



Network for Industrially Contaminated Land in Africa

Introduction to Contaminated Land Management

NICOLA

- **Forum for contaminated land management in Africa**, which aims to establish a solid platform for the development, application and dissemination of sustainable practices, knowledge and technologies.
- Promotes **co-operation** between industry & mining, academia, regulators and service providers while **linking** closely with the fields of contaminant hydrogeology, geochemistry and waste management.
- **Objective**: Empower the African contaminated land management sector to identify, assess and manage contaminated land within a science based sustainable best practice framework.
- **Visit: <https://nicola-org.com> or e-mail: admin@nicola-org.com**

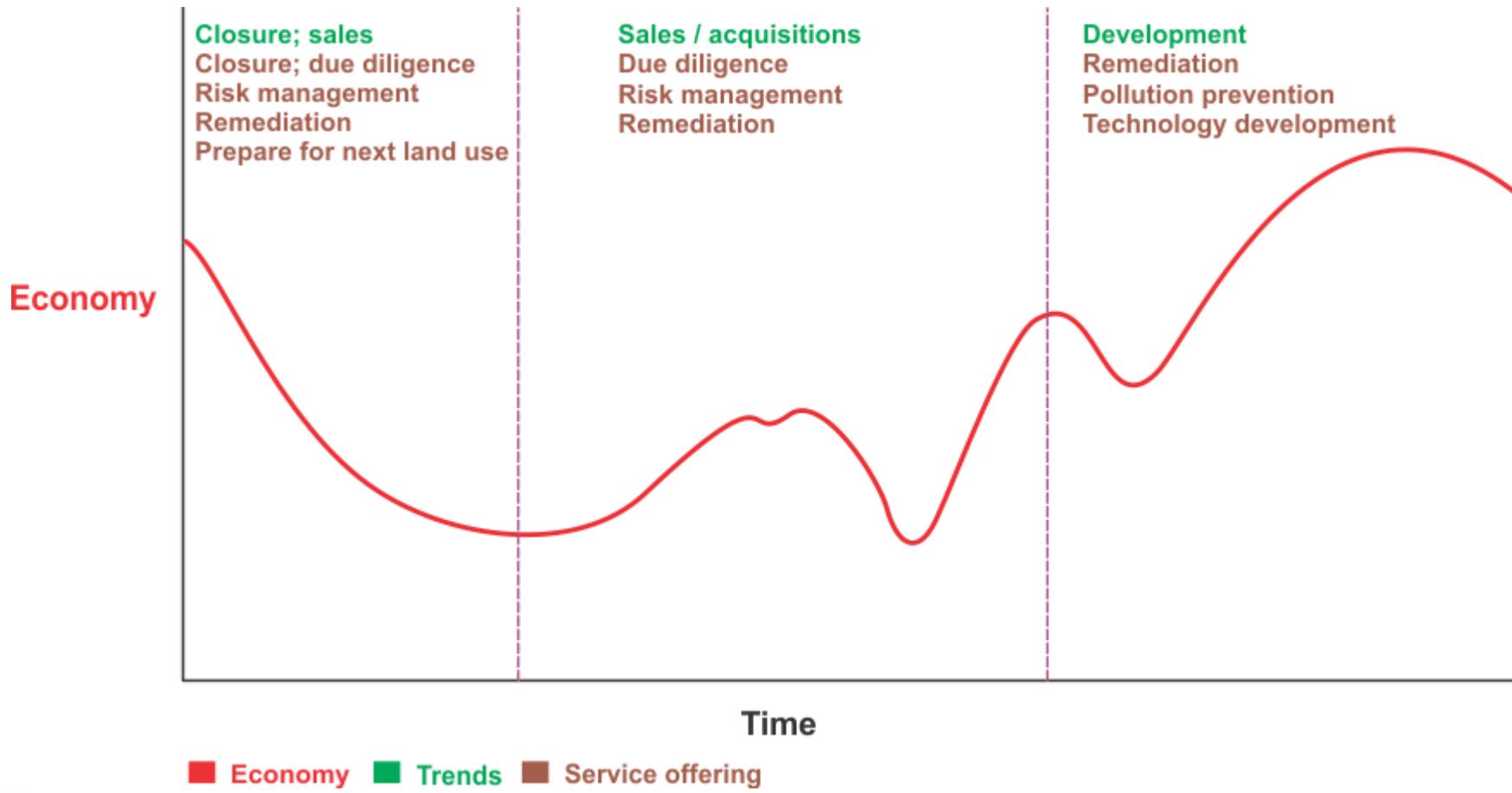


NICOLA

- This lecture is an introduction to contaminated land management (1 hour contact time)
- NICOLA presents:
 - Contaminated Land Management 101 (2-3 day course) that touches on 10 themes:
 - Theme 1: Legal framework
 - Theme 2: Environmental Site Assessment
 - Theme 3: Introduction to Environmental Chemistry
 - Theme 4: Organic Based Contamination in the Environment
 - Theme 5: Sampling and Analyses Strategies
 - Theme 6: Ground water and Soil sampling Technologies
 - Theme 7: Site Conceptual Models (SCM)
 - Theme 8: Risk Based Approach
 - Theme 9: Fate and Transport of Contaminant in the Environment
 - Theme 10: Remediation Technologies
 - More in depth courses: 17 September 2019 – Vapour Intrusion course



