



Bu proje Avrupa Birliđi ve Türkiye Cumhuriyeti tarafından finanse edilmektedir.

International Stepwise Approach of the Sustainable Management of Contaminated Sites

Best Available Techniques and Best Environmental Practices

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(1) POPs contaminated sites





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(1) POPs contaminated sites - Currently a hot topic in the media

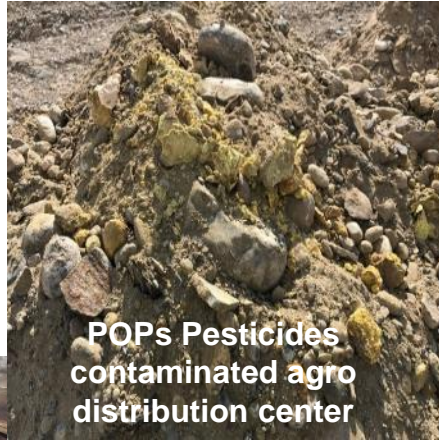
Per-fluoro-octane sulfonic acid, its salts or PFAS and per-fluoro-octane sulfonyl fluoride or PFOS

- Widespread used
 - ✓ Electric and electronic parts
 - ✓ Fire-fighting foam
 - ✓ Photo imaging
 - ✓ Hydraulic fluids
 - ✓ Textiles
- Fulfills the toxicity criteria of the Stockholm Convention
- Extremely persistent
- Bioaccumulations and biomagnifying properties
- Binds to proteins most notably in the blood and the liver
- Long-range transport
- Water soluble very challenging to remediate in groundwater, soils, sediments
- Complex fate and transport profile
- High potential for offsite migration of contaminants in groundwater plumes
- Destruction of PFOS and other PFAS is proving difficult and is often incomplete with standard POPs destruction techniques
- Research in the area is intense and new treatment methods are under development



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(1) POPs pesticides contaminated sites



POPs Pesticides contaminated agro distribution center



Former POP pesticides store



Storage POPs pesticides (lindane) production waste



Sarcophagi/ bunker with POPs pesticides



DDT contaminated site Viet Nam



Landfill with POP pesticides



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(1) The objectives of this presentation

- **Introduce**

- ✓ Stockholm Convention BAT & BEP guidance on the sustainable management of POPs contaminated sites

- **Explain**

- ✓ The five phases of the sustainable management of contaminated sites
- ✓ The use of a CSM when managing contaminated sites

BAT = Best Available Techniques

BEP = Best Environmental Practice

CSM = Conceptual Site Model

The CSM is the tool to sustainable manage contaminated sites



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(1) Objectives sustainable management contaminated sites

- **Protect human from contact with contaminants**
 - ✓ Direct contact: dermal contact, swallowing and inhalation
 - ✓ Indirect contact: through food & water
- **Protect ecosystem**
 - ✓ Protect soil and groundwater from getting contaminated
 - ✓ Protect drinking water resources from getting contaminated
 - ✓ Protect surface water from getting contaminated
- **Prevent migration of contaminants**
 - ✓ Prevent contaminants to become airborne
 - ✓ Prevent contaminants to run-off
 - ✓ Prevent contaminants to leach into soil & groundwater

Environmental risks are:

- *Human health risks*
- *Risks for the ecosystem*
- *Risks for migration of contaminants*



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(1) Dealing with contaminated sites

When you have a wide scientific knowledge concerning contaminant fate and transport processes in soil and groundwater, site characterization, Human Health Risk Assessment, Ecological Risk Assessment and Groundwater-related Risk Assessment, AND have experience with designing cost-efficient Risk Management solutions AND have a creative personality AND have good communication qualities AND are in a position to take policy decisions: Go ahead. Otherwise: Build a team.

Frank Swartjes

Dealing with Contaminated Sites

From Theory Towards Practical Application

National Institute of Public Health and the Environment (RIVM), Bilthoven, The Netherlands



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(2) Conceptual Site Model - CSM

Definition

- A model of a contaminated site that describes the distribution, release mechanisms, exposure pathways and migration routes and potential receptors of the contaminants of concern
- ‘Visually oriented, comprehensible representation of what is already known about a site’

Goal/aim

- CSM organizes all available historical and current information and facilitates the identification of information gaps
- Tool to support decision making process by reducing and managing contaminated site-related uncertainties
- Basis for optimized site-related decisions



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(2) We use the following types of CSM

- Initial Conceptual Site Model
 - Is made with available data
 - Is made by experienced expert, expert judgement is crucial
 - Is made after a site visit
 - Should not be costly and time consuming to make
- Improved/completed Conceptual Site Model
 - Initial CSM is the input
 - Improved with on-site field data, chemical & physical sample analyses
 - Is made by a multidisciplinary team
 - Is made in an iterative way with data collected in various campaigns
 - Is costly and time consuming to make
- Updated Conceptual Site Model
 - Improved CSM is the input
 - Is made when on-site situation is changed
 - Should be after the site remediation measures are implemented
 - Should be made when the remediation is completed



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(2) The pieces of the puzzle / the Conceptual Site Model

- Site history
- Past and current site lay-out above and below ground
- Current and future land-use
- Site and surrounding geology
- Site soil type(s), structure and heterogeneity
- Site and surrounding hydrology
- Site groundwater depth aquifer(s) and aquitard(s)
- Groundwater and flow direction
- Etc.
- Source(s) of the contaminants
- Contaminant(s) types and properties
- Soil Contamination(s): load, location, state, extent horizontal & vertical
- Groundwater contamination(s): load, location, state, extent horizontal & vertical
- Geochemistry & redox conditions
- Natural attenuation potential
- Receptors of the contaminants: ecosystem and/or, humans
- Source – receptor pathway(s): Contaminant(s) fate, transport & migration



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(2) Conceptual Site Model always reveal

- Source(s) of contamination(s)
- Source – receptor pathways / exposure pathways / contaminant migration routes
- Receptors / exposure and uptake

