - < 2	1	Very small	> 1 - < 2
2	Possible	> 2 - < 3	2	Small	> 2 - < 3
3	Likely	> 3 - < 4	3	Reasonable	> 3 - < 4
4	Probable	> 4 - < 5	4	Large	> 4 - < 5
5	Very likely	> 5 - < 6	5	Very large	> 5 - < 6

These scores are given for each of the identified risks, with regard to human health, ecosystem and migration of the contaminants, as shown in the example of Table 2.3.

Table 2.3 The risks scores given for the identified risks (example)

No	Risk	Human health		Ecosystem		Migration	
		L[2]	I[3]	L	I	L	I
1	Exposure to hazardous waste in dump/pit	1,5	5,5	3,0	4,0	4,0	4,0
2	Exposure to strongly contaminated soil at the site	2,0	5,0	3,5	2,5	4,0	3,0
3	Exposure to slightly contaminated soil at the site	3,0	2,0	6,0	2,1	4,0	2,0
4	Exposure to contaminated groundwater at the site and surroundings	1,0	4,0	1,0	3,0	4,0	1,0
5	Exposure to contaminated surface water at the site	3,0	2,0	3,0	3,0	4,0	2,0
6	Exposure to contaminated sediment at the site	1,0	5,0	4,0	2,5	4,0	2,3
7	Exposure to contaminated airborne contaminated particles	2,0	1,0	2,0	2,0	4,0	1,5

Once the risks have been scored as presented in Table 2.3, the total scores can be calculated. The score for a specific risk is the *likelihood score* multiplied by the *impact score,* which is calculated for the risk to human health, the risk for the ecosystem and the risk of migration, as presented in Table 2.4. A total score for a specific risk is the sum of human risk score, the ecological risk score and the migration risk score. The total risk score of the *whole site* is the sum of all the total scores of the specific risks, shown in the lower right corner of the table.

Calculating the total score of a specific risk (presented on the rightmost column of the table) makes it possible to prioritize the remediation measures of the site and only focus on the ones with a very high-risk score.

[2] L: likelihood score
[3] I: Impact score

Table 2.4 Example of calculating the Total Risk Score and Total Site Risk Score for the identified risks

No	Human health				Ecosystem				Migration			Total Risk Score
	L		I		L		I		L		I	
1	1,5	X	5,5	+	3,0	X	4,0	+	4,0	X	4,0	36,3
2	2,0	X	5,0	+	3,5	X	2,5	+	4,0	X	3,0	30,8
3	3,0	X	2,0	+	6,0	X	2,0	+	4,0	X	2,0	26,0
4	1,0	X	4,0	+	1,0	X	3,0	+	4,0	X	1,0	11,0
5	3,0	X	2,0	+	3,0	X	3,0	+	4,0	X	2,0	23,0
6	1,0	X	5,0	+	4,0	X	2,5	+	4,0	X	2,5	25,0
7	2,0	X	1,0	+	2,0	X	2,0	+	4,0	X	1,5	12,0
Total Site Risk Score												**164,0**

2.5.3 The results of Preliminary Risk Assessment

The Preliminary Risk Assessment is completed when the Total Risk Scores are calculated as presented in Table 2.4. The results can be presented in a table (see Table 2.5 for an example) or a graph (see Figure 2.7 for an example).

Table 2.5 Preliminary Risk Assessment results (example)

No	Risk[4]	Direct risk	Probable risk	Potential risk	Latent risk
1	Exposure to hazardous waste in dump/pit	E M		H	
2	Exposure to strongly contaminated soil at the site	M		H	E
3	Exposure to slightly contaminated soil at the site		H E M		
4	Exposure to contaminated groundwater at the site and surroundings		M	H E	
5	Exposure to contaminated surface water at the site	E	H M		
6	Exposure to contaminated sediment at the site			H E M	
7	Exposure to contaminated airborne contaminated particles			M	H E

[4] H: Human health risk E: Ecosystem risk M: Migration Risk

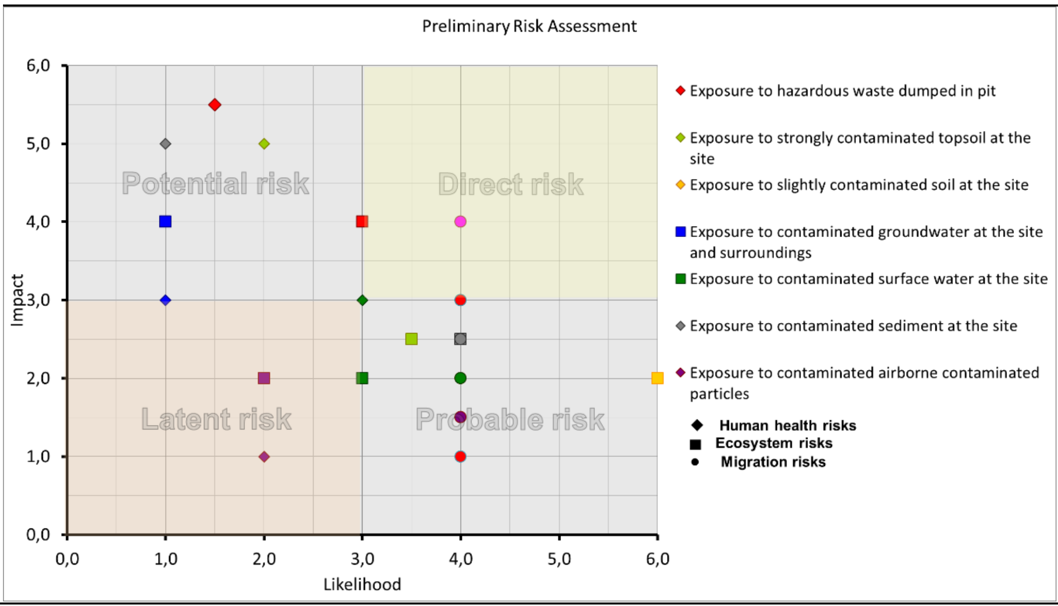

Figure 2.7 Preliminary Risk Assessment results (example)

2.6 Reporting of Preliminary Site Assessment

Based on the results of all steps taken as described above, sufficient data should be available for drafting a Preliminary Site Assessment report. This report will be the input for the following phase, the Site Assessment (Phase 2, described in the following section).

The Preliminary Site Assessment report should include at least the following subjects:

Summary of the Preliminary Site Assessment (0.5 - 1 page)

1. **Introduction**
    1.1. Motivation and objectives for the Preliminary Site Assessment
    1.2. Methodology and status of the Preliminary Site Assessment
    1.3. Structure of Preliminary Site Assessment report
2. **Assessment results**
    2.1. General background of the site
    2.2. Site history
    2.3. Current use of the site and surroundings
    2.4. Future use of the site and surroundings
    2.5. Site characteristics (i.e. site lay-out and its site components)

2.6. Initial Conceptual Site Model
2.7. Preliminary Risk Assessment

3. Conclusions and Recommendations

3.1. Conclusions
3.2. Recommendations

References

Appendices

1. A map of Macedonia indicating the site location
2. Site Lay-out Map(s) as a part of an ICSM
3. Cross section(s) as part of an ICSM
4. Photo Report with photo report map
5. List of interviewees
6. Minutes of Interviews
7. Other relevant documents collected

3 Phase 2: Site Assessment

Disclaimer
It is expected that the reader(s), or person(s) using these Guidelines, have professional knowledge in reporting and interpretation of analysis results in environmental investigations. The actual interpretation and appraisal of analytical data requires experience, and if done incorrectly, could result in conclusions that are incorrect / invalid and conclusions not warrant by the analytical data

3.1 Objectives and Tasks

A Site Assessment is required on sites where a Preliminary Site Assessment has suggested contamination to be present in the soil or groundwater and caused environmental risks. A site assessment involves primarily the inventory of the amount of hazardous waste, a detailed assessment of the toxicity and amount of a contaminated building, the detailed assessment of the quantity and extent of buried hazardous waste, the installation of soil boreholes, groundwater monitoring wells, soil and groundwater sampling and analysis, an assessment of the extent of the contaminated soil and groundwater and data evaluation and reporting.

The objectives of the Site Assessment (Phase 2) are to establish quantitatively the contamination situation of a site and the associated risks to human health, the ecosystem and for contaminant migration. Site Assessments are costly and time consuming and a trained team is needed for carrying out the procedures. At the end of the Site Assessment, it can be decided based on the updated Conceptual Site Model (CSM) and a Tier 2 Risk Assessment if remediation measures are needed at the site.

The Site Assessment tasks are:
- Carrying out a Gap Analysis of the ICSM (Section 3.2)
- Designing an Investigation Plan (Section 3.2)
- Carrying out Fieldwork (Section 3.3)
- Data Interpretation and Evaluation (Section 3.4)
- Updating the ICSM (Section 3.5)
- Conducting a Tier 2 Risk Assessment (Section 3.6)
- Reporting the results of the Site Assessment, including Gap Analyses and Investigation Plan, Updated CSM, and Risk Assessment (Section 3.7)

The process for effectively carrying out the Phase 2 Site Assessment is visualized in Figure 3.1.