Contaminated Land Management: Drivers



Source: H Snyman (Golder Associates)

Level of site assessment

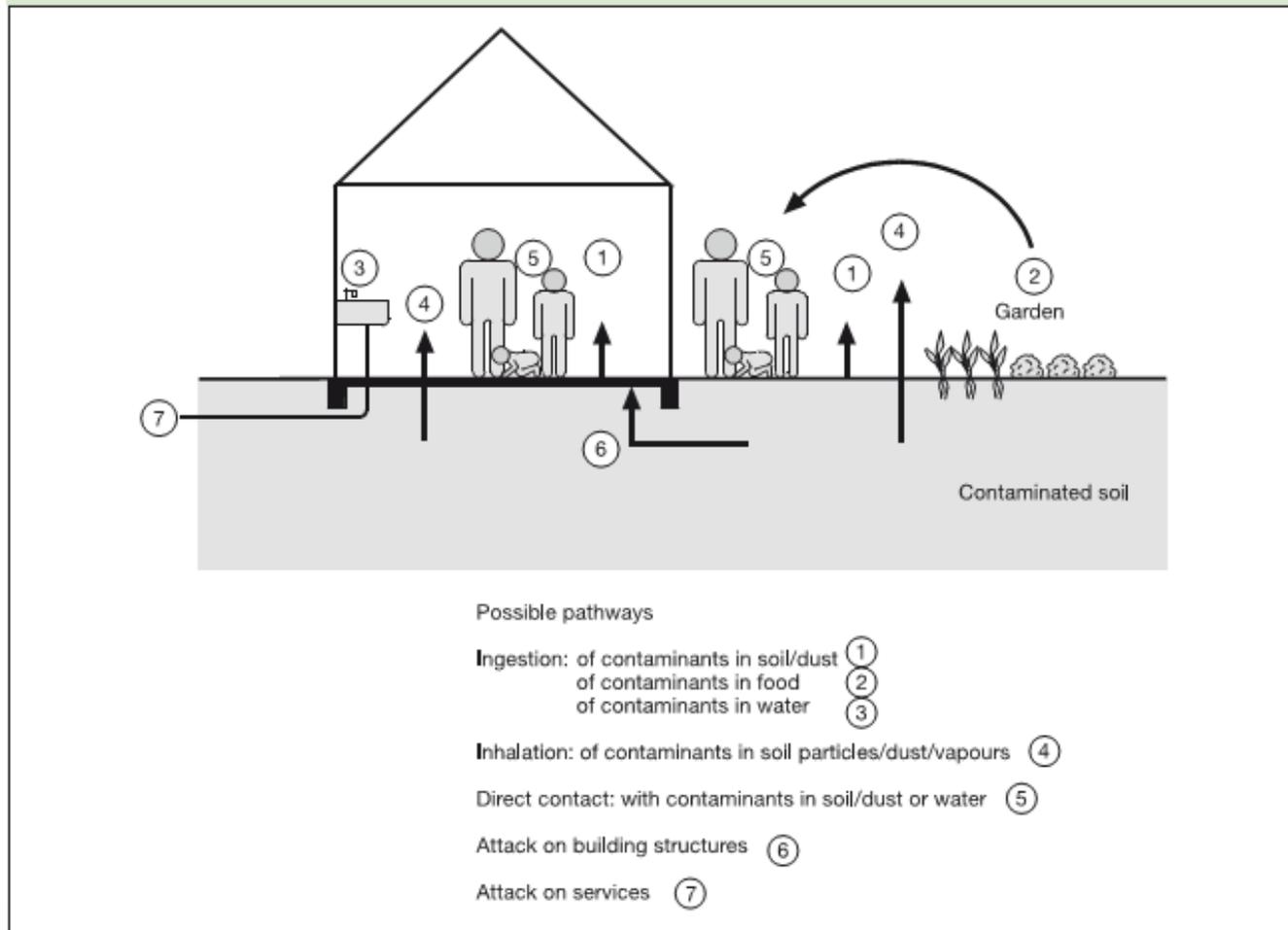
- Fit for purpose
- All levels involves a Source-Pathway-Receptor assessment



Environmental Site Assessment (ESA)



Source-pathway-receptor assessment



An environmental site assessment aims to:

- Identify sources, pathways and receptors (SPR)
- Develop a Site Conceptual Model
- Establish whether linkages between the S-P-R can or have realised
- The extent of the problem
- Assess the risk
- Inform further intervention

Class discussion:

Gauteng – Existing office building in commercial area



Source: Commercial Rental Website

Class discussion:

Lagos - Accident involving Tanker laden with 33000 liters of Petroleum



Source: NewNigerianNews June 2018, Photo: AKINOLA ARIYO

Class discussion:

Crude oil tank farm terminal, Turkmenistan



Source: <http://www.ilconstruction.com/project/crude-oil-tank-farm-terminal-project.html>

Sources

- **Variables**

- Contaminants
- Concentrations
- Time
- Locations

- **Considerations**

- Source exists/active
- Secondary source exists
- Sources can be stopped, isolated, removed
- Sources can be treated



Pathways

- **Variables**

- Media
- Rates of Migration
- Time
- Loss and gain function

- **Considerations**

- Pathways exists
- Pathways can be interrupted
- Pathways can be eliminated



Receptors

- **Variables**

- Types
- Sensitivities
- Time
- Concentrations
- Numbers

- **Considerations**

- Receptor is not or impacted by migration of contaminants
- Receptor can be relocated
- Institutional controls can be applied
- Receptor can be protected



Phase 1 ESA: Preliminary assessment

- Consider the following elements:
 - **Site description** – location and size
 - **Nature and extent of contamination** - contaminants of concern or historical activities that may be sources of contamination
 - **List all past and present activities** - storage, production, use, treatment or disposal of hazardous materials that could contaminate the site
 - Describe the current condition of the site and results of any previous assessment reports
 - Local topography and geology, drainage, surface cover, vegetation
 - Status of groundwater, approximate depth to water table
 - Proximity to surface water
 - Proximity to drinking water supplies
 - Land and water use for the site and nearby areas



Phase 1 ESA: Preliminary assessment

All data may not be available, or data may vary in terms of uncertainty, it is thus important to recognise gaps in the knowledge base and to decide whether additional data must be obtained on the site characterisation.

This may trigger the commencement of Phase 2 Investigations

- Phase 1 report must make clear recommendations on the status of the contamination risk posed by the site
- If a complete site history clearly demonstrates that the site activities do not pose a contamination threat then no further investigation is warranted and the site should be recommended as suitable for re- use
- In most cases it is likely that some level of preliminary investigation will be required to provide the level of certainty required to enable property re-development or transfer



Phase 2 ESA: Field assessment

- Involves sampling and analysis of soil, sediment, groundwater and surface water
- Investigation must be related to site specific conditions
- The Phase 2 ESA give information on:
 - The type, extent and level of contamination anticipated on site
 - Samples collected, the sampling procedures followed, including QA/QC
 - The analyses undertaken, methodologies used and laboratory quality assurance / quality control procedures, including laboratory certificates and appropriate accreditation listed
 - The actual extent and concentrations of contaminants in all appropriate environmental media on site based on verified test data
 - Any likely dispersal in air, surface water, groundwater, soil
 - Any potential effects of contaminants on human health, the environment, or building structures and property



Phase 2 ESA

- Phase 2 Site Assessment Reports must list the results of chemical analyses of soils obtained against the **Soil Screening Values (GN 331)** and other **international screening values** and preferably **Site Specific Screening Values** together with all assumptions and limitations of Soil Screening Values used
- The report must make a clear statement regarding the adequacy and completeness of all information used in the assessment and list any further studies or investigations that may be required to verify the status of the site and the risks posed



Phase 2 ESA: Site Assessment Report (SAR)

- SAR must satisfy the requirements of Section 37 of the NEM:WA
- *A SAR must at least include information on whether the investigation area is contaminated.*
 - *Where the findings of the site assessment report are that the investigation area is contaminated, the site assessment report must at least contain information on whether-*
 - *the contamination has impacted on the environment;*
 - *the substances present in or on the land are toxic, persistent or bioaccumulative or are in large quantities or high concentrations or occur in combinations;*
 - *there are exposure pathways available to the substances;*
 - *the uses of the land and land adjoining increases or is likely to increase the risk to health or the environment;*
 - *the substances have migrated or are likely to migrate from the land;*
 - *the acceptable exposure for human and environmental receptors in that environment have been exceeded*
 - *any applicable standards have been exceeded: and*
 - *the area should be remediate or any other measures should be taken to manage or neutralise the risk.*



Phase 2 ESA: Site Assessment Report (SAR)

- Report recommendations should be made to inform the regulatory status of contamination as required under Section 38 (1) of the Waste Act:
 - (a) *the investigation area is contaminated, presents a risk to health or the environment, and must be remediated urgently;*
 - (b) *the investigation area is contaminated, presents a risk to health or the environment and must be remediated within a specified period;*
 - (c) *the investigation area is contaminated and does not present an immediate risk, but that measures are required to address the monitoring and management of that risk;*
or
 - (d) *the investigation area is not contaminated*