The initial CSM is input for a tier 1 risk assessment

A CSM is the input for a tier 2 and tier 3 risk assessment



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(3) Guidance on BAT & BEP for management of POP contaminates sites

- Executive summary
- Module 1 - Background to POPs contaminated sites
- Module 2 - Principles and Approaches for Contaminated site Management and Remediation
- Module 3 - Site investigation, Assessment and Conceptual Site Model
- Module 4 - Environmental Risk Assessment
- Module 5 - Remediation technologies and techniques
- Module 6 - Technology selection tool for remedial options
- Module 7 - Stakeholder Engagement, Public and Worker Safety and Health
- Module 8 - Contaminated Sites Remediation and Monitoring and Aftercare
- Module 9 - Getting started: Legislation, Policy and Inventory Development
- Module 10 - Case Studies

Available on the website of the Stockholm Convention
Order of modules in this BAT BEP guidance will soon adapted as presented here



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(4) Phased approached of the contaminated sites management

Phase 1 Preliminary Site Assessment

Phase 2 Site Assessment

Phase 3 Site Remediation Assessment

Phase 4 Site Remediation Management

Phase 5 Site Monitoring & Aftercare

For each phase

- *The responsible party should be appointed*
- *Accountable party should contracted*
- *The parties to be informed should established*

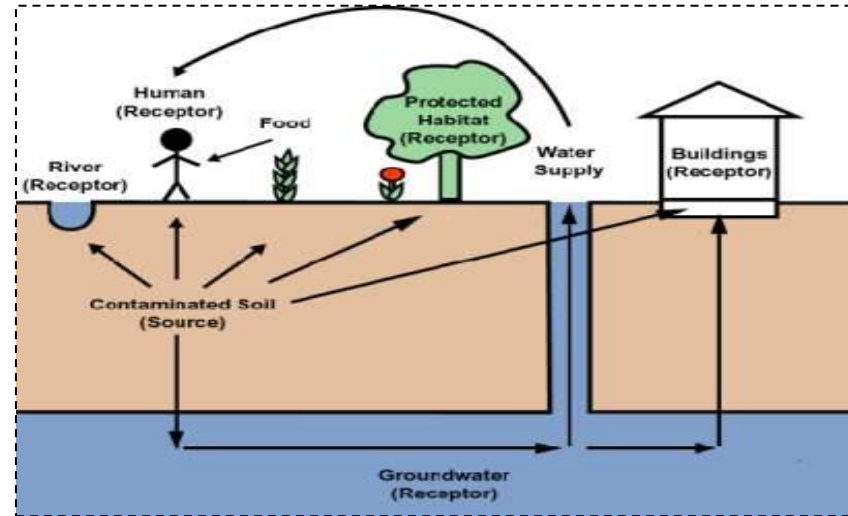
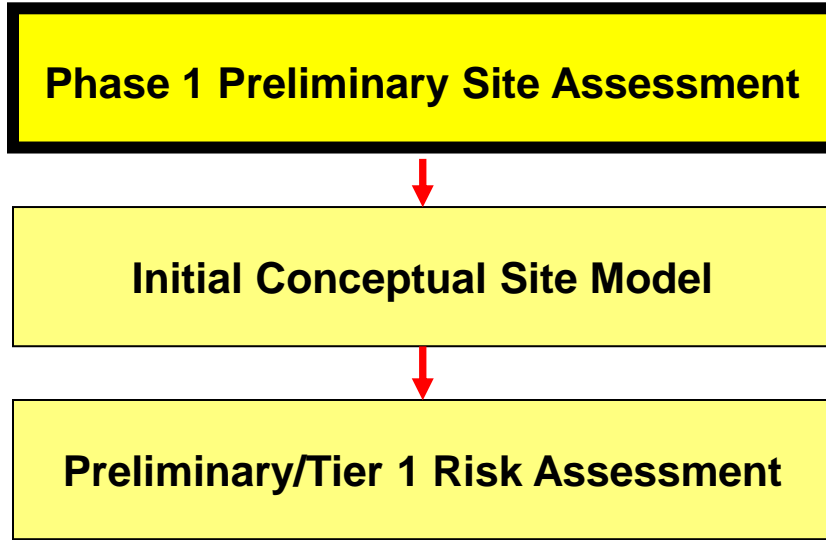
The project planning should be