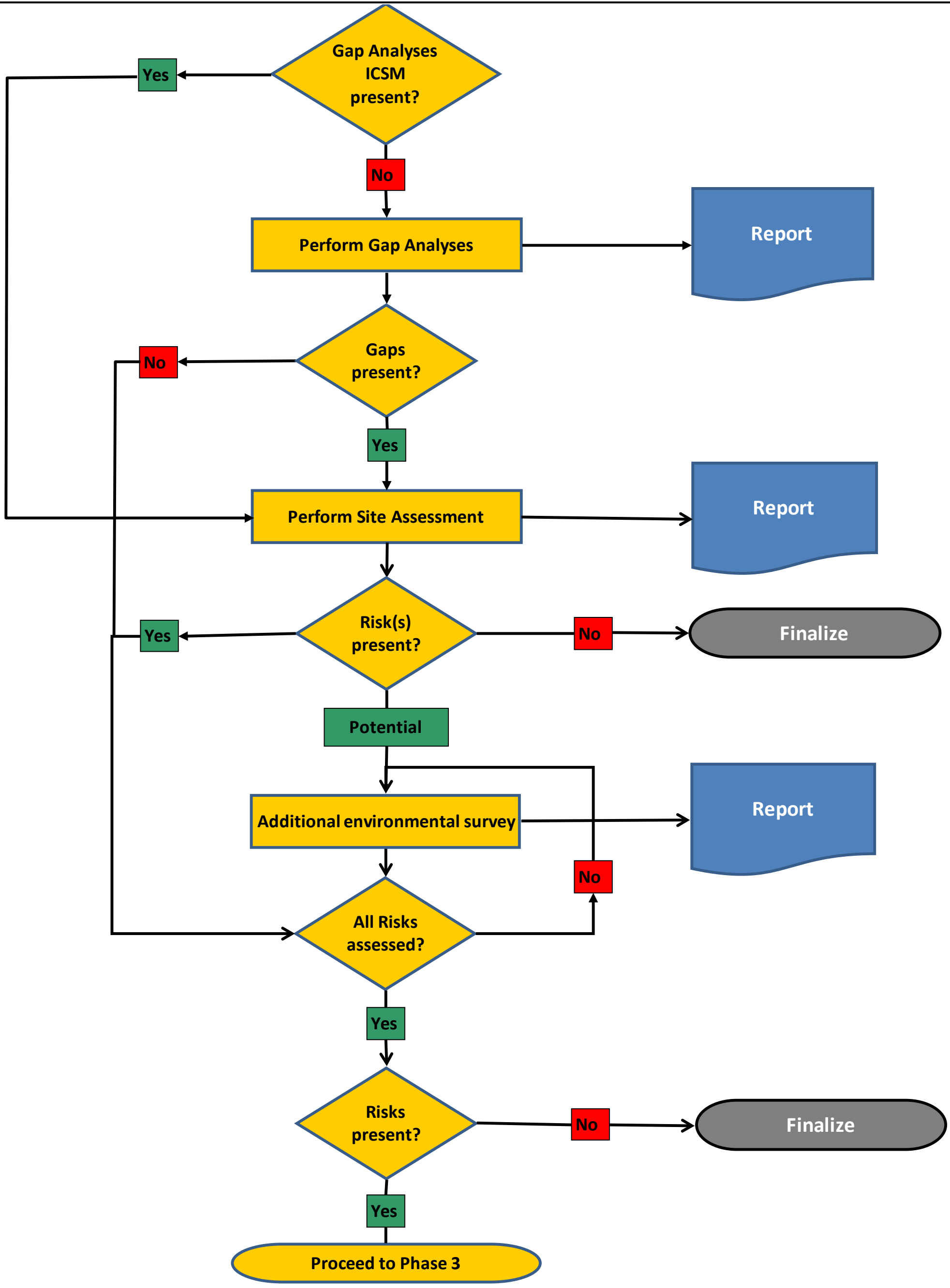

Figure 3.1 Process for the Phase 2 Site Assessment of the sustainable management of contaminated sites (source: Tauw, 2015 b)

3.2 Gap Analysis and Investigation Plan

The ICSM drafted in Section 2.4 is partly based on facts and partly on assumptions. The assumptions that have not been verified are actually the knowledge gaps of the ICSM. Identifying all knowledge gaps in the ICSM, or the gaps in understanding the site contamination situation, is called Gap Analysis.

- With a comprehensive Site Assessment, the ICSM can be improved and updated, so that all environmental risks can be quantitatively assessed. The Gap Analysis therefore creates the basis for the design of the Investigation Plan of the Site Assessment. Through conducting a Gap Analysis, at least the following questions should be answered What is (are) the potential source area(s) for soil and groundwater contamination?
- What is (are) the extent(s), quantity and degree of the soil and groundwater contamination at the source area(s)?
- What is (are) the impact(s) on the soil and groundwater quality of the source area(s)?
- What information is needed to confirm or refuse potential receptor pathway(s) of (a) contamination(s)?
- What information is needed to confirm or refuse potential receptor(s) of a contamination?
- Is all required information on the potential on-site contaminant(s) available?
- If one of these above questions cannot be fully answered, what additional information is required?

3.2.1 Tabular presentation Gap Analysis

A Gap Analysis can be presented in a tabular format (see Table 3.1), or as text, but should also be visually presented on a map or diagram (see Section 3.2.2). Using all of these methods can be very helpful for identifying all gaps in the ICSM.

Table 3.1 provides an example of a Gap Analysis of a contaminated site. The site components listed in Table 3.1 (second column) can be either a source, a pathway or a receptor. The third column (Information Status) presents information on the status of the site component, whereas the fourth column (Knowledge Gap) presents the identified knowledge gaps for the site specific components. The last column is used to describe the recommendations for investigation in order to fill the knowledge gaps. This is the first step for the design of the site Investigation Plan.

Table 3.1 Example of a Gap Analysis

Source	Site Component	Information status	Knowledge gaps	Recommendations for Investigation
1.	**Hazardous waste in pit**	Hazardous waste are dump in a pit	Information about past and current site operations	Desktop study of the site administration Interview site management and site operational staff
		Pit dimensions on the surface	Size of pit, quantity and types of hazardous waste dumped	Pit survey
		Assumed soil and groundwater contamination	The degree and extent of soil and groundwater contamination	Detailed soil and groundwater survey
2.	**Sump inside building**	Leaking sump	Integrity of the sump	Interview site management to reveal technical information on condition sump Assessment of environmental quality of the construction
		Pit dimensions on the surface	Exact depth of sump	Desktop study technical drawings and measuring
		Waste water and sludge are in sump	Thickness sludge layer in the sump	Sludge measurement sump
		Sump was used as settlement tank of waste water before discharge in sewer	Amount and composition of waste water discharged Connection to sewer	Interview site management and site operational staff Technical information on the sump and influent and effluent piping
		Assumed soil and groundwater contamination	The degree and extent of soil and groundwater contamination	Detailed soil and groundwater survey
		Assumed contaminated sediment in trench is	The degree and extent of contaminated sediment in trench	Detailed sediment survey

Source	Site Component	Information status	Knowledge gaps	Recommendations for Investigation
		Assumed contaminated surface water in trench is	The degree and extent of contaminated surface water in trench	Surface water survey

3.2.2 Visual presentation Gap Analysis

Knowledge gaps can also be presented visually in a map or diagram. One option is to draw question marks (?) on a copy of the ICSM (see Figure 2.5), in order to indicate the knowledge gaps. As an example, if it is unclear whether soil around the dumped hazardous substance is contaminated, question marks should be drawn on this part of the ICSM. Targeted different types of surveys can later on reduce the knowledge gaps.

3.2.3 Investigation Plan

The objective of the Investigation Plan is to draft a strategy for the complete assessment of the contaminated site situation. A clear objective of why the data needs to be collected and what it will be used for will help focus the investigation. Therefore, a careful examination of Preliminary Site Assessment results by conducting a Gap Analysis can minimize sampling efforts and costs. Examining the results of Phase 1 can help determining the locations of important site components for the quantitative investigation during Phase 2.

When planning a site investigation, the following should be considered: objectives of the site investigation; data quality objectives; number, type, and locations of the samples to be collected; the most appropriate (and cost-effective) field sampling procedures for each of the targeted environmental media; Health, Safety (H&S), and environmental concerns.

