Conceptual Site Model
(Part I)

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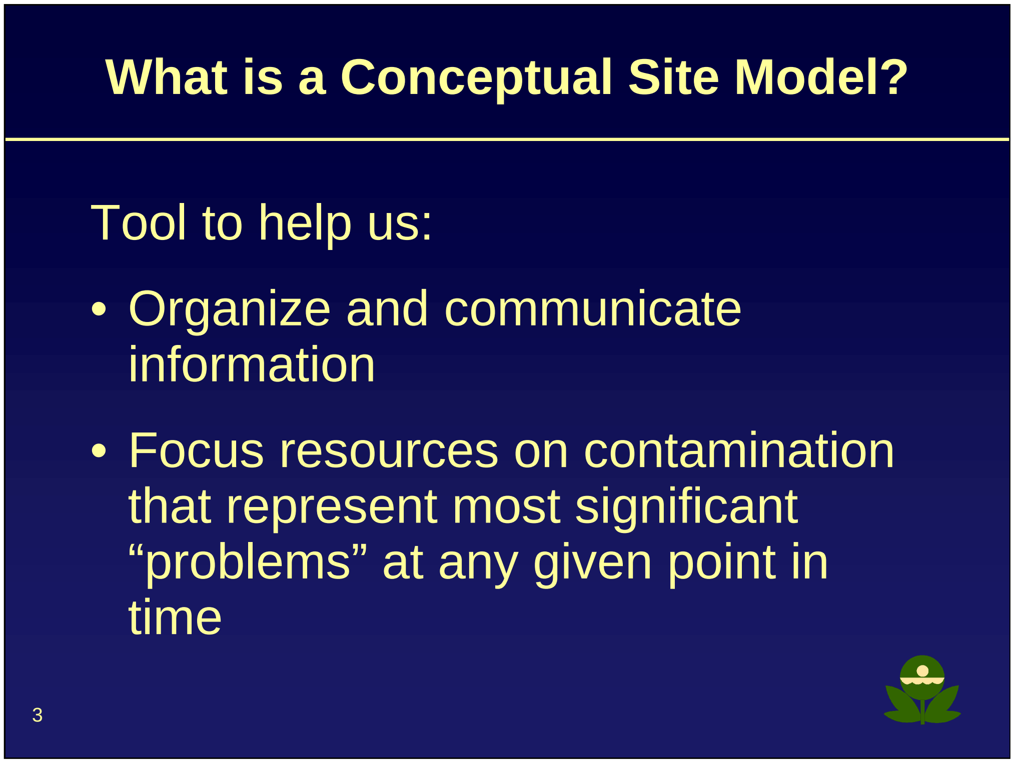
CSM Module Objectives (Part I)

Participants will:

- be able to Define a “Conceptual Site Model”, and describe how it can help focus resources
- be able to describe how action levels, problem statements, and decision rules enhance a Conceptual Site Model
- be introduced to the Workshop Case Study (AMT, Inc.)



Notes:

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The CSM is used to organize and communicate information about site characteristics. It should reflect the best interpretation of available information at any point in time. As a consequence, if new data are inconsistent, either the data need evaluation, or the model needs to be revised.

The CSM is a primary vehicle for communicating technical data. It provides a good summary of how and where contaminants are expected to move and what impacts such movement may have. Hence, it supplies additional information to explain why a problem is a problem, why it is inconsistent with Corrective Action Results, and, therefore, why a response is anticipated. By highlighting Human receptors and groundwater releases, the CSM facilitates identification of environmental indicator concerns.

The CSM can help, for example, to establish whether there is a likelihood of imminent and substantial endangerment; justify characterization approaches; and prioritize investigation and remedial resources.

What is a “problem” in context of Results-Based Project Management?

- Condition(s) that likely warrants a response to achieve interim or final Corrective Action Results
- Defining the problem early in a Corrective Action is possible and prudent
- Defining problems helps prioritize resources
- Problem definition will evolve as data are collected

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Notes:

The definition of a “problem” is presented in the context of “Results-Based Project Management.”

Problems are conditions that require a response that will remove, modify, or otherwise reduce the impact of the problem. Problems are a subset of releases or potential releases. For example, contamination below an action level may indicate that a release has occurred, but it may not be at a concentration that would constitute a problem and warrant a response. Problems are what must be characterized, evaluated, and ultimately resolved.