- *Project specific*
- *Realistic – cost – objectives - time*
- *Flexible*



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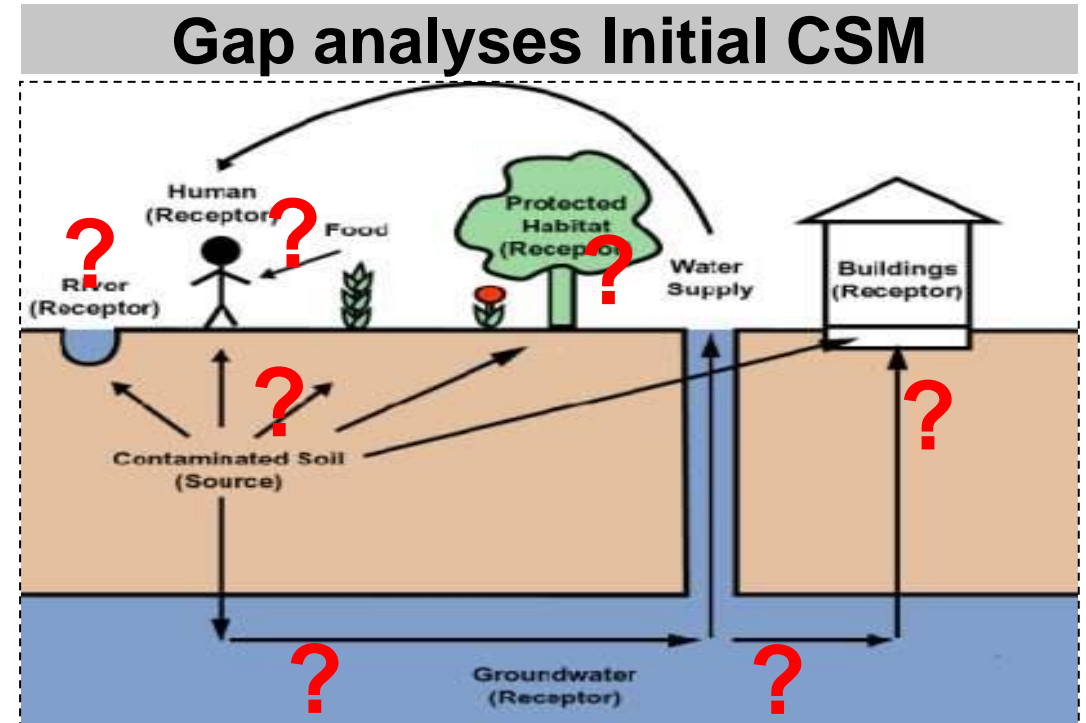
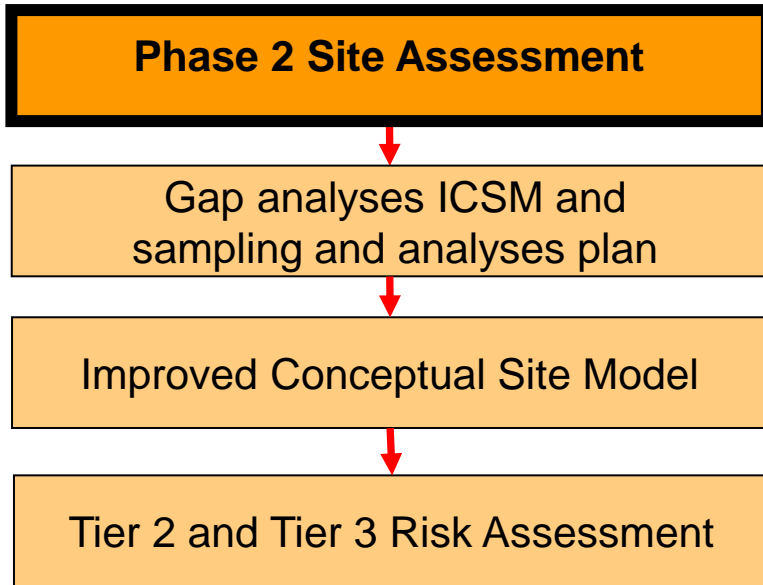
(4) Phase 1 - Deliverables





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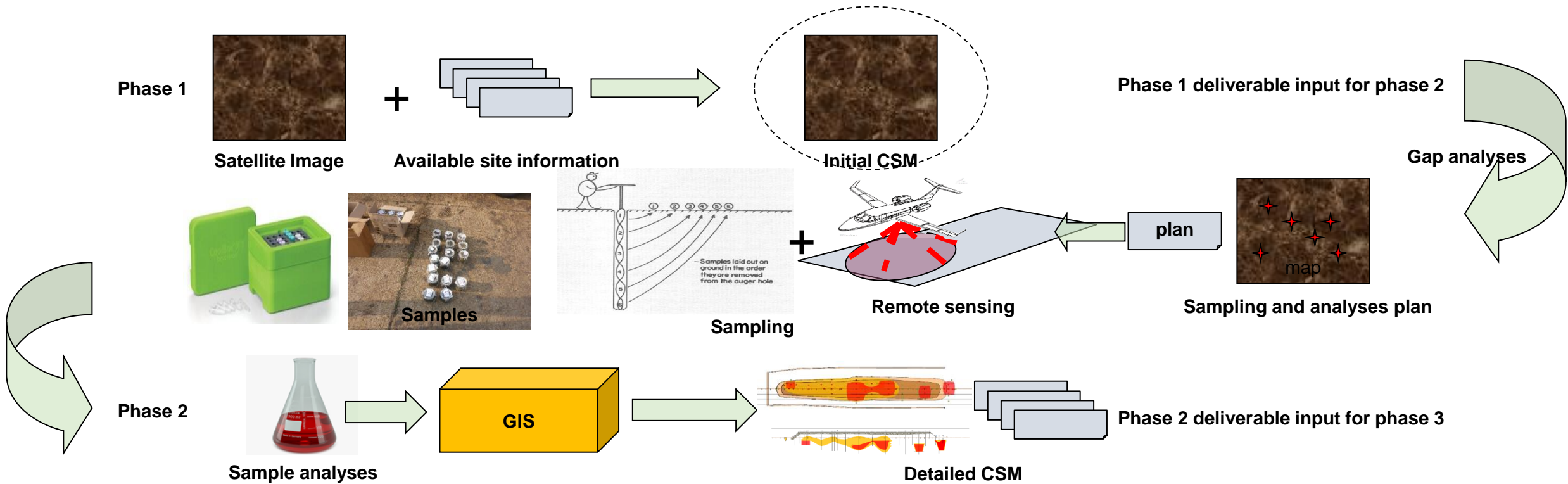
(4) Phase 2 - Deliverables





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(4) Phase 1 and 2 – Survey strategy