An Investigation Plan for a suspected contaminated site addresses all site components and contains related plans to investigate these. The most common site components of a contaminated site are: (1) Storage areas for hazardous substances, (2) contaminated building(s) and infrastructure(s), (3) buried hazardous waste, and (4) contaminated soil and groundwater.
For each of these four site components, the following specific plans to investigate the site component should be prepared:

1. **Storage areas for hazardous substances:**
   – An inventory plan to make an inventory of the hazardous substances
2. **Contaminated building(s) and infrastructure(s):**
   – A building and infrastructure assessment plan to assess the contaminated (parts of) building and infrastructure

3. **Buried hazardous waste:**
   – A pit survey plan to survey the horizontal and vertical extent of the buried hazardous waste
4. **Contaminated soil and groundwater, including the source area(s):**
   – A soil and groundwater sampling and analyses plan to assess the horizontal and vertical extent of the source area(s) and the total extent of the soil and groundwater contamination

Table 3.2 presents an example of an Investigation Plan addressing the different site components in line with the gaps listed in Table 3.1.

Table 3.2 Investigation Plan

Site component	Knowledge gaps	Recommendation investigation	Human resources	Collaborating agencies and Equipment
Hazardous waste in pit	Information about operation period, past	Desktop study of the site administration Interview site management and operational staff	Environmental expert	Site management Site operational staff Site lay-out map
	Size of pit and quantity and types of hazardous waste dumped	Pit survey with a minimum number one of borehole in the middle to establish the depth and several boreholes around to map the extend	Trained fieldwork team	PPE, photo camera, field form and stationeries Set of (hand) augers with at least 2 meter extension rods Sampling equipment like foil, jars, stickers and cooler box
	The degree and extent of soil and groundwater contamination	Detailed soil and groundwater survey with boreholes and observation wells to map the extend in horizontal and vertical direction	Trained fieldwork team	PPE, photo camera, field form and stationeries Set of (hand) augers with at least 2 meter extension rods Groundwater well materials Sampling equipment like foil, jars, bottles, stickers and cooler box

Site component	Knowledge gaps	Recommendation investigation	Human resources	Collaborating agencies and Equipment
Sump inside building	Integrity of the sump	Interview site management and operational staff Assessment of environmental and technical quality of the construction	Technical expert	PPE, photo camera, field form and stationeries
	Exact dimension of sump In- and effluent piping (connection to sewer?)	Desktop study technical drawings Technical field inspection	Technical expert	PPE, photo camera, field form and stationeries Measuring devices
	Thickness sludge layer in the sump	Sludge measurement sump	Technical and environmental expert	Multi-sampler and equipment like bailers Sampling equipment like foil, sediment sample jars, stickers and cooler box
	Amount and composition of waste water discharged	Interview site management and operational staff	Technical and environmental expert	Field form and stationeries
	The degree and extent of soil and groundwater contamination	Detailed soil and groundwater survey with boreholes and observation wells to map the extend in horizontal and vertical direction	Trained fieldwork team	PPE, photo camera, field form and stationeries Set of (hand) augers with at least 2 meter extension rods Groundwater well materials Sampling equipment like foil, jars, bottles, stickers and cooler box
	The degree and extent of contaminated sediment in trench	Detailed sediment survey	Trained fieldwork team	PPE, photo camera, field form and stationeries Set of sediment sampling equipment like foil, sediment sample jars, stickers and cooler box

Site component	Knowledge gaps	Recommendation investigation	Human resources	Collaborating agencies and Equipment
	The degree and extent of contaminated surface water in trench	Surface water survey	Trained fieldwork team	PPE, photo camera, field form and stationeries Surface water sampling equipment like water sample bottles stickers and cooler box

The following sections describe each of these four types of Investigation Plans mentioned above, that may be included in an Investigation Plan. Please note that if for example only two of the site components are relevant at a site, the Investigation Plan will only handle these two site components. For each of the site component plans, the work should be carried out according to the methodology described in the sections below (3.2.4, 3.2.5, 3.2.6, and 3.2.7) and the relevant SOPs. The Investigation Plan shall also contain information about:

- The allocation of tasks, roles and responsibilities of the different parties involved
- Accessibility of the site and sample location(s)
- Required additional safety measures needed for the site and sample locations
- Summary of general site information:
  - Location and address of the site
  - Site owners, main contacts and contact details of site representative and site security organisation
  - Site history
  - Hydrogeology and climate conditions
  - Site development plan (if available)
  - Site lay-out maps including topographic cross section (if available)

3.2.4 Inventory plan for hazardous substances

During the storage inventory, the amount of the different hazardous substances is estimated and documented on maps and by photographs. During the inventory, the investigator has to wear appropriate PPE. If hazardous substances are not labelled, the physical properties (for example colour; smell; powders, solid or liquid forms et cetera) should be recorded. Labelled chemicals / hazardous substances / pesticides and / or newly manufactured ones should be classified separately. The inventory also needs to describe the package of each type of substance / chemical (for example bags, glass bottle, plastic bottle, plastic tanks, metal tanks et cetera), and the condition the package (for example rusty barrel or strong rice sacks).

Inventory plan for hazardous substances should at least contain:

- Basic site information (address, contact details and accessibility)
- Required PPE

- Required manpower and their qualifications
- Required sampling materials
- Required equipment
- Timeframe and detailed planning for the inventory
- Scaled map with an arrow indicating the North, showing:
  - The location of the storage(s) with hazardous waste to be inventoried
- Required field forms such as:
  - Logbook
  - Inventory field forms
  - Sample transport form (if samples will be submitted for analysis)

3.2.5 Building / infrastructure assessment plan

If suspected contaminated buildings and infrastructures exist on a site, an assessment should be carried out to assess the contamination situation to identify appropriate mitigation and remediation measures for the building(s) / infrastructure(s). The information that should be collected and reported includes:

- Description of the building(s) as far as available:
  - Name of storage building
  - Building dimensions
  - Storage room(s) name(s) and / or number(s) and dimensions
  - Condition of floor, walls, ceiling, door(s) and window(s)
  - Description of the contamination
    - Surface of contaminated parts (check for dust, discoloration, stains)
    - Indication (and dimensions) of permeation of hazardous substances into the floor and walls (usually seen as dark stains, making bricks and concrete appear ‘wet’)
- Description of the infrastructure(s)
  - Type of infrastructure (UST, AST, sewer, open drainage et cetera)
  - Dimensions
  - Condition of
  - Description of the contamination
    - Surface of contaminated parts (check for dust, discoloration, stains)
    - Indication (and dimensions) of permeation of hazardous substances into the floor and walls (usually seen as dark stains, making bricks and concrete appear ‘wet’)
- Simple lay-out map of the infrastructure(s)
- Photographs
- Description of the sampling plan to estimate / assess the volume of different suspected:
  - Contaminated materials
  - Clean materials

Building assessment and infrastructure plan should at least contain:

- The basic site information (address, contact details and accessibility)
- The needed PPE
- The needed manpower and their qualifications
- The needed sampling materials
- The needed assessment equipment
- A timeframe and detailed planning for the building and infrastructure assessment
- A scaled map with an arrow indicating the North, showing:
- The building(s) and infrastructure(s) to be assessed
- The necessary field forms such as:
  - Logbook
  - Sample transport form (for samples to be submitted for analysis)

3.2.6 Pit survey plan for buried hazardous waste

The objective of a pit survey is to: (1) determine the exact location of the pit / bunker or dump that was discovered in Phase 1 (Preliminary Site Assessment), and (2) to estimate the amount and type of waste buried in the pits / bunker / dumped at the surface (or to make more accurate estimates than the estimates made during Phase 1).

A distinction needs to be made between a pit, a bunker and / or dump. The difference is:

- A pit is a hole that has been excavated and filled with hazardous waste, and then may be covered with soil
- A bunker is clearly visible, typically consists of concrete or brick laid walls, bottom and top-cover, in many cases the top of the bunker is above ground level
- A dump is a location where waste is dumped on the surface with or without facilities like a bunds and surface drainage

While the dimensions of a bunker or dump are easy to measure (limited number of drillings needed to verify the height / depth), pits are more laborious to assess. Usually there are visible signs of buried hazardous waste on the surface, such as difference in surface height, the absence of vegetation cover, stressed vegetation, or other (obvious) signs of contamination (e.g. presence of plastic, scrap metal, hazardous waste, or other wastes). It is recommended to carry out a limited intrusive survey and / or to use remote sensing techniques.

An intrusive survey can be performed by soil drillings or digging small sample pits just at the expected borders of the buried hazardous waste. Remote sensing techniques such as ground radar and or aerial photographs are used more and more to trace anthropogenic relics in the subsoil because it is more accurate, safer and often cheaper.

If the exact location of the pit is unknown, and ground radar or other non-intrusive techniques are not available, exploratory drilling should be performed to locate and delineate the pit. A grid of 2 x 2 meters overlaying the suspected site of the pit is useful to determine the exact pit location (see example in Figure 3.2). The drilling should be advanced at minimum 0.5-meter intervals and soil cuttings checked for visual presence of hazardous waste. The bore logs (see examples in Figure 3.3) should be prepared in sufficient detail as these are critical for assessing the approximate volume of the pit.