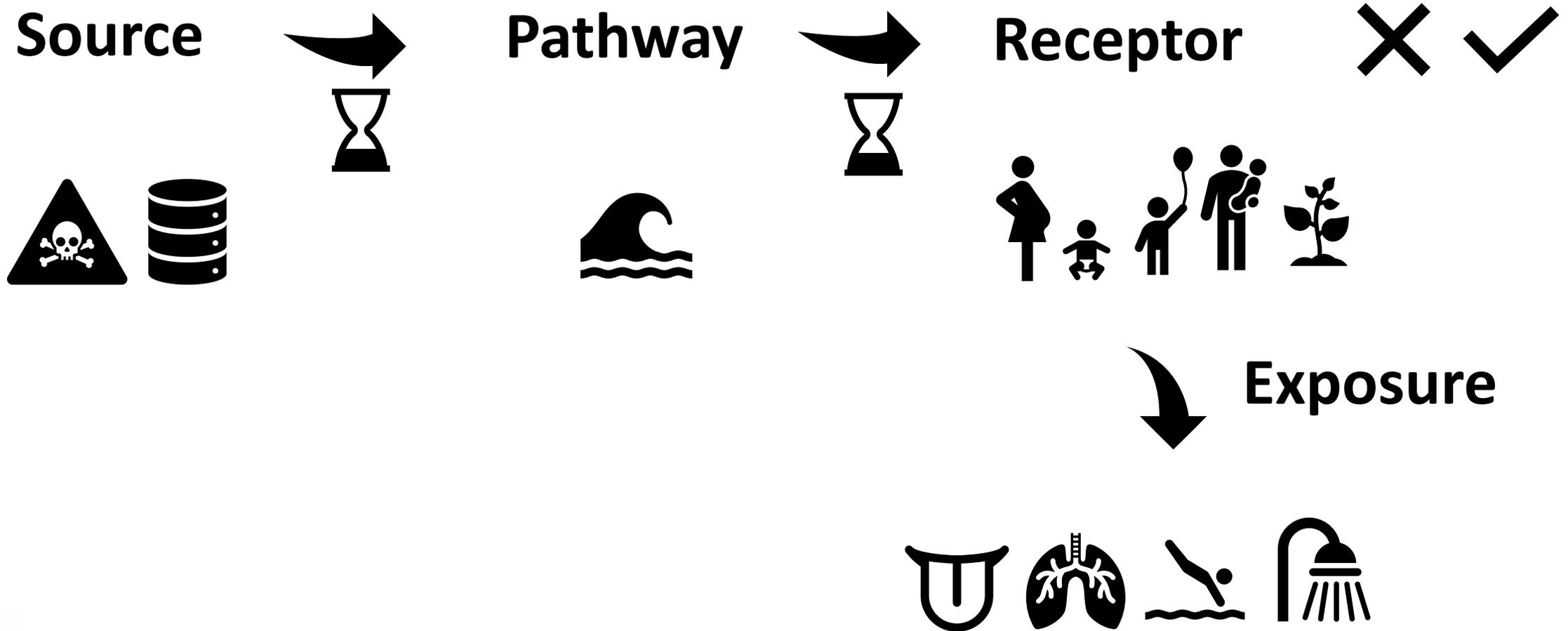


Phase 3 ESA: Contaminated Site Remediation Plans

- The site remediation plan should be prepared as follows:
 - **Set remediation or management objectives** (including numerical soil and groundwater targets) that ensure the site will be suitable for its **current or future proposed land-use** and will pose no unacceptable risk to human health or the environment, either on-site or off-site
 - Document in detail all procedures to be adopted to achieve the remediation objective. Establish safeguards and contingency measures for safe implementation of all remediation activities.
 - Develop a quality assurance monitoring plan that establishes a record of activities that must be carried out to ensure compliance with the approved action plan
 - Obtain the relevant approvals, permits or licenses required by regulatory authorities to undertake the proposed remediation activities



Risk Based Approach



Human Health Risk Assessment (HHRA)

- Process developed by the USEPA in the 1990s – formally documented in Risk Assessment Guidance for Superfund (RAGS) documents – Parts A-F
- Key processes and algorithms also documented in ASTM E1739-95 *Standard Guidelines for Risk Based Corrective Action at Petroleum Release Sites*
- HHRA uses a tiered approach to assessing risk of exposure to contamination:
 - **Tier 1:** Screening contaminants against published risk-based guidance
 - **Tier 2:** Using site-specific information to focus on specific risks
 - **Tier 3:** Additional site-specific considerations, toxicity assessment, bioavailability assessment, etc.