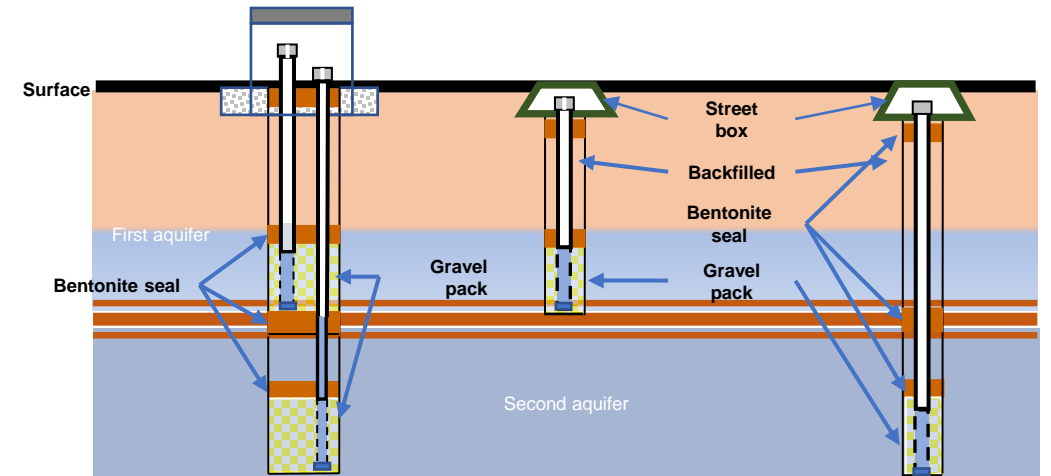


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(4) Phase 2 - Improved Conceptual Site Module

Source(s) of contamination

- Description of the cause of the contamination
 - ✓ The history of the contamination
 - ✓ The current situation
 - ✓ If the source(s) is/are eliminated or still is emitting
- Description of the type of contaminants
 - ✓ The compounds and the concentrations in soil and groundwater
 - ✓ Do they exceed the target levels
- Description of the extent of the source
 - ✓ Horizontal
 - ✓ Vertical



Not to scale



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(4) Phase 2 - Improved Conceptual Site Module

Receptor – source pathway(s)

- Description of the identified receptor's pathways
 - ✓ Wind dispersing contaminated fine soil particles
 - ✓ Run-off of rainwater spread contaminated soil off-site
 - ✓ Percolation of rainwater leaches contaminants in soil and groundwater
 - ✓ Groundwater flow disperse contaminants in the groundwater
- Description of the type of contaminants
 - ✓ The compounds
 - ✓ The concentrations in soil and groundwater
 - ✓ Do they exceed the target levels
- Description of the extent of the pathways
 - ✓ Vertical
 - ✓ Horizontal



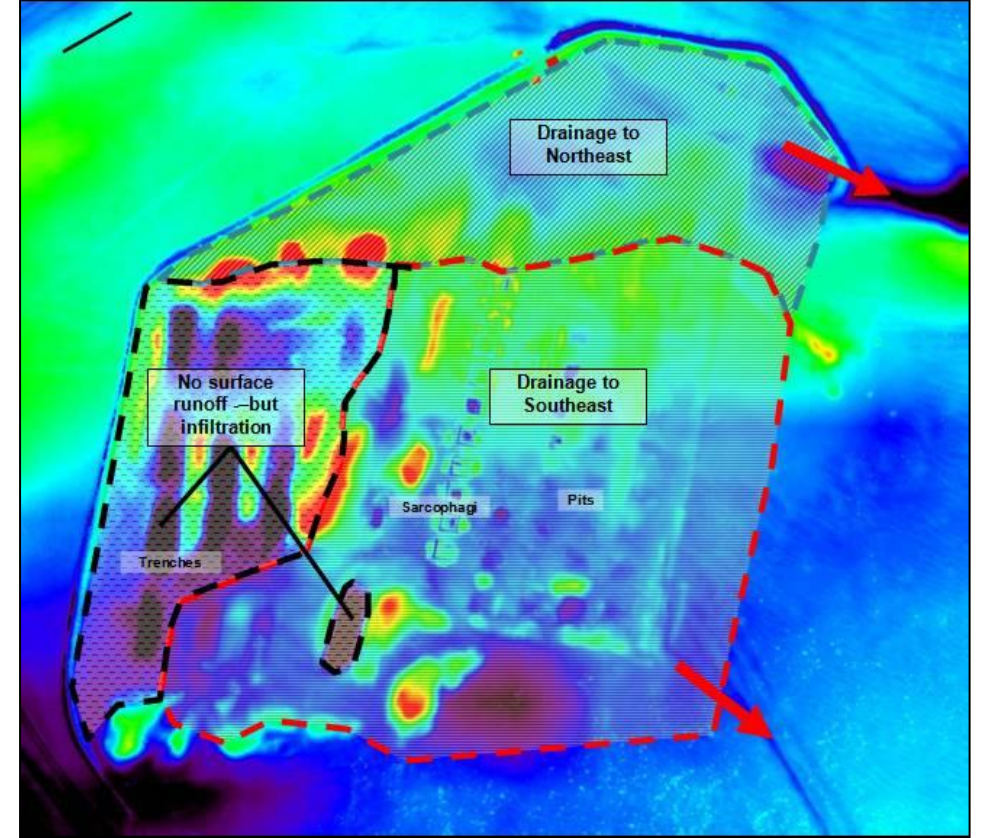


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(4) Phase 2 - Improved Conceptual Site Module