The location of the boreholes should be recorded on a map, with an overlay of the 2 x 2 meter grid. Figure 3.2 presents an example of such a map, with the borehole locations indicated. Note that some boreholes are located on the grid, whereas some are not.
These latter boreholes are used to delineate the approximate dimensions of the pit. Only one borehole is placed in the pit itself to determine the depth of the pit. The mapping starts with placing boreholes that are most likely not in the pit, i.e. that are clean. This is followed by the installation of boreholes that are probably just on the borders of the pit. The very last borehole is constructed in the pit when the pit boundaries are known. In general, the mapping and delineation is done from clean to contaminated borehole locations to avoid cross contamination as much as possible. Borehole(s) at a strategic location(s) such as downstream of the pit could be developed as monitoring well(s) for verification of impacts to the groundwater.

The following information should be collected during the pit survey and reported:
- Description of the pit / bunker or dump location (add to the map)
- The x-, y-, and z-coordinates of each corner of the pit / bunker (use GPS - a 'VN2000' map is to be drawn when back from the field)
- Photo report of the pit / bunker
- Description of observation methods (drillings and / or test pits and / or remote sensing images)
- The depth, length and width of pit / bunker
- The estimated volume of the pit / bunker
- The type of buried hazardous waste (unknown liquids in drums, powder in bags, et cetera)
- The groundwater level in the dry season and in the rainy season (locals may know)
- The number of households, water wells within a 100 m radius from the pit / bunker (add to the map)

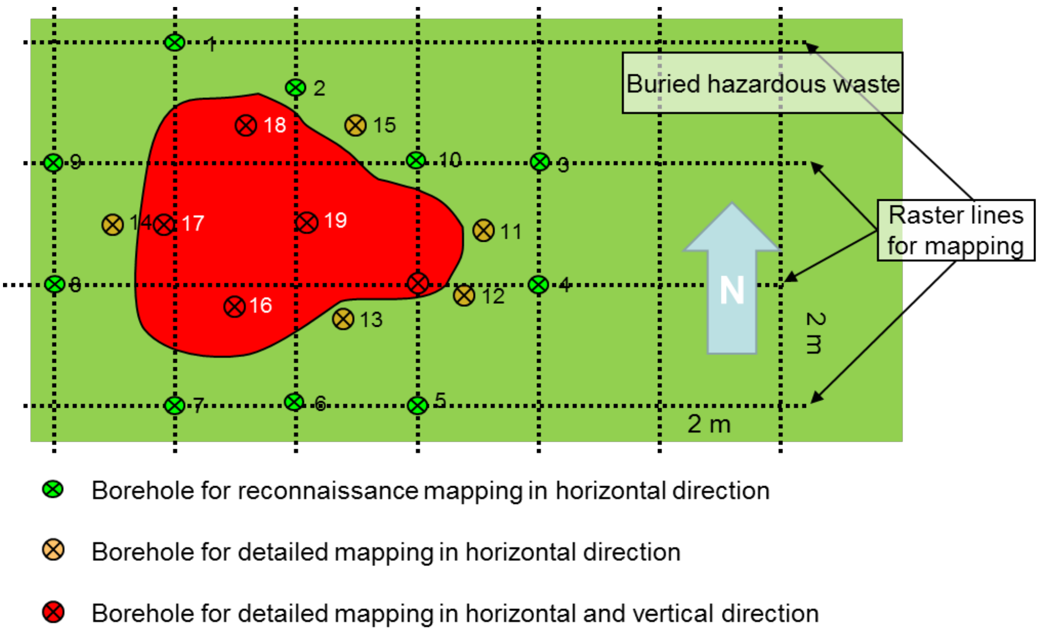

Figure 3.2 Example of a drilling plan for a pit survey

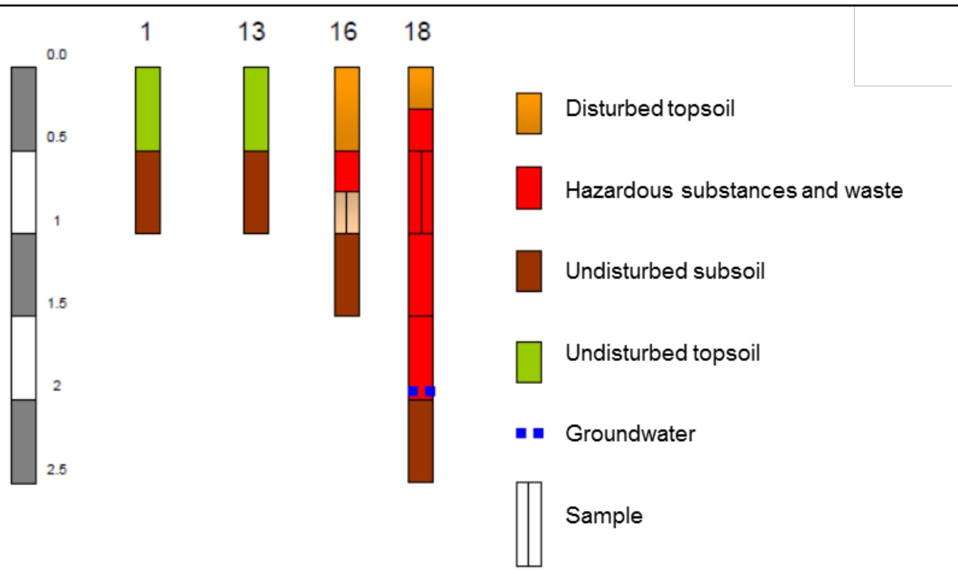

Figure 3.3 Example of bore logs indicating presence / absence of hazardous waste

The Pit Survey Plan should at least contain:

- The needed PPE
- The needed manpower and their qualifications
- The needed sampling materials
- The needed survey equipment
- A timeframe and detailed planning for the pit investigation
- A scaled map with an arrow indicating the North, showing:
  - The location of the pit(s) or bunker(s) to be surveyed
- The necessary field forms such as:
  - Logbook
  - Bore logs
  - Sample transport form (for samples to be submitted for analysis)

3.2.7 Soil and groundwater Investigation Plan

In general, there are four different sampling approaches for contaminated sites (see Figure 3.4):

1. Systematic sampling
2. Random sampling
3. Judgemental sampling
4. Combination sampling

In the systematic approach, the site is covered with a grid of sampling locations, whereas the judgemental approach is used to confirm the presence of the contaminant as suggested by the ICSM. The random sampling approach is currently not well regarded as a standalone method, because more samples are needed for reaching acceptable levels of confidence than in the other approaches. The sampling approach should always be selected based on the site-specific conditions.

The number of sampling locations needs to be chosen to adequately characterize the vertical and horizontal extent of the contamination. Since the aim of the investigation is to delineate the area of potential contamination, samples also need to be taken in areas where contamination was previously not suspected. The amount of sampling points that are necessary depend on e.g. size of the site, extent of the suspected contamination, costs, future land use, and availability of time and suitable equipment.