In many cases, existing data will suggest a problem may exist, but the problem cannot be substantiated until additional site characterization is conducted. The CSM is a tool to help visualize and prioritize actual and potential problems and what should be done about them.

What Type of Information?

- General site information
- Site characteristics
- Actual/potential receptors, and release and transport mechanisms
- Soil contaminant source characteristics

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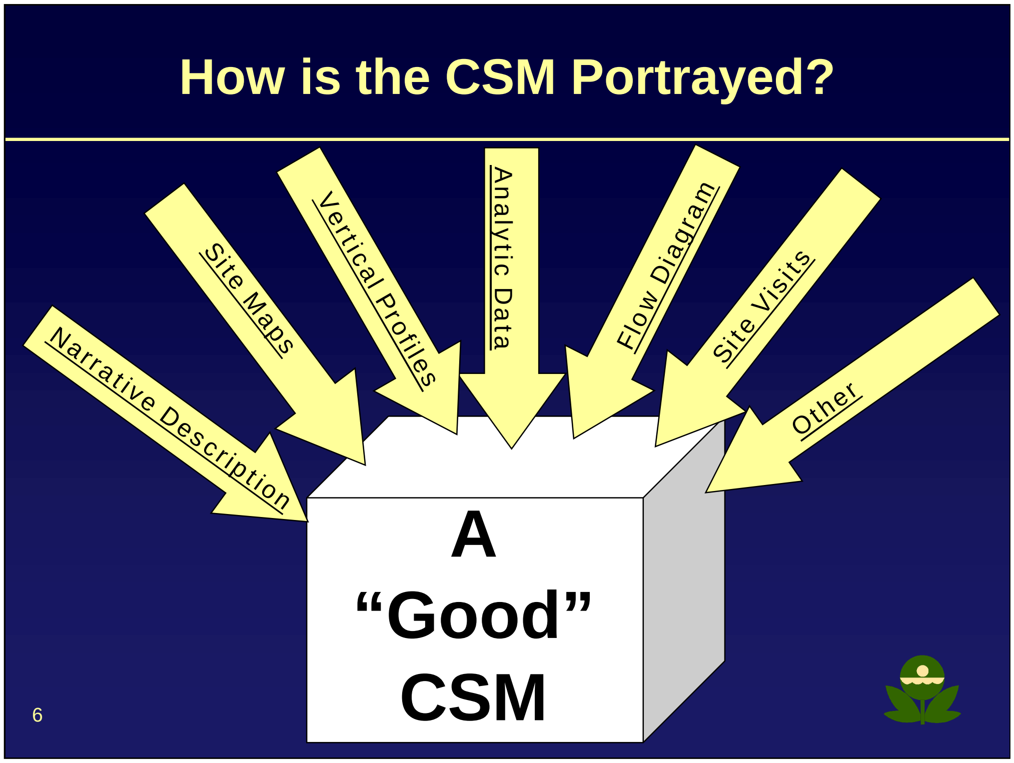
Notes:

- CSM can be initially based on limited information, then developed as data needed to make decisions are collected and analyzed.
- CSM guidance can be found in Appendix A to "Soil Screening Level User's Guide" (EPA 9355.423, July, 1996).
- General site information involves information relevant to site operations and past investigations.
- Site characteristics include a wide range of information related to geology, hydrogeology, and meteorology.
- Actual or potential receptors focus on identifying current, surrounding, and future land uses; and potential for acute effects and ecological concerns, based on potential media affected and exposure pathways.
- Soil contaminant source characteristics include process history of past releases and spills, including area effected, contaminants present, identification of possible NAPL presence, soil characteristics, and contaminant-specific properties.



Notes:

A CSM benefits from use of multiple formats to best portray available information.

A good narrative description is the best means of describing the site, its history, the nature of sources, quantitative aspects of migration pathways, and the identity of ecological and human receptors as well as the circumstances under which exposure is anticipated.