Receptors

- Description of the identified receptors
 - ✓ Human
 - ✓ Ecosystem



Improved Conceptual Site Module



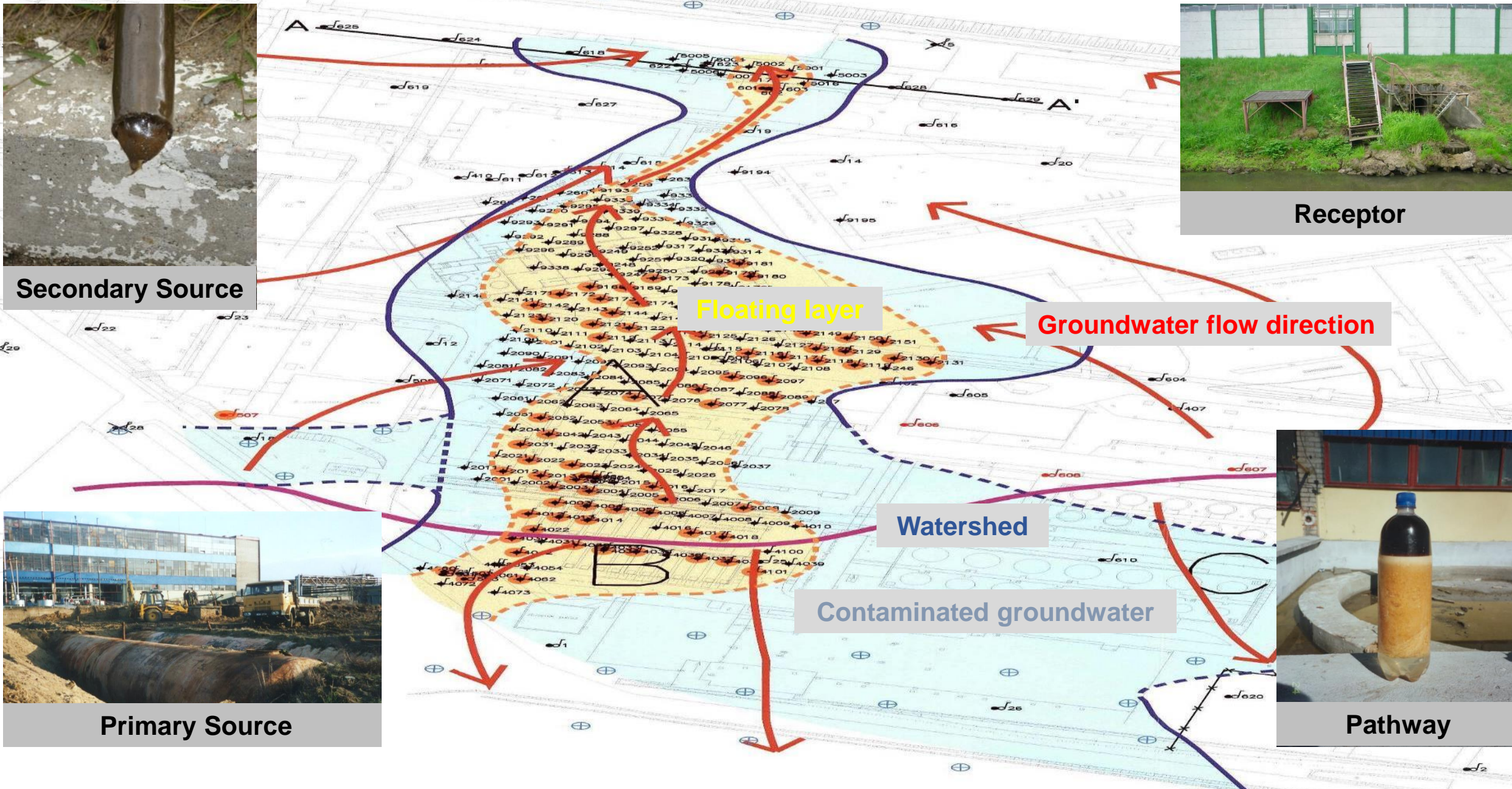
Secondary Source



Receptor



Primary Source



Pathway



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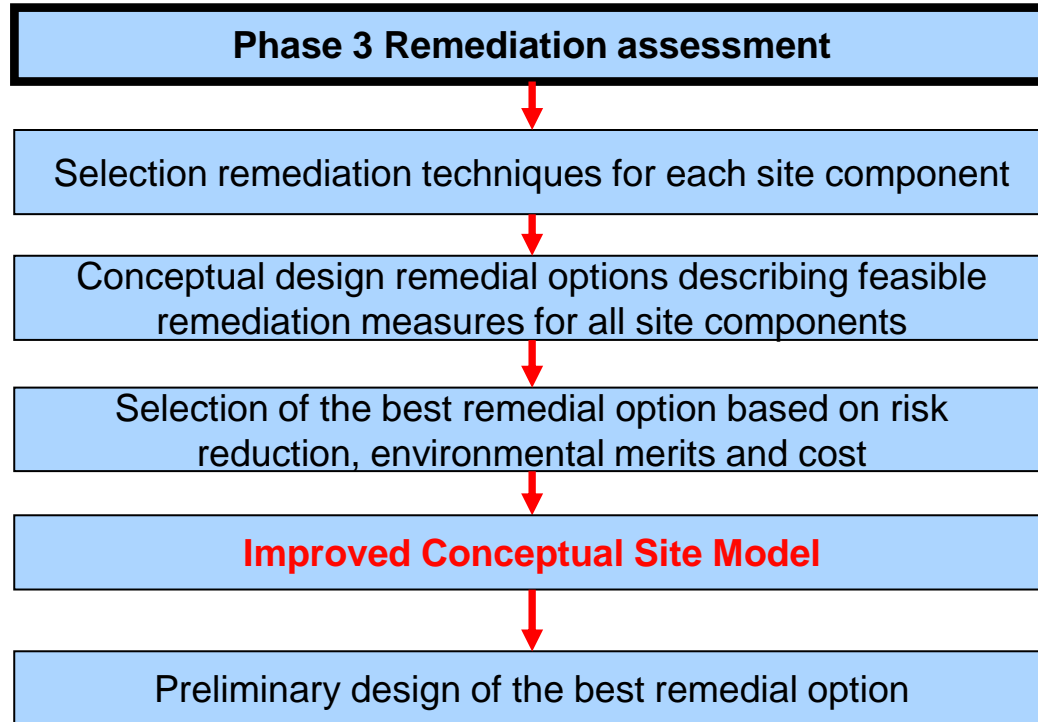
(4) Phase 2 – Risk Assessment

- **Quantification of direct, potential & latent risks for**
 - Human health
 - Ecosystem
 - Migration into the environment
 - **The levels of contaminants in soil & groundwater**
 - ✓ Are analyzed
 - ✓ Analytical results are tested against national reference levels -**Tier 2**
- And/or
- ✓ Risk assessment models are used to establish the risks - **Tier 3**