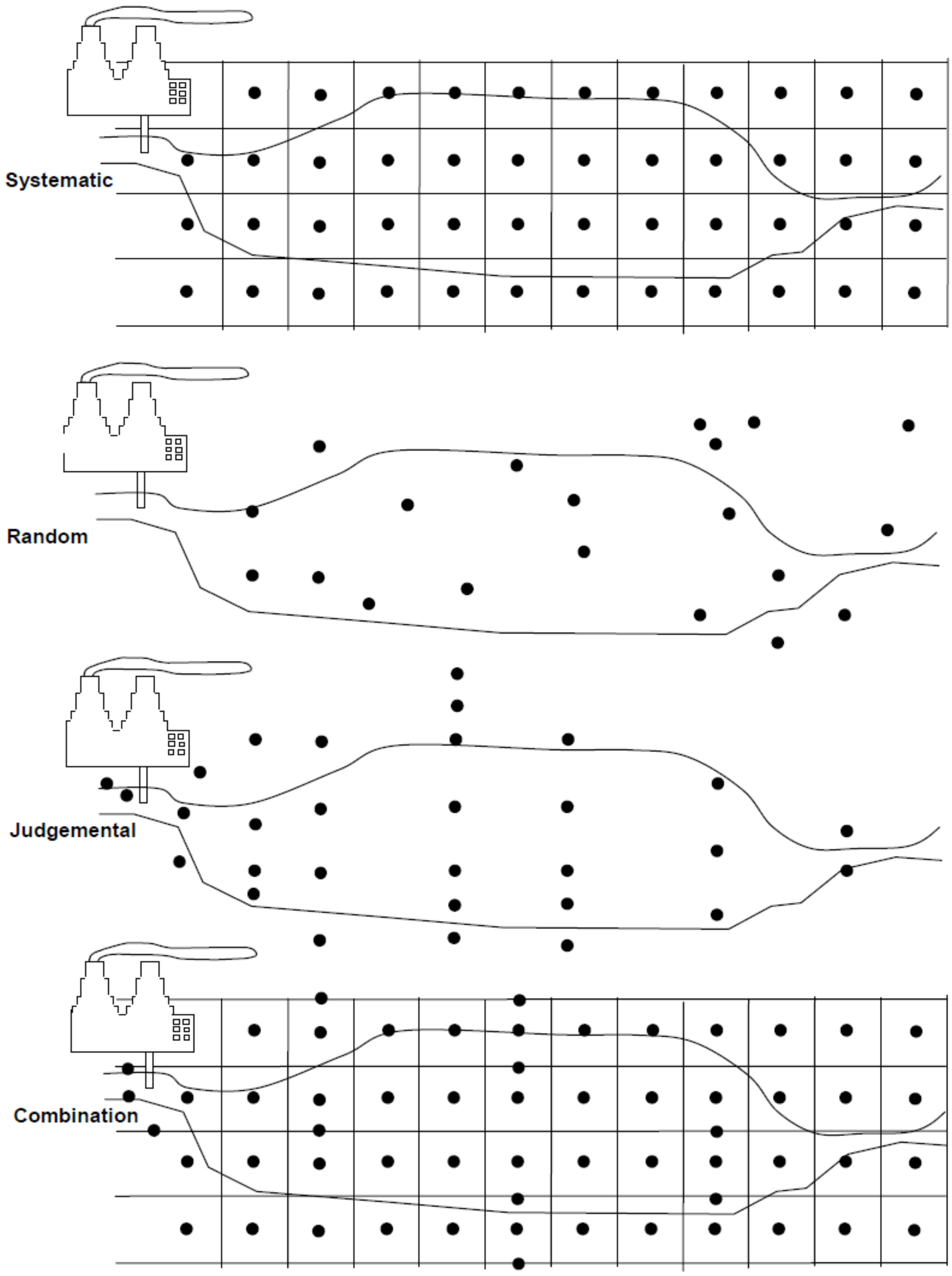

Figure 3.4 Examples of sampling types (modified from Keith, 1983 by UNIDO, 2010)

In these Guidelines, a distinction is made between the sampling of the source areas (hotspots) and the remaining contaminated land:

- **Source areas or hotspots** are areas that are usually visually affected, located close the pollution source
- **Remaining land** is the area surrounding the hotspot, and does not appear affected, but may have been

Hotspot

The focus of a hotspot survey is on the strongly contaminated topsoil (mostly from 0.0 until 0.5 meters below surface) most likely implying direct environmental risks. The result of the hotspot survey should allow that a complete and safe hotspot remediation could be carried out. Therefore, the extent (quantity) and level of contamination should be established.

The **first step** in a hotspot survey is to check for locations suspected of being contaminated as identified in the Preliminary Site Assessment. Usually there are visible signs of soil contamination, such as the absence of vegetative cover, stressed vegetation, or other (obvious) signs of contamination (for example presence of product, plastic, scrap metal or other wastes). It is expected that in most cases the degree of contamination outside the visibly affected hotspot, (‘the contamination contour’) is much lower. The **second step** is soil sampling and analyses. Sampling and analyses to verify the field observations are proposed on a contour that lies a few meters outside the outer contour of the visibly contaminated area of the hotspot. The sampling interval depends on the size of the visible contamination contour. Only the topsoil will be sampled. The **third step** comprises of the installation of one or two drillings in the hotspot. These boreholes will be deeper than the visibly contaminated topsoil to determine the depth of the hotspot.
The **fourth step** is to mix five to ten individual samples to make one Composite Soil Sample (CSS) for analysis.

To map the contamination contour, the number of CSSs depends on the size (surface area of the source area) of the visibly contaminated area. As a rule of thumb:

- Two CSSs are sufficient for a contaminated area under 25 m^2
- For areas of 25 to 100 m^2, 3 CSSs should be taken
- For areas above 100 m^2, 4 CSSs should be taken
- Every CSS consists of 5 to 10 individual samples (from drillings)

Figure 3.5 is an example of how to construct a hotspot-sampling plan. The ‘stars’ in Figure 4.3 are the boreholes locations used to take individual samples. The ‘stars’ with the same colour are the borehole locations to compose one CSS.

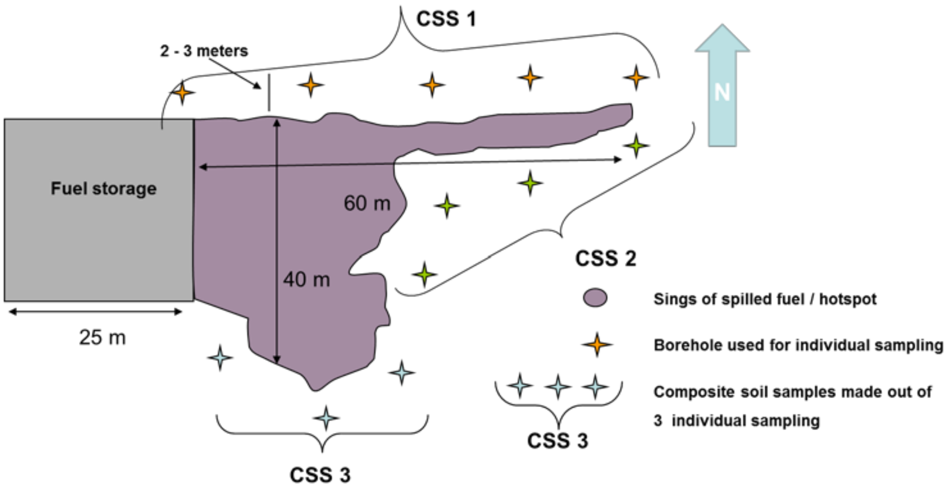

Figure 3.5 Example of hotspot survey in front of a fuel storage (modified from Tauw, 2015 b)

For verification of the visibly contaminated area within the hotspot, one CSS made up of five to ten individual samples is sufficient. **The fifth and last step** is the analyses of the CSSs for preferably the Chemical of Concern (in this example Total Petroleum Hydrocarbons) and sum parameter to establish the total content of hazardous substances. Analytical results will confirm if the visibly contaminated area really is (much) more contaminated, compared to the outer area, which does not immediately appear to be contaminated. Typically, the results will indicate that this is the case. This means that the hotspot is now delineated. The volume of the contaminated hotspot can be estimated based on the surface area times the depth, established with one or two deeper boreholes inside the hotspot.

In case the site is suspected to be contaminated by Persistent Organic Pollutants (POP, such as HCH isomers), analysing total extractable organic halogen compounds (EOX) in soil samples can be useful while conducting a hotspot survey. EOX is a parameter indicative of organic halogen pesticides, including all POP pesticides and a broad range of other pesticides and herbicides. The hotspot material often has EOX concentrations of 50 mg per kg (dry matter) and above. Having EOX as an indicator has the benefit that broad and reliable screening is obtained at relatively low cost.

Please note that the laboratory should be notified if high contaminant concentrations in the samples to be analysed are suspected as this may damage analysing equipment (in this case, the laboratory will first dilute the sample).

Remaining land
Unlike an obviously contaminated hotspot, the areas surrounding may also be contaminated and may need to be assessed if the Preliminary Site Assessment indicated that it is of relevance to know the soil and / or groundwater quality (for example when there are potential environmental risks). The remaining land should be divided into logical sub-locations or plots according to logical boundaries, such as property boundaries, land use and / or topography. The survey of a sub-location has to verify their individual contamination level and to confirm or rule out if the sub-location is a receptor pathway. The number and location of sampling points across a site depends on for example the variability of the ground conditions; the accessibility of potential investigation locations and areas around the site; H&S; and timescale or budgetary constraints.