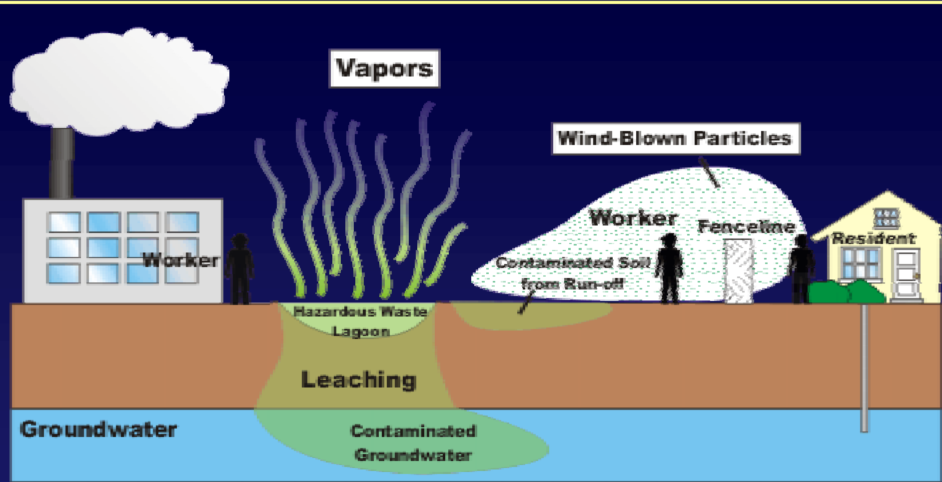
Maps should always be included in a CSM. At a minimum, maps should include relative position of sources, pathway determinants and near-field boundary constraints, surface water features, prevailing wind pattern, and plume contours.

If subsurface contamination is present, vertical profiles of the site should be included. These profiles should be supported by boring logs.

Tabular data should be included to support groundwater flow and contaminant distribution maps, but tables should be keyed to map features and should contain representative data only, not an exhaustive display of all data.

Flow diagrams are often helpful to illustrate the "interrelationships" from the original sources to the final receptors.

Picture Version of CSM



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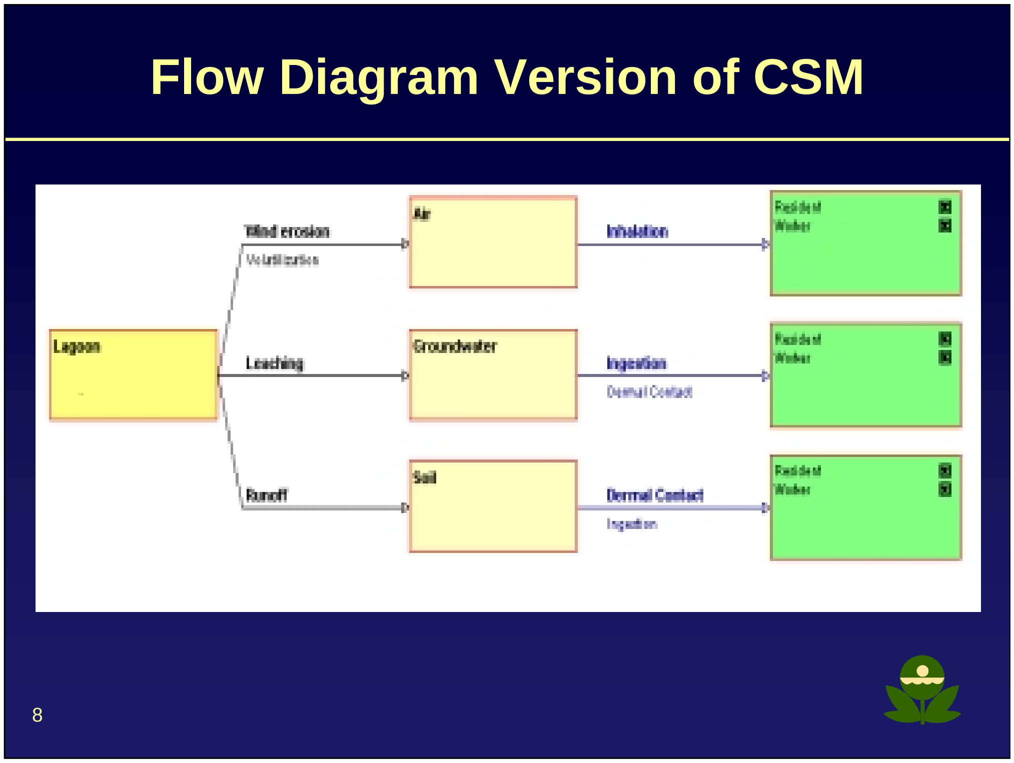

Notes:

For non-artists, you can use a flow diagram version of a CSM to illustrate the same questions as the previous pictorial CSM.