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(4) Phase 3 - Deliverables

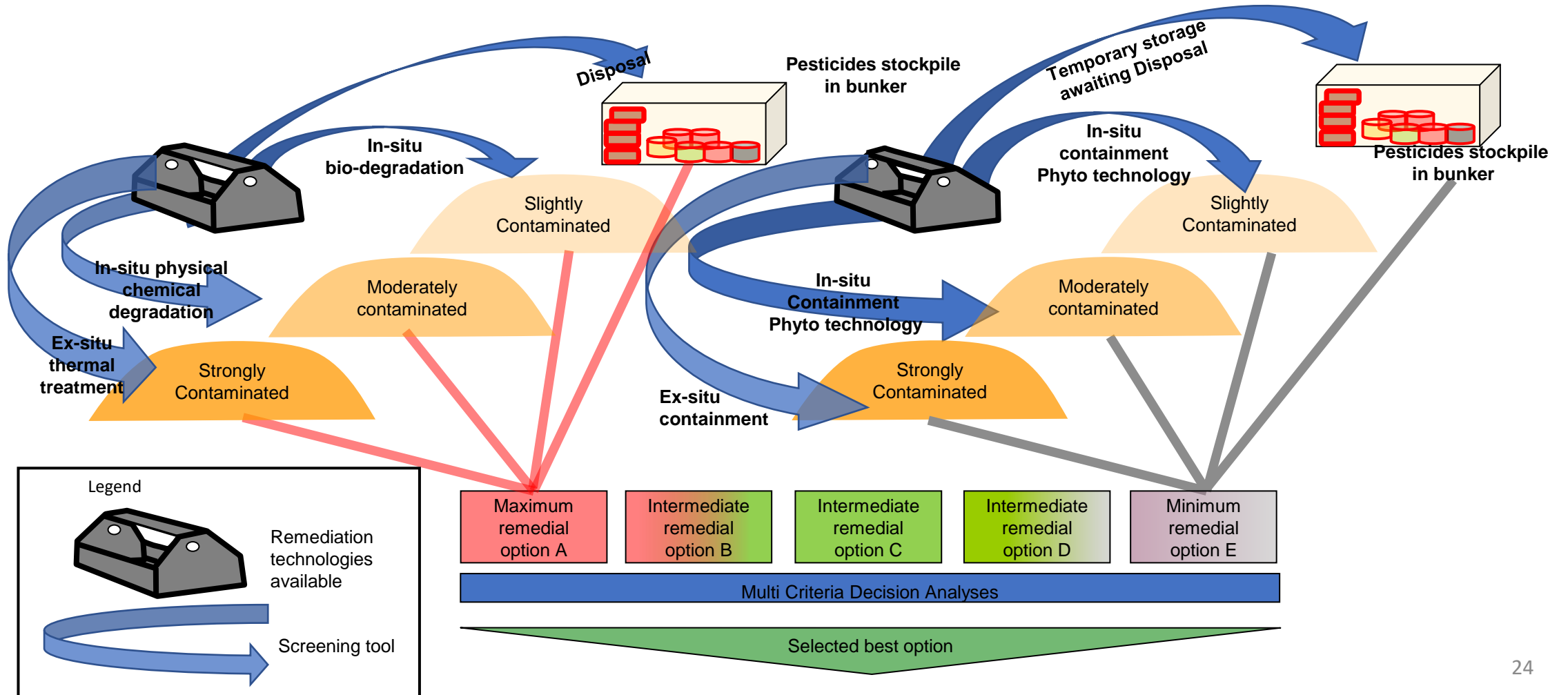


Best remedial option is using the best available techniques, using environmentally sustainable methods, while not entailing excessive costs, reducing as much as possible the environmental risks