As a conclusion, the Soil and groundwater Sampling Investigation Plan and analysis plan should at least contain:

- The needed PPE
- The needed manpower and their qualification
- The needed sampling materials
- The needed survey equipment
- A timeframe and detailed planning for the investigation
- A scaled map with an arrow indicating the North, showing:
  - The source area to be surveyed
  - The suspected subareas / plots of contaminated soil and groundwater
  - The location of underground infrastructure to avoid taking samples in places where such infrastructure exists
  - Soil boreholes for topsoil investigation with depth given in meters below ground level (m bgl)
  - Soil boreholes for subsoil investigation with depth given in m bgl
  - Groundwater monitoring wells with depth and filter length given in m bgl
  - Note that strategic borehole locations are usually located:
    - At increasing intervals from the source area as to assess migration
    - Along the migration route(s) of the contaminant such as: area of deposited run-off, and fans of deposited soil
  - Surface water bodies to be sampled (for example drainage canals)
  - Bottom sediments to be sampled (for example ponds)
- A list of samples to be taken:
  - A system to give each sample an unique code (**ASP1.1**) indicating for instance:
    1. The site – A for site named **A**
    2. The medium to sample – **S** for soil, **W** for groundwater, **B** for bottom sediment
    3. The sub-location / site component – **P** for the site component, the pit with hazardous waste

4. Sample location - **1** for the first borehole at the site component
5. Sample depth - **1** for the first sample from the first borehole at the site component from 0.0 - 0.1 m bgl

- Soil, groundwater, surface water and bottom sediment with sampling depth in m bgl
- Indication if the sample is a 'single / individual' sample or a 'Composite Soil Sample'. CSS can ONLY be composed of soil taken from different boreholes within the same sub-area with the same characteristics
- The planned analyses and analytical requirements

- The necessary field forms such as:
  - Logbook
  - Bore logs
  - Sample transport form

Please note that several rounds of soil and groundwater investigations may be required in order to understand the full contamination situation with respect to soil and groundwater. After knowing the chemical analytical results of the samples, one or more initial hypotheses may be refused (for example, an area expected not to be contaminated was analysed and turned out to be highly contaminated). In this case, more detailed investigation and sampling may be needed until the nature and level of contamination is determined.

Checklist for fieldwork equipment

When drafting the Investigation Plan, it is important to assure that all fieldwork equipment, disposables and non-disposables will be available at the time that the fieldwork is carried out. A standard checklist of equipment (not exhaustive) needed for the fieldwork is listed below:

- Stationery such as notebook, pen, pencil, water-prove markers, rulers et cetera
- A digital camera: photo reports should be made for the site, site components and each important sub-location before, during and after the fieldwork
- Personal Protective Equipment (PPE) such as safety boots, gloves, gas masks, goggles, safety helmet et cetera
- Land survey equipment such as digital camera, measuring tape, GPS, Tachy meter, Theodolite et cetera
- Soil drilling equipment such as (hand) augers with extension rods, shovels, pickaxe, hammers, sampling spoons et cetera
- Equipment to install groundwater monitoring wells such as bailers and casings
- Groundwater monitoring wells such as filters, risers, connectors, bottom and top caps and street box
- Groundwater sampling equipment such as ball valves, peristaltic sampling pump, sampling hoses and water filter et cetera
- Sampling containers such as jars, bags and bottles

- Sample cooling equipment such as cool boxes with ice packs
- Stickers for sample containers
- Field labels for observation wells
- Field forms such as bore logs, sample shipment documents et cetera

The **sampling and analysis plan / Investigation Plan** should also take into account following planning aspects:

- It is advised that the plan indicates the analytical laboratory and the level of their participation in the sampling process
- A good site location map should be available. If a detail topographic map (scale 1:1,000) of the site is not available, the field investigation team or a professional land survey contractor should draw one. It is advised that the plan clearly indicates the responsibilities of the professional land survey agency, if the measurements in the field require their participation
- Contracts with the laboratory and land surveys agency need to be in place before the field investigation starts

A comprehensive overview of materials and methods required for field activities are given in the Part 3 of these Guidelines, Standard Operating Procedures (SOPs).

3.3 Field Investigation

3.3.1 Planning and management aspects

An investigation plan is usually based on the information collected during the past Phase 1 site visits. However, frequently during fieldwork, the planned locations are not accessible or available for borings or the subsoil qualities hinder installing boreholes to the desired depth. Therefore, the technical expert responsible for designing the investigation plan should be available during the field investigation in order to quickly identify alternative boreholes and sampling locations, if needed.

Before starting with the planned tasks for the day, a briefing on the fieldwork tasks, objectives and H&S aspects should be organized. During these short meetings, all fieldwork staff have the opportunity to ask questions. The fieldwork team leader should make notes on the content of these daily meetings.

H&S aspects at the site should be evaluated before the start of the field investigation, so that appropriate control measures can be developed for minimizing the impacts. At the site, all PPE must be issued and checked before starting the field activities. One person should always stay and observe other team members working. If a team member is working in an unsafe manner, the observer should warn the team member immediately and the work should be stopped.

After this, the team leader takes appropriate action, which can vary from changing the PPE to even stop the entire fieldwork. Fieldwork is only started again when the situation is safe.

3.3.2 Standard Operating Procedures for fieldwork

This Part 1 of the Guidelines is focused on conceptual and coordinating aspects and is intended for staff in charge of drafting the plans and acting on a management level, whereas the Part 3 is intended for staff performing the actual fieldwork on instruction from their manager. Therefore, we refer to the Part 3 of these Guidelines, Stand Operating Procedures (SOPs)[5] for detailed descriptions of how to carry out fieldwork and the related H&S aspects. The SOPs can be used as a manual until the fieldwork activity is mastered and can be performed independently without guidance from the SOPs.

The following SOPs are relevant for the field investigations:

Personal Health and Safety

- Health and safety equipment SOP 2.1.1
- Health and safety regulations SOP 2.2.1
- First Aid measures related to contamination SOP 2.2.2
- The use of Respiratory Protective Equipment (RPE) SOP 2.3.1
- Safety meeting / Toolbox meeting SOP 2.4.1
- Start Work Analysis SOP 2.4.2

General

- Field investigation SOP 4.2.1
- Instruction for the setup of a field logbook SOP 4.2.2
- Soil texture identification SOP 4.2.3
- Sensorial observation SOP 4.2.4
- Use of the oil pan SOP 4.2.5
- Soil profile description SOP 4.3.1
- Geographical positioning and levelling of sampling points SOP 4.4.1
- Data management SOP 4.5.1

Field Installations

- Prevention of damage to subsurface facilities SOP 5.1.1
- Operation of a C.A.T. cable detector SOP 5.1.2
- Drilling methods soil SOP 5.2.1
- Installation of monitoring wells SOP 5.3.1

[5] Guidelines for the Sustainable Management of Contaminated Sites in the former Yugoslav Republic of Macedonia – Part 3: Standard Operating Procedures (SOPs, Tauw, 2018)

• Installation of monitoring wells used for LNAPL measurements	SOP 5.3.2
• Installation of monitoring wells used for measuring permeability	SOP 5.3.3
• Development and purging of wells	SOP 5.3.4
• Drilling for aquatic sediment sampling	SOP 5.4.1
• Assessing quantities of aquatic sediment	SOP 5.4.2
• Field installations for soil gas sampling	SOP 5.5.1
• Geophysical techniques for subsurface review	SOP 5.6.1
• Prevention of cross-contamination during soil sampling	SOP 5.7.1
• Equipment decontamination	SOP 5.7.2

Field-testing

• Soil permeability measurements	SOP 6.1.1
• Groundwater table measurement	SOP 6.2.1
• Recording the thickness of LNAPL floating layers	SOP 6.2.2
• Conductivity field measurement in groundwater	SOP 6.2.3
• pH field measurement in groundwater	SOP 6.2.4
• Field measurement in groundwater	SOP 6.2.5

Sampling

• Soil sampling	SOP 7.1.1
• Composite soil sampling in the field	SOP 7.1.2
• Groundwater sampling	SOP 7.2.1
• Drinking water well sampling	SOP 7.2.2
• Coding and labelling of soil and groundwater samples	SOP 7.4.1
• Packaging and preservation of groundwater	SOP 7.4.2
• Quality control during sample handling	SOP 7.5.1
• Chain of custody procedure	SOP 7.5.2
• Sample storage & shipment	SOP 7.5.3

3.4 Data Interpretation and Evaluation

The interpretation and evaluation of the analysis results against technical regulation reference values is key to the determination and classification the contamination situation of the site.

3.4.1 General

After the field investigations, the sampling and testing results can be used for evaluating the degree of contamination at the site and if further site investigations are required. The data interpretation and evaluation comprises of the following tasks:

- Determining the reference technical regulations / national standard frameworks
- Establishing the evaluation framework – classification methodology

- Comparing and interpreting the analytical results of soil, bottom sediment, and groundwater and surface water with the reference values.
- To facilitate the review of interpretation results, it is recommended to refer to: Official laboratory analysis results certificates
- Sampling maps and list of samples

3.4.2 Reference technical regulations / national standards framework

The reference technical regulations / national standards framework presents the referential values for the interpretation and evaluation of soil, bottom sediment, groundwater and surface water analysis results from the site. The reference values specify the maximum concentration of which the soil and groundwater quality of a subject property is considered a concern.

Only (still effective) circular, technical regulation / national standards of the Macedonian Government should be used as referential values. In case the existing technical regulations / national standards do not (yet) include referential values for a specific substance, it is advised to use referential values recommended by international conventions or organizations. Some reference values from other European countries are listed in SOP 4.5.2 of these Guidelines: Target and intervention values for harmful substances in soil and Limit values for harmful substances in groundwater. These values are derived from Annex 1 of the Rulebook on types and levels of concentrations of hazardous substances in soil and groundwater and ecosystems, under the Draft Law on Soil Protection. For getting insight into the baseline of soil geochemical properties in Macedonia, please refer to the Geochemical Atlas of the Republic of Macedonia (Stafilov, 2016) or Geochemical Atlas of Skopje (Stafilov and Almeti, 2017).