Tier 1 Screening Guidelines

- Comparing site contaminant concentrations to published screening criteria to evaluate risk
 - Values are generic and conservative, protective of all scenarios and receptors
 - Contaminants occurring below Tier 1, no further actions
- Tier 1 guidance:
 - South Africa – Soil Screening Values (industrial, residential, protective of water resources)
 - WHO – drinking water, petroleum hydrocarbons
 - USEPA – Regional Screening Levels – soil, air, tap water, MCLs
 - Various others: Dutch, UK, Australia, Canada, etc.
 - Industry: Shell RBSLs, BP RISC RBSLs



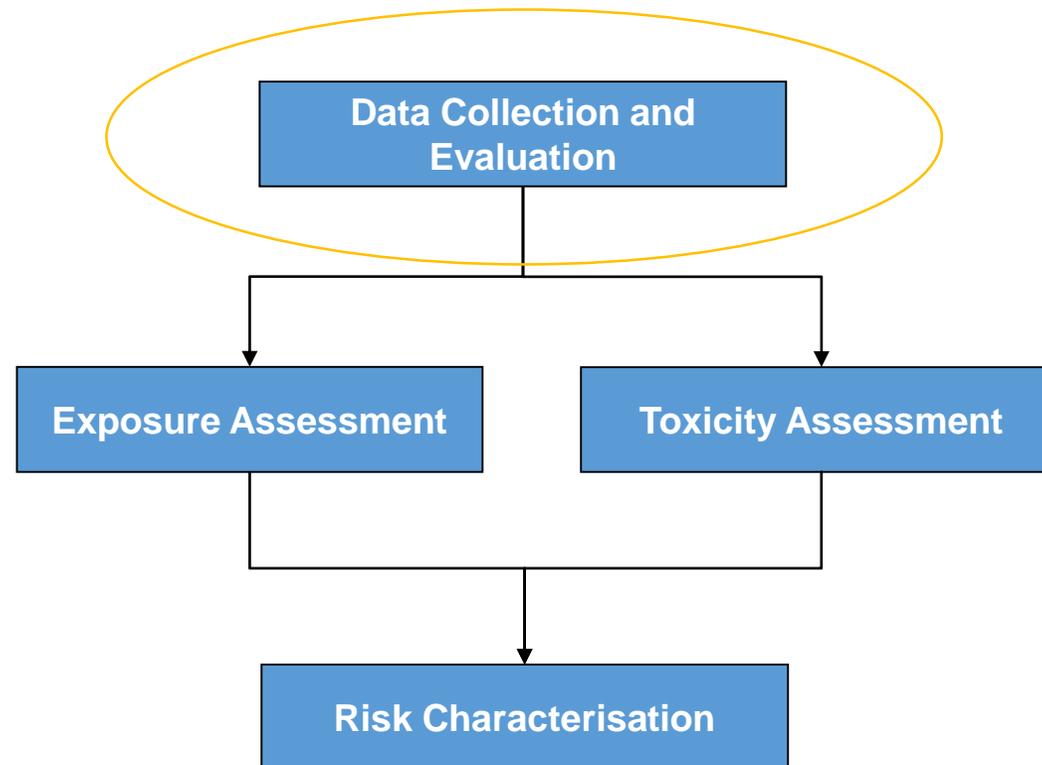
Tier 1 Screening: Soils – Residential

mg/kg	Dutch	UK	Italy	South Africa	Belgium	Belgium	US
	DIV	C4SL/SGV		SSV2	Flanders	Wallonia	Regional Screening Levels
	Multifunctional Land Use	Residential Land Use	Residential Land Use	Standard Residential	Residential Land Use	Residential Land Use	Resident
Arsenic	76	37	20	47	103	40	0.68
Cadmium	13	22	2	32	6	3	71
Chromium (VI)	180	21	2	13	240	125	0.3
Lead	530	200	100	230	560	200	400
Benzene	1.1	0.82	0.1	1.4	0.5	0.2	1.2
Toluene	32	610	0.5	120	7	3	4900
Trichloroethene	2.5	NP	1	NP	1.4	0.2	0.91
1,2 Dichloroethene	1	NP	0.3	1200	0.7	0.3	160
Vinyl Chloride	0.1	NP	0.01	0.11	0.1	0.1	0.059
Phenol	14	420	1	NP	NP	0.7	19000
Naphthalene	40	NP	5	32	5	1.7	3.8
Benzo(a)pyrene	(sum of 10 PAH)	5	0.1	0.71	3.6	0.5	0.016