How can a CSM Help a Project Manager?

It provides a rational framework to organize

- what you know
- what you don't know
- what you need to know
- questions asked
- answers given
- decisions made

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Notes:

If what you ask, answer, and decide flow from a CSM, then other stakeholders likely would benefit from also using the CSM as the primary organization/communication tool.

A CSM can be used to help justify what information is essential for successful management of actual/potential risks.

Notes:

The intent to characterize the full nature and extent of contamination has lost its context and become an end in its own right. Many current investigations go well beyond necessary and sufficient data to determine if a problem exists and what to do about it.

... And Forms the Foundation for...

Alternative Results-Based approach:

- Focusing on interim or final results that need to be achieved and the decisions that need to be made to achieve those results
- Asking the right questions at the right time
- Identifying and filling data gaps that need to be reduced to make decisions
- Making decisions in the presence of remaining unknown conditions, when adequate contingencies are provided

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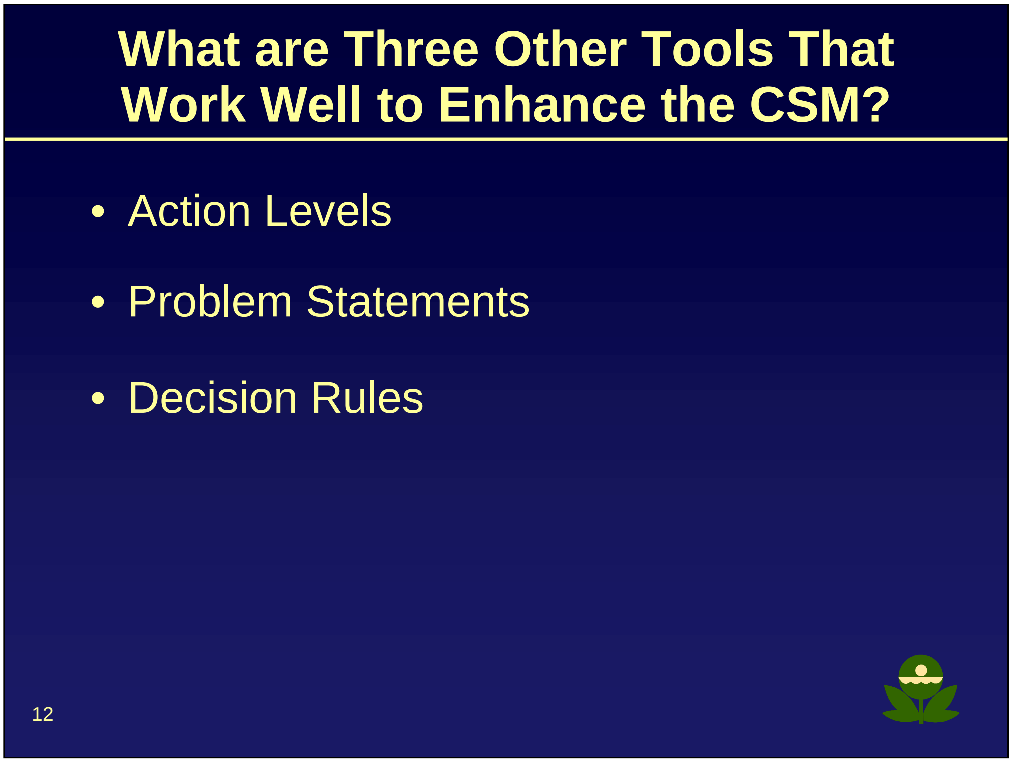

Notes:

EPA continues to support the concept of action levels (or screening levels) as a trigger mechanism for conducting additional corrective action activities (e.g., additional investigations, evaluation of remedial alternatives, site-specific risk assessments). Contamination found in a particular medium below an appropriate action level would not generally be subject to remediation or further study.

Action levels are health- or environmental-based concentrations derived using chemical-specific toxicity information and standardized exposure assumptions. Action levels are often established at the more protective end of the risk range (e.g., 10(-6)) using conservative exposure and land use assumptions; however, action levels based on less conservative assumptions could be appropriate based on site-specific conditions. For example, if the current and reasonably anticipated future uses of a site are industrial, an action level based on industrial exposure scenarios could be appropriate.