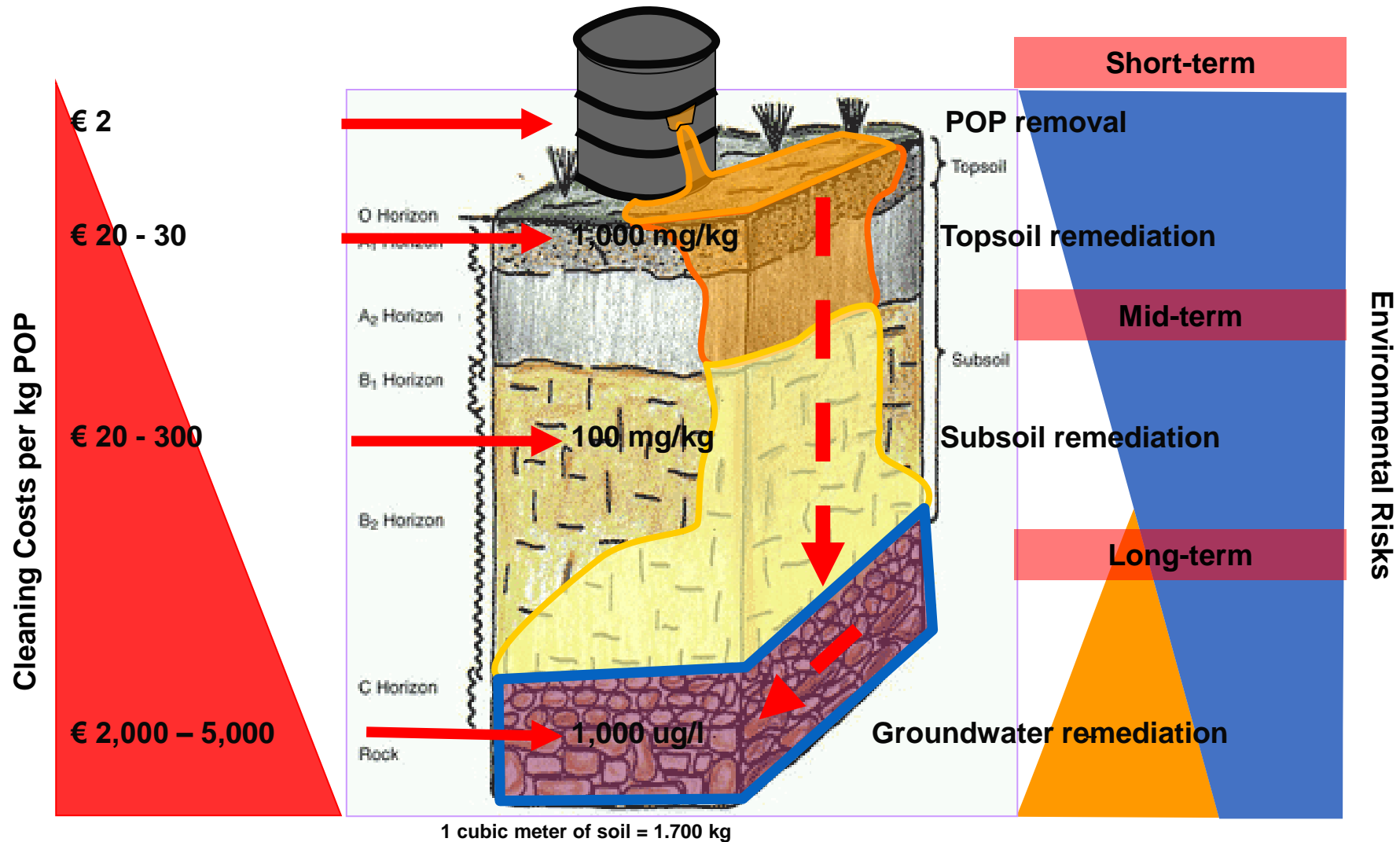


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(4) Phase 3 - Remediation Assessment process



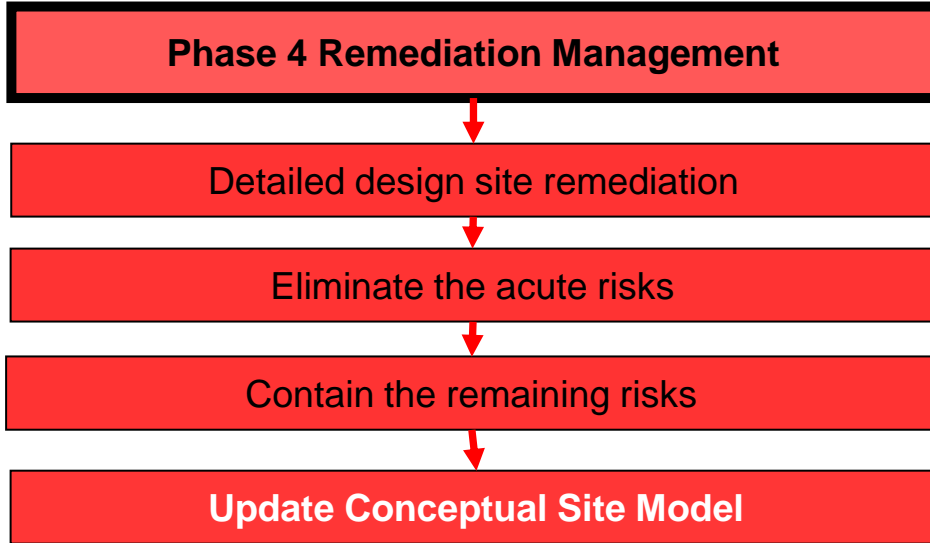
(4) Phase 3 - Why focus on removal pure POPs?





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(5) Phase 4 - Deliverables



*Detailed design best remedial option**

- *Eliminate the direct risks*
- *Contain remaining potential risks*
- *Monitor the remaining latent risks*



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(4) Phase 4 - Site Remediation Management

Remediation strategy

- Risk based approach
- Phased implementation
- Dynamic work plan

Start by elimination of direct risks

- Remove the source(s)
 - ✓ Excavate, repack and destruct source areas
- Cut of the receptor's pathways
 - ✓ Control erosion
- Protect the receptors
 - ✓ Fence source areas
 - ✓ Restrict land-use

Containing potential risks

- Maintain fencing
- Maintain restricted land-use
- Implement erosion control measures
- Pump & treat contaminated groundwater
- Restore vegetation cover



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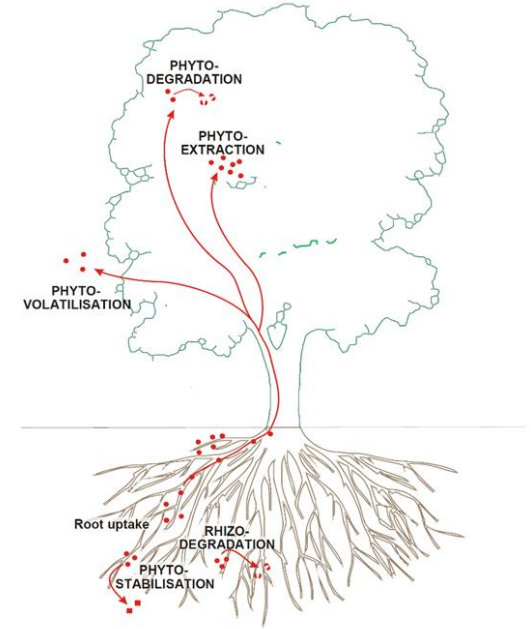
(4) Phase 4 - Ex-situ versus In-situ soil remediation

Ex-situ

- Excavate and thermal treatment
 - ✓ Combustion
 - ✓ Co-incineration/processing
 - ✓ Indirect Thermal Desorption
 - ✓ Base Catalyzed Decomposition
- Excavate and bio-degradation
- Excavate and physical-chemical degradation
- Excavate and phyto-containment/remediation
- Excavate and landfill

In-situ

- Thermal
 - ✓ Indirect Thermal Desorption
 - ✓ Base Catalyzed Decomposition
- Bio-degradation
- Physical-chemical degradation
- Phyto-containment/remediation
- Containment



Before a full-scale in-situ soil remediation plant is installed, lab scale, bench scale testing and piloting have to prove that the considered techniques are effective



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(4) Phase 4 - Ex-situ groundwater - Pump and treat in treatment train versus In-situ groundwater

Ex-situ

- Pump or drain
- Sedimentation in basin
- Aeration oxidize iron followed by
- Sand filtering removing iron
- Active carbon filter absorbing the CoC

or

- Stripping, bringing CoC in a gaseous phase followed by
- Active carbon filtering or combustion.