Risk Assessment Process

Development of CSM



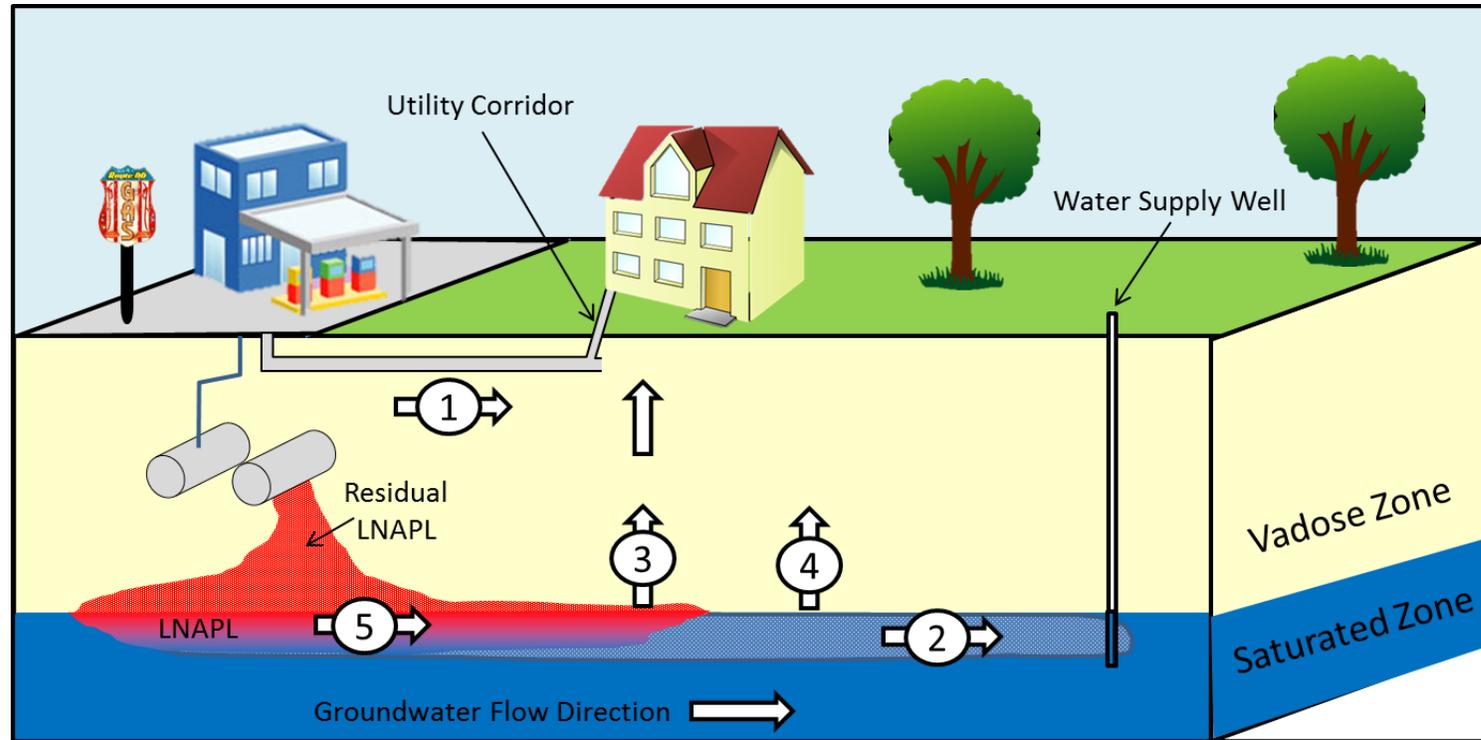
Conceptual Site Model

- Preliminary Conceptual Site Model / Site Characterisation
 - Desk-based information, possibly some site investigation
 - Identify PCOC, data gaps, etc.



- Detailed CSM / Site Characterisation
 - Further site assessment
 - More site-specific, less conceptual!
- With more information, further develop CSM
- CSM evolves with time: Changes in knowledge, changes in site conditions, etc.





Emergency considerations when LNAPL in the ground	Risk considerations	Additional considerations when LNAPL in wells
<p>① Vapor accumulation in confined spaces causing explosive conditions</p> <p>Not shown - Direct LNAPL migration to surface water</p> <p>Not shown - Direct LNAPL migration to underground spaces</p>	<p>② Groundwater (dissolved phase)</p> <p>③ LNAPL to vapor</p> <p>④ Groundwater to vapor</p> <p>Not shown - Direct skin contact</p>	<p>⑤ LNAPL potential migration</p> <p>LNAPL in well (aesthetic, reputation, regulatory, recoverability)</p> <p style="text-align: right;">Modified from Garg</p>



Exposure Pathways

- Once a contaminant has migrated from its source by means of a specific transport mechanism, there are four common exposure scenarios which will expose a receptor to the contaminant:

1. Soil Ingestion/ Absorption



2. Inhalation



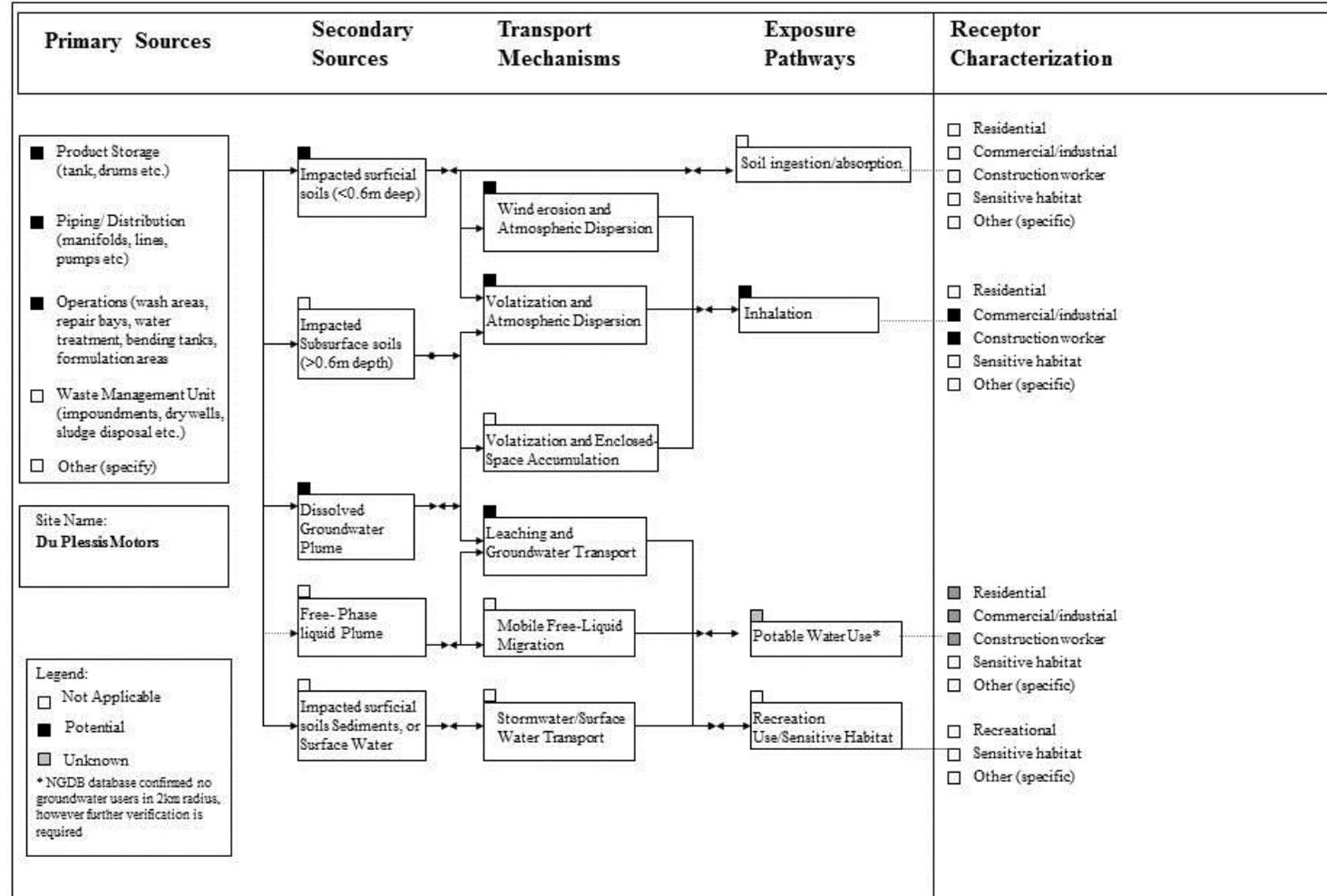
3. Potable Water



4. Recreational Use/ Sensitive Ecosystems



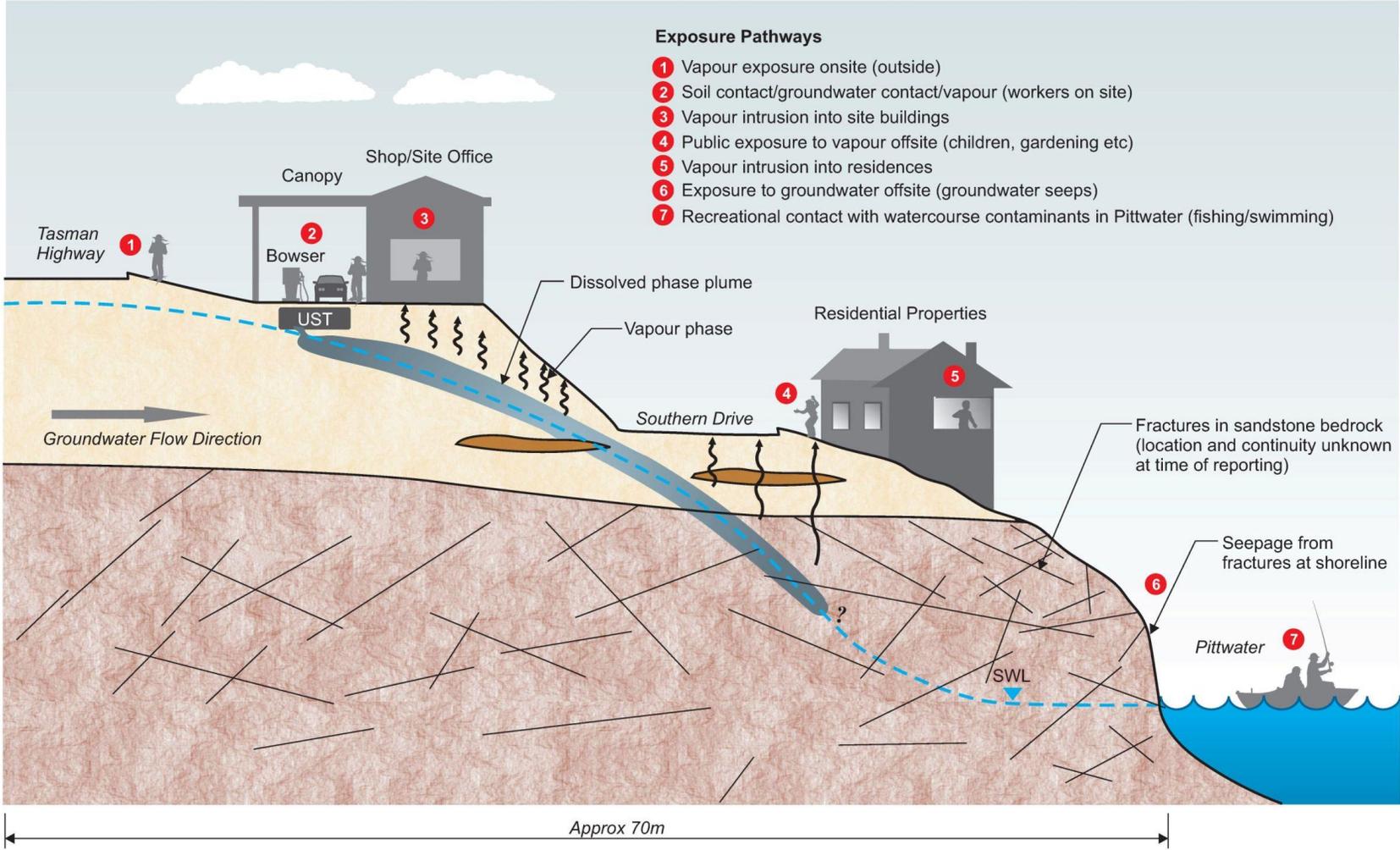
CSM/SPR Example



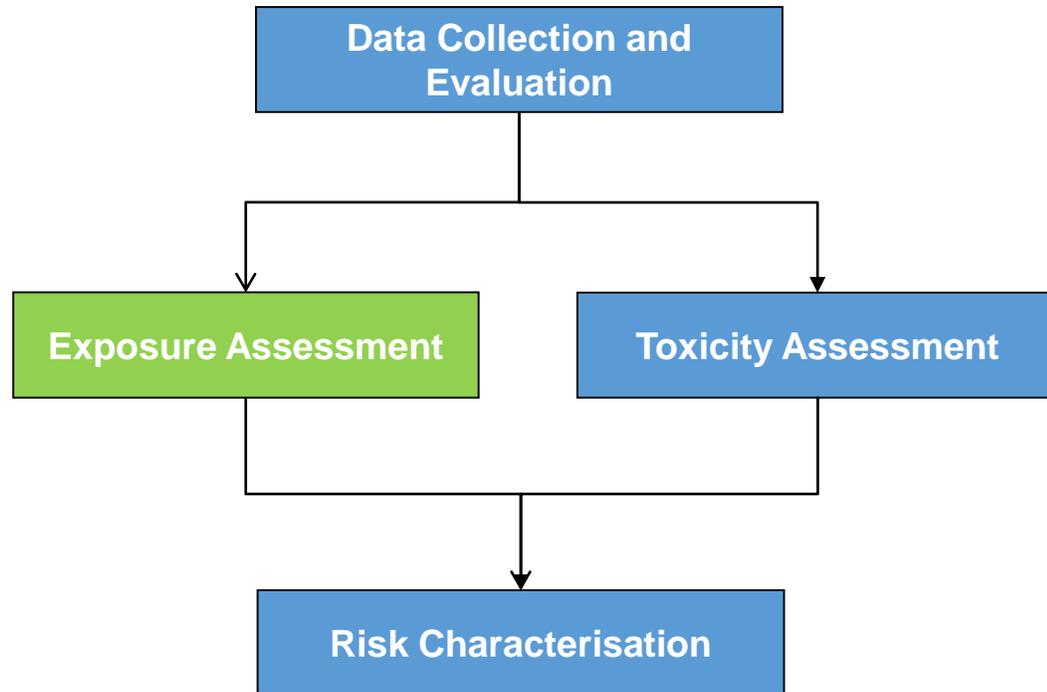
Reference: Modified table from *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (ASTM E-1739)*.



CSM/SPR Example (2)



Exposure Assessment



Using CSM to identify:

- Exposed populations
- Potential exposure pathways
- Exposure concentrations for each pathway



Fate and transport of contaminants

- Fate and Transport modelling can be useful when site data is limited
- BUT....the “act” of modelling does not necessarily give any more clarity
- The CSM should inform the fate and transport modelling, not the other way around
 - Models are more accurate when site-specific data is used for input (need to limit number of assumptions)
 - Models are more accurate when calibrated with field data
 - Modelling should not be used as a substitute for proper site characterisation
 - Simple models are typically only valid in homogeneous primary aquifers and not complex aquifers



Conclusion

- Phase I, II and III environmental site assessments using
 - Source-pathway-receptor assessment
 - Risk Based Approach
 - Fate and transport of contaminants
- **Join and participate in NICOLA, a forum for contaminated land management in Africa**
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