Action Levels

- Action or screening levels are a very helpful streamlining tool
- Superfund Soil Screening Guidance represents EPA HQ's most current approach

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Notes:

EPA HQ lastest guidance associated with action levels is the "Soil Screening Guidance" which is included behind the CSM tab of the Workshop toolbook. More detailed guidance assocaited with soil screening levels can be found at http://www.epa.gov/superfund/resources/soil/index.htm. Presently, the Soil Screening guidance is based on residential exposure scenarios; however, new guidance is being developed for non-residential exposure.

Program implementers and facility owners/operators should ensure that action levels used at RCRA Corrective Action facilities reflect up-to-date toxicity information and that action level assumptions are consistent with the physical conditions and current or reasonably anticipated exposure assumptions at any given facility. For example, risk to ecologic receptors is not accounted for in the action levels included in the 1990 proposal. If ecologic risks are a concern at a given Corrective Action facility, program implementers and facility owners/operators should consider developing facility-specific action levels to account for ecologic risk issues.

Problem Statements Effectively Communicate the Focus of Corrective Action

- A problem statement is a clear, concise format for communicating the condition that needs a response
- Example of a problem statement:
  - Lead above the preliminary remediation goal of 400 ppm is found in the upper 2 feet of soil

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Notes:

Problem statements are an effective tool for communication because they focus on participating in the decision-making process, and on what specific problem(s) need to be addressed.

Problem statements can be unit- or area-specific or can apply to a broader site-wide problem. An example of a site-wide problem statement could be: Contaminated groundwater is migrating beyond the facility property.

A problem statement provides linkage to the key decisions that need to be made at any point in time by:

- –Specifying the condition requiring a response
- –Reflecting current understanding
- –Evolving with our knowledge of the site

Decision Rule

- When coupled with probable response, the problem statement becomes a

"DECISION RULE"

- A decision rule is an if/then statement that clearly indicates what decision will be made when specified conditions are encountered
- Decision rules clearly communicate
  - why response is needed, and
  - what that response will need to accomplish

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Notes:

Decision rules are an effective tool for communication because they provide the stakeholder with information on the criteria on which a decision is being made, as well as the response that likely will result from the decisions.

The problem statement is the conditional "if" element of the decision rule. As such, it provides the justification for collecting additional data and/or making a remedial response. Decision rules can be used to focus both investigation and remediation resources. To focus an investigation, for example, a decision rule could read: "If contamination is found in excess of 5 ppb in groundwater, then additional samples will be collected down-gradient to define the extent of the plume." Owner/operators have often complained about not knowing when "enough is enough" with regard to data collection. Decision rules provide the basis for giving the owner/operators an end point. Generally, owners/operators should prepare problem statements. In particular, the site manager must be prepared to redirect efforts that are improperly focused or prioritized. Decision rules can be general, such as in the first example, where the type of response to halt further migration of contaminated groundwater is not specified. However, the more specific the problem statement is, the clearer interested stakeholders are with respect to both the nature of the problem and of the response. For example, the second example dealing with chromium contamination clearly indicates the type of response that will be used for soil found with chromium in excess of the preliminary remediation goal.

Introduction to Case Study

Conceptual Site Model
(Part II)

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CSM Module Objectives (Part II)

Participants will:

- be able to describe how "mass balance approach" using "Fugacity" helps us understand chemical occurrence, transport, and exposure potential
- discuss additional data needs for case study

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Focusing on EIs First, What are the Two Most Important Questions?

- Is contaminated groundwater migrating above levels of concern?
- Are current human exposures under control?

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Notes:

Recall the two environmental indicators:

- Migration of contaminated groundwater under concern;
- Current human exposures under control.

If EIs have been achieved, then the key questions should be related to final remedial objectives..

Some Type/Amount of Data is Generally Needed to Answer Key Questions...

- But how much?
- Results-Based Focus directs data collection on what is **necessary and sufficient** to:
  - enable identification and implementation of interim and/or final remedies, and/or
  - determine that Corrective Action is complete.
- CSM is useful tool to identify "necessary and sufficient."

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Notes:

Uncertainties with environmental characterization, especially when dealing with the subsurface, are inherent and will always exist. Knowing when "enough is enough" with regard to data collection has historically been the subject of significant contention between owner/operators and regulators. Understanding the concept of "necessary and sufficient" can minimize these conflicts and accelerate cleanups in general.