In-situ

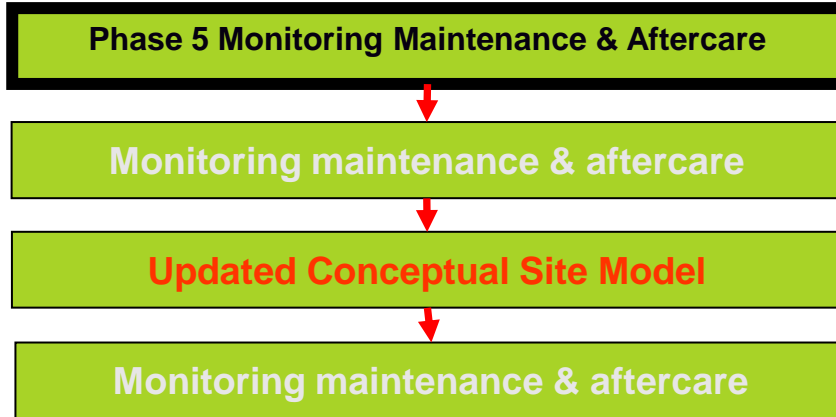
- Chemical oxidation and reduction - Permeable Reactive Barrier PBR – Funnel and gate
- Biological treatment - Reactive mat / Natural Catch
- Containment
- Phytoremediation/containment
- Monitored Natural Attenuation

Before a full-scale in-situ or ex-situ groundwater treatment plant is installed, lab scale, bench scale testing and piloting have to proof that the considered techniques are effective



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(4) Phase 5 - Deliverables



Monitor the latent risks

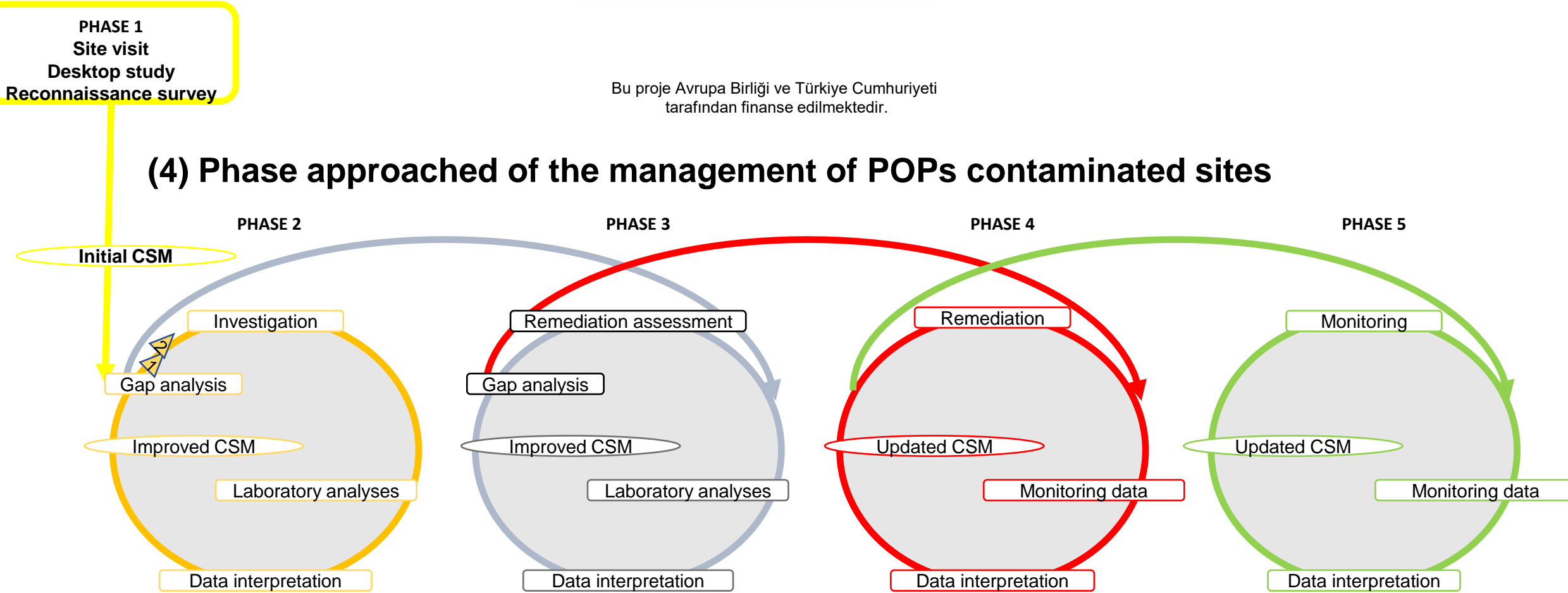
- Inspect and repair containment measures
- Sample and analyse groundwater quality
- Sample and analyse drinking water quality
- Sample and analyse surface water quality





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(4) Phase approached of the management of POPs contaminated sites





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Module	Guidance on BAT & BEP for management of POP contaminates sites	Phase
	Executive summary	All
1	Background to POPs contaminated sites	
2	Principles and Approaches for Contaminated site Management and Remediation	
3	Site investigation, Assessment and Conceptual Site Model	1 & 2
4	Environmental Risk Assessment	1 & 2
5	Remediation technologies and techniques	3 & 4
6	Technology selection tool for remedial options	3 & 4
7	Stakeholder Engagement, Public and Worker Safety and Health	All
8	Contaminated Sites Remediation and Monitoring and Aftercare	5
9	Getting started: Legislation, Policy and Inventory Development	
10	Case Studies	



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Thank you very much for your attention

Any questions?