Some reference values have also been listed by UNIDO (2010), which has gathered Screening levels for soil and groundwater from various governmental Internet sources. The Screening Levels, for example, found for hexachlorobenzene in soil are 3.6 mg/kg (fine soil, industrial / commercial / residential land use), 6.0 mg/kg (coarse soil, industrial / commercial use), 0.5 mg/kg (coarse soil, residential use) and in groundwater 0.00057 mg/l (fine or coarse soil, industrial / commercial/ residential land use).

3.4.3 Evaluation framework - classification methodology

The evaluation framework for the analysis results (‘classification of the contamination situation’) needs to be based on currently effective technical regulations / national standards. In these Guidelines, the above-mentioned technical regulations are used for the classification of contamination levels of a site, or a site component or sub-location within a survey site.

3.5 Conceptual Site Model (CSM)

By using the results of soil, bottom sediment and groundwater investigation as basis for validation, the sources, the receptors pathways and receptors of the site can be identified. Updating the ICSM with this analytical information aims at creating an overview of the contamination situation and the environmental risks at the site. The risks are the trigger to proceed to the next phase of the sustainable management of contaminated site, the Remediation Assessment.

3.5.1 Introduction

The goal of a CSM is to provide a description of relevant site features and the surface and subsurface conditions, in order to understand the extent of identified contaminants of concern and the (potential) risks they pose to receptors. The level of detail of the CSM should match the complexity of the site and available data. The CSM is an iterative tool that should be developed and refined as information is obtained during the whole Site Assessment process. Development and refinement of the CSM will help to identify data gaps in the site characterization and is made to be used in the next phase, the Remediation Assessment. With the updated CSM, all risks related to the site contamination can be assessed.

The updated CSM should include validated information on the following items:

- Description of the source(s) of contamination, the pathway(s) and the receptor(s)
- Sketches of the source(s) of contamination, the pathway(s) and the receptor(s)
- Representative cross sections of the site with source(s), pathway(s) and receptor(s)
- A description of the still existing knowledge gaps to complete or improve the CSM

3.5.2 The process of updating the ICSM

Follow the steps for updating the ICSM (both the site layout and the cross section):

- Use the ICSM developed in Preliminary Site Assessment (see Section 2.4)
- Update the local direction of groundwater flow and local geological situation based on the results of the field investigation
- Draw all sampling points with their ID in the CSM
- Draft a table giving the following information for sampling points:
  - Date of sampling, Number of samplings points and depth of analysis samples
  - Concentration levels of contaminants
  - Indicate if measured contaminant levels are above applicable limit values
- Draw lines for the horizontal delineation of the contamination above the applicable limit values in all surveyed media (soil, groundwater and bottom sediment)
- Draw a question mark (‘?’) for those areas where the delineation is incomplete
- In case hazardous substances are present on the site, indicate all locations, quantities and types of hazardous substances

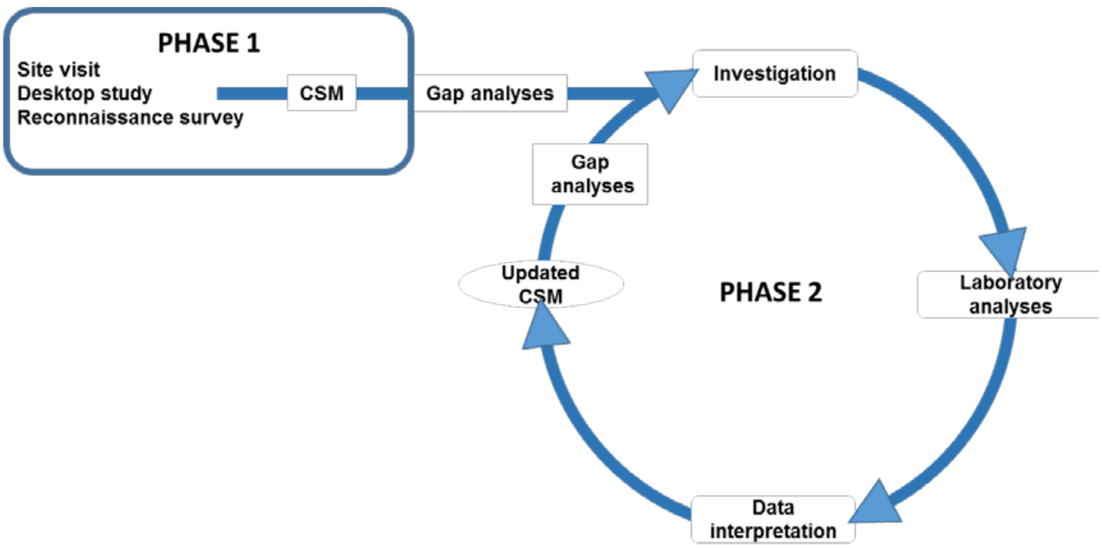

Figure 3.6 The ICSM is updated based on the results of the soil, bottom sediment and groundwater investigations

3.6 Risk Assessment

Risk assessment (RA) allows the most significant risks for human health, ecosystem and contaminant migration to be identified and quantified. With the updated CSM, the environmental site risks can be assessed in more detail than during the Preliminary Site Assessment (described in Section 2.5). Before starting with the Risk Assessment, please make sure that you have performed the tasks described in the previous sections (Gap Analysis and Investigation Plan, Field Investigation, Data Interpretation and Evaluation, and updating the CSM.

3.6.1 The Tiers of Risk Assessments

Risk assessment can be used for estimating the potential impact of a contaminant on humans or the ecosystem, and/or for determining the desired clean up target levels that are protective of human and environmental receptors. Three levels of Risk Assessment exist:

- Tier 1 – A non-site-specific, qualitative RA (Preliminary Risk Assessment in these Guidelines)
- Tier 2 – A site-specific, semi-quantitative RA (Risk Assessment in these Guidelines)
- Tier 3 – A site-specific, quantitative RA based on numerical or highly detailed fate and transport or exposure models

The Tier 2 RA is based on comparison of measured contaminant concentrations in soil and groundwater with a set of reference values. If the measured contaminant concentrations are less than the reference values, the site may be suitable for the nominated use. However, if the reference values are exceeded, the Tier 2 RA indicates potential for a significant risks and a Tier 3 RA may be initiated. The results of a Tier 2 Risk Assessment, a semi-quantitative analysis is sufficient for most cases of the sites assessed in the scope of the sustainable management of contaminated sites. A Tier 3 RA is therefore needed only when the results of a Tier 2 RA indicate that mitigation measures demand major investments, more justification for the investment is needed and / or the results are not conclusive.

For assistance in the quantitative Tier 3 RA, various programs exist. The (Risk Based Corrective Action) RBCA Risk Assessment tool of the US-EPA is one of the most widely used. Background information on various quantitative Risk Assessment tools can be consulted on the website of the US-EPA. During a Tier 3 RA, receptors could be identified in detail in accordance with reference manuals such as *Assessing soil contamination*[6], in which dispersion equation for contaminations are described. An experienced toxicologist should do these RA. As such, no further information on Tier 3 RA is incorporated in these Guidelines.

The RA generally requires physical and chemical data for the present contaminants, the soils, underlying rock, and ground- and surface waters. In cases where site-specific data is not available for all parameters, values from books, the internet or other references might be used. When choosing data, the most conservative values (the most protective of the environment) should be used. The parameters that have the greatest impact on the results of the RA should be chosen very carefully. In order to identify these parameters, a sensitivity analysis can be conducted.

3.6.2 Categorization Tier 2 Risk Assessment

This section demonstrates the use of tables with reference values and analytical results in order to categorize the environmental risk into ‘direct risk’, ‘remaining risk’ and ‘no risk’ categories, with regard to the exposure pathways (i.e. a sample exceeding the direct risk threshold should not be listed as ‘direct risk’ if there is no potential to reach a receptor). The risk assessment should be discussed with appropriate experts before finalization.

Direct or acute risks

The analytical results evaluated against the reference values from national standards / technical regulations are the first input of the RA (see Section 3.4.2).

[6] Food and Agriculture Organization of the United Nations, 2000: Assessing soil contamination, reference manual, Rome (http://www.fao.org/docrep/003/x2570e/X2570E03.htm#ch3).

In addition, other Site Assessment information, such as the land-use status, groundwater and soil characteristics, should be used for the RA. In case of a complex contaminant situation (e.g. unexpected contaminants present on the site), consultation from an experienced toxicologist or another qualified expert is needed to assess if there are any significant risks. The direct risks can be reported in a table format, as presented in Table 3.3 (direct risks) and 3.5 (other potential and latent risks). The risks presented are in line with the update ICSM as presented in Figure 3.4 and 3.5.