Latest Agency position on the objective for site characterization:

Site characterization should describe the facility and identify and describe releases and potential releases of hazardous waste and hazardous constituents at the facility, including releases from solid waste management units and materials posing principal threats, as necessary to enable identification and implementation of interim and/or final remedies and/or to determine that Corrective Action is complete.

The focus of a results-based approach to site characterization is identifying the necessary and sufficient information to answer important questions at a given point in time, without being tied to traditional processes or specific documents. When filling a data gap will not change your answer to a question, the missing data is not needed and may serve only to divert time and resources from higher priorities.

How do We Focus Data Collection?

- Again, focus on EIs first!
- Helpful to understand what phase (soil, water, NAPL, air) chemicals want to be in
- Ultimately, understanding phases helps understand migration/exposure potential

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Notes:

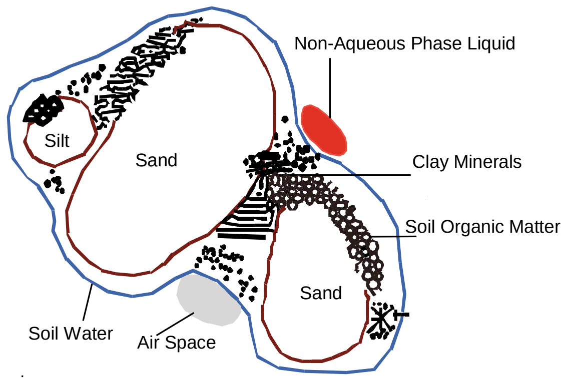
Focusing data collection on final results is appropriate if EIs have already been achieved.

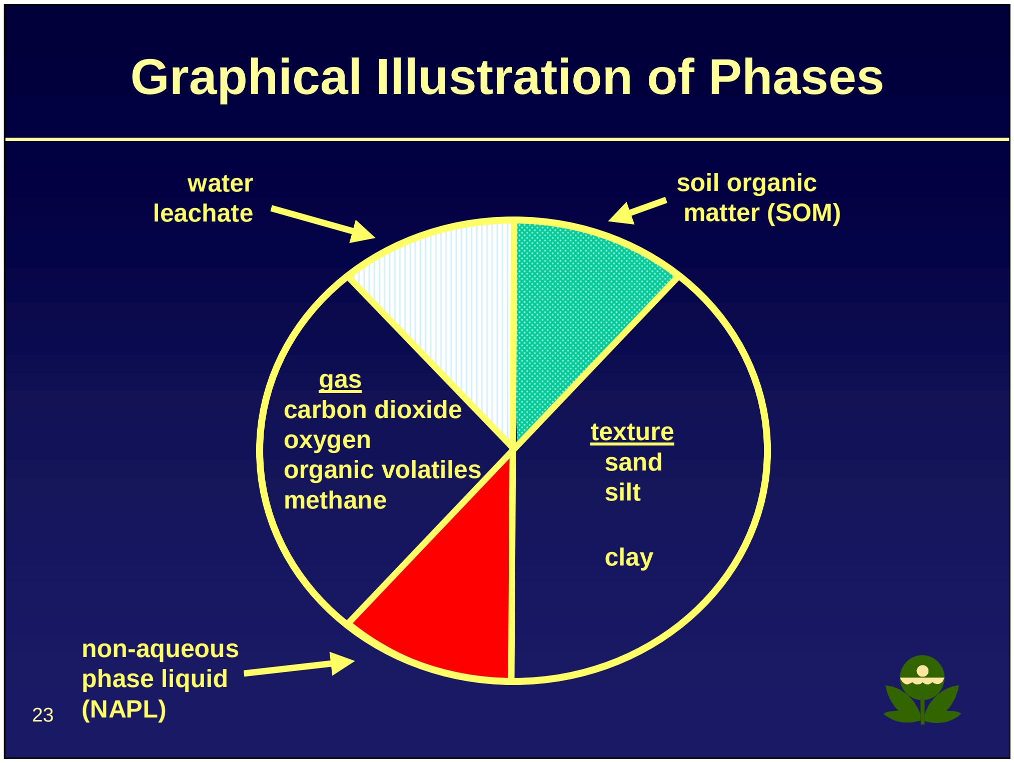
NAPL (Non-Aqueous Phase Liquid): Contaminants that remain undiluted as the original bulk liquid in the subsurface, (e.g., spilled oil).

Components of Soil Phases

Soil Phase % (Vol)		Typical	
	Range	Soil[1]	Aquifer
Soil Organic Matter	0-5	3	0.5
Mineral Matter	45-60	47	59.5
Water	0-50	25	40
Air	0-50	25	0
NAPL	0-50	0	0

[1]Vadose Zone





Notes:

Chemicals are associated with physical phases for exposure to receptors.

CSM considers chemicals in association with physical phases, including water, air, NAPL, and subsurface solid phase (soil-solid and aquifer-solid).

One or more physical phases link sources to receptors. Receptors become exposed to chemicals /contaminants through one or more physical phases.

Thinking of phases in terms of a “Mass Balance Approach”

- “Mass Balance Approach” attempts to answer how the chemicals are distributed among physical phases (i.e., air, water, solid, oil)?
- Where are the phases going (release/transport)?
- What are the exposures to phases (risks)?
- Which phases to manage with interim/final Corrective Actions?
- Which phases have the potential to prevent meeting EIs?

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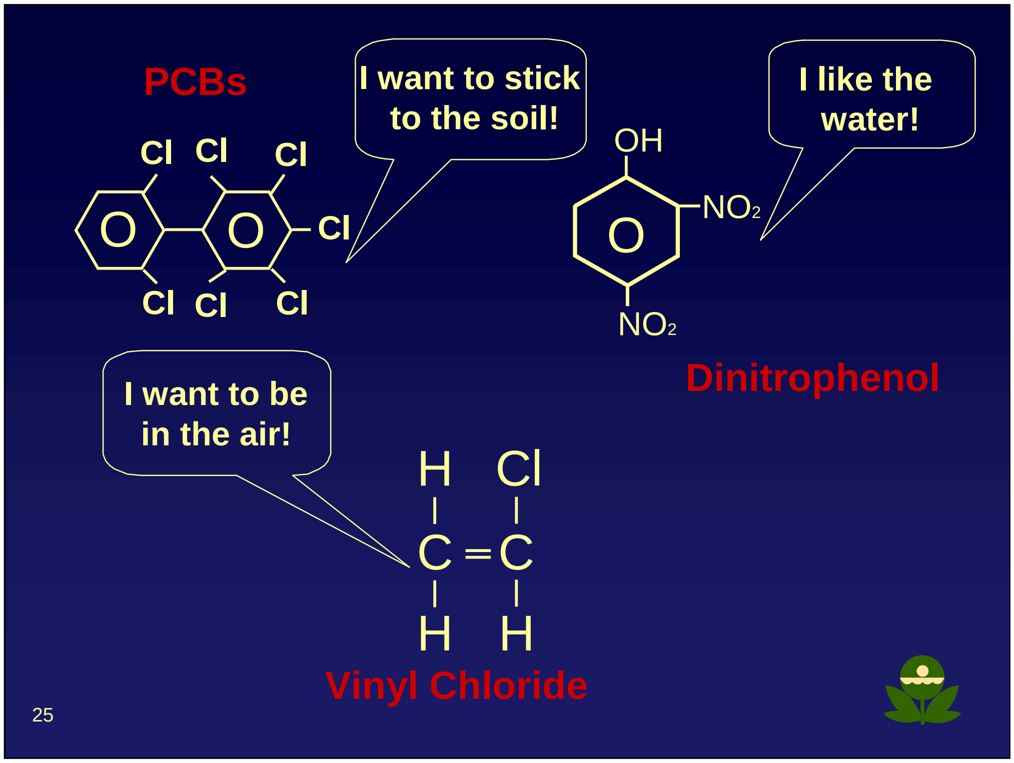
Notes:

Based on a general understanding of the chemicals managed at a facility, we can use a “mass balance” approach to determine which chemical wants to be in which phase. Likewise, the mass balance approach can help determine whether the phases could move and be available for exposure.


PCBs
I want to stick to the soil!
Cl Cl Cl Cl Cl Cl Cl
I like the water!
OH
NO2
NO2
Dinitrophenol
I want to be in the air!
H Cl
C = C
H H
Vinyl Chloride
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