Table 3.3 Example: Direct or acute risks

Sub-location	Land use type	Contaminant levels	Associated direct risk
Hazardous waste dumped in pit	Industrial	Concentration of COC in the hazardous waste exceed action values	**Human health risks** Human exposure by direct contact, vapours, and contaminated dust This causes acute poisoning symptoms
	Industrial	Concentrations of COC in soil exceed action values	**Human health risks** Human exposure by direct contact, vapours, and contaminated dust This causes acute poisoning symptoms
	Industrial	Concentrations of COC in soil exceed action values	**Ecosystem risk** Bird, rodents and insect have direct contact, vapours, and contaminated dust This causes acute poisoning symptoms and contaminants end up in the food chain
	Urban and industrial	Concentrations of COC in airborne dust exceed action values	**Migration risk** Contaminants and contaminated dust spread by wind Site surrounding (downwind) is exposed to contaminated dust
	Industrial	Concentrations of COC in percolating rainwater exceed action values	**Migration risk** Contaminants are spread by percolating rainwater to deeper soil layers
Sump inside building	Industrial	Concentration of COC in the hazardous waste exceed action values	**Human health risks** Human exposure by direct contact, vapours, and contaminated sediment sump This causes acute poisoning symptoms
	Nature		**Ecosystem**

Sub-location	Land use type	Contaminant levels	Associated direct risk
		Concentrations of COC in the sediments exceed action values	Exposure of the ecosystem by the contaminated sediment This causes acute poisoning symptoms
	Nature	Concentrations of COC in surface water exceed action values	**Migration risk** Contaminants are spread by streaming surface to other parts

Table 3.4 Potential and latent risks

Sub-area	Land use type	Contaminant levels in soil / water	Associated human health risks
Hazardous waste dumped in pit	Industrial	Concentrations of COC in soil exceed background values and are below action values	**Human health risks** Human exposure by direct contact, vapours, and contaminated dust This may potentially effect human health
	Industrial	Concentrations of COC in soil exceed background values and are below action values	**Ecosystem risk** Bird, rodents and insect have direct contact, vapours, and contaminated dust This may potentially effect the ecosystem and contaminants may end up in the food chain
	Urban and industrial	Concentrations of COC in airborne dust exceed background values and are below action values	**Migration risk** Contaminants and contaminated dust spread by wind Site surrounding (downwind) is potentially exposed to contaminated dust
Sump inside building	Nature	Concentrations of COC in the sediments exceed background values and are below action values	**Ecosystem** Exposure of the ecosystem by the contaminated sediment This may have a negative impact on the ecosystem
	Nature	Concentrations of COC in surface water exceed action values	**Migration risk** Contaminants are spread by streaming surface to other parts

3.6.3 Risk Assessment Evaluation

The RA should be finalized with drafting conclusions and recommendations:

1. Summarized conclusions focusing on whether the site as a whole does or does not have an issue with soil / sediment / groundwater contamination
2. Summarizing the established site-specific risks and site-specific recommendations. This information is to compare site components and is used to prioritize remediation measures within a site. Direct or acute risks should be mitigated in the short term, the potential risks in the mid-term, and the latent risk should be contained for the long term

Both sections in the report should make use of a short and factual reporting style. To give the reader an idea of the way this information should be presented, examples of the two levels of risk evaluation are given below.

Example of risk evaluation on site level

This site is classified as an urgent site because of the direct human health and ecosystem risks due to the dumped hazardous waste. Direct risk for migration by air, runoff and groundwater are also established. Emergency measures such as capping the hazardous waste should be taken on the very short term.

The groundwater contamination extent is not completely known. This should be mapped by installing groundwater-monitoring wells. The groundwater assessment should be future assessed with the focus on the downstream village wells used for domestic purposes.

3.7 Reporting of Site Assessment

Based on the results of all steps taken as described above, sufficient data should be available for writing Site Assessment report.

The Site Assessment report should include at least the following subjects:

Summary of the Site Assessment (0.5 - 1 page)

1. **Introduction**
   1.1. Motivation and objectives for the Site Assessment
   1.2. Site history, including location of any known or suspected activities which may have posed a risk to human health or the environment
   1.3. Structure of the Site Assessment report
2. **Site background information**
   2.1. Legal aspects – owner and responsible people of the site
   2.2. Geology, soil characteristics and hydrogeology
   2.3. Climatology

2.4. Past, present and future land use and activities
2.5. List of chemicals used on site
2.6. ICSM
2.7. Results and Conclusions of the Preliminary Risk Assessment

3. Site Investigation Plan

3.1. Inventory of the hazardous substances
3.2. Building Assessment plan to assess the contaminated (parts of) buildings and infrastructures
3.3. Survey plan to investigate the horizontal and vertical extent of the buried hazardous waste
3.4. Soil and groundwater sampling and analyses plan

4. Field investigation

4.1. Number of field work days
4.2. Number and depth of all boreholes
4.3. Number and depth of all samples
4.4. Other direct observations

5. Field and analytical results

5.1. Site specific geology, geohydrology and soil properties
5.2. Reference values used for comparison
5.3. Analysis results and their evaluation

6. Conclusions drawn from field work activities and analysis results

6.1. Overview of all primary and secondary source zones
6.2. Overview and description of all contaminant pathways
6.3. Overview of all receptors

7. Updated Conceptual Site Model

7.1. Summary of the site and its natural and man-made environment
7.2. Summary of the contamination sources, pathways and receptors
7.3. Description of information needed to proceed with the Remediation Assessment
7.4. Illustration(s) of the site layout with site sub-location(s) and site component(s)
7.5. Illustration(s) of representative longitudinal section(s) and cross section(s)

8. Results of the Risk Assessment

9. Conclusions and Recommendations

9.1. Conclusions
9.2. Recommendations

References

Appendices

1. Site location map (preferably a regional map)
2. Scaled detailed site layout map (showing site components, sub-locations and other important site features, north arrow, and scale)
3. The same scaled detailed layout map(s) as previous (2) with:
   - Location, type and depth of all sampling points
   - Location of the cross and longitudinal sections
   - The contour of the source area(s)
   - The identified soil and groundwater contours
   - The identified receptor(s)
4. Cross and longitudinal sections with:
   - Site components and sub-locations
   - Soil composition
   - Groundwater depth
   - Soil and groundwater contamination contours in vertical direction
5. Bore logs
6. Groundwater sampling logs
7. Laboratory certificates
8. Phase 2 photo report

4 References

Food and Agriculture Organization of the United Nations, 2000: Assessing soil contamination, reference manual, Rome

Tauw, 2018: Guidelines for the Sustainable Management of Contaminated Sites in the Former Yugoslav Republic of Macedonia – Part 3: Standard Operating Procedures (SOPs)

Law on Environment of the Republic of Macedonia (("Official Gazette of the Republic of Macedonia" Official Gazette No.53/05, 81/05, 24/07, 159/08, 83/2009, 124/2010, 51/2011, 123/12, 93/13, 163/13, 42/14, 44/15, 129/15, 39/16)

Law on Chemicals of the Republic of Macedonia (("Official Gazette of the Republic of Macedonia" Official Gazette of RM “No 145/10, 53/11, 164/13, 116/15, 149/15, 37/16)

Law on Safety and Health at Work of the Republic of Macedonia ("Official Gazette of the Republic of Macedonia" No. 136/11, 25/13, 137/13, 164/13, 158/14, 15/15, 129/15 , 192/15, 30/16);

Rulebook on types and levels of concentrations of hazardous substances in soil and groundwater and ecosystems (draft), Ministry of Environment and Physical Planning of the Republic of Macedonia and Ministry of Health of the Republic of Macedonia

Geochemical Atlas of the Republic of Macedonia, Faculty of Natural Sciences and Mathematics, Ss. Cyril and Methodius University, 2016 Skopje, Republic of Macedonia, Skopje

Geochemical Atlas of Skopje, T. Stafilov, R. Šajn and L. Ahmeti, Faculty of Natural Sciences and Mathematics, Ss. Cyril and Methodius University, 2017 Skopje, Republic of Macedonia,

Report summarizing the results of the reviews and outlining the literature and legal acts and practices for the development of the national regulatory acts, Stefanoni and Pejcinovska-Andonova, October 2015 Skopje, Republic of Macedonia,

Tauw, 2015 a: EMP Guidelines for Sustainable Management of POP pesticides contaminated sites, PHASE 1 the Preliminary Site Assessment

Tauw, 2015 b: EMP Guidelines for Sustainable Management of POP pesticides contaminated sites, PHASE 2 the Site Assessment

UNIDO, 2010: Persistent Organic Pollutants: Contaminated Site Investigation and Management Toolkit
http://www.unido.org/fileadmin/user_media/Services/Environmental_Management/Stockholm_Convention/POPs/toolkit/Contaminated%20site.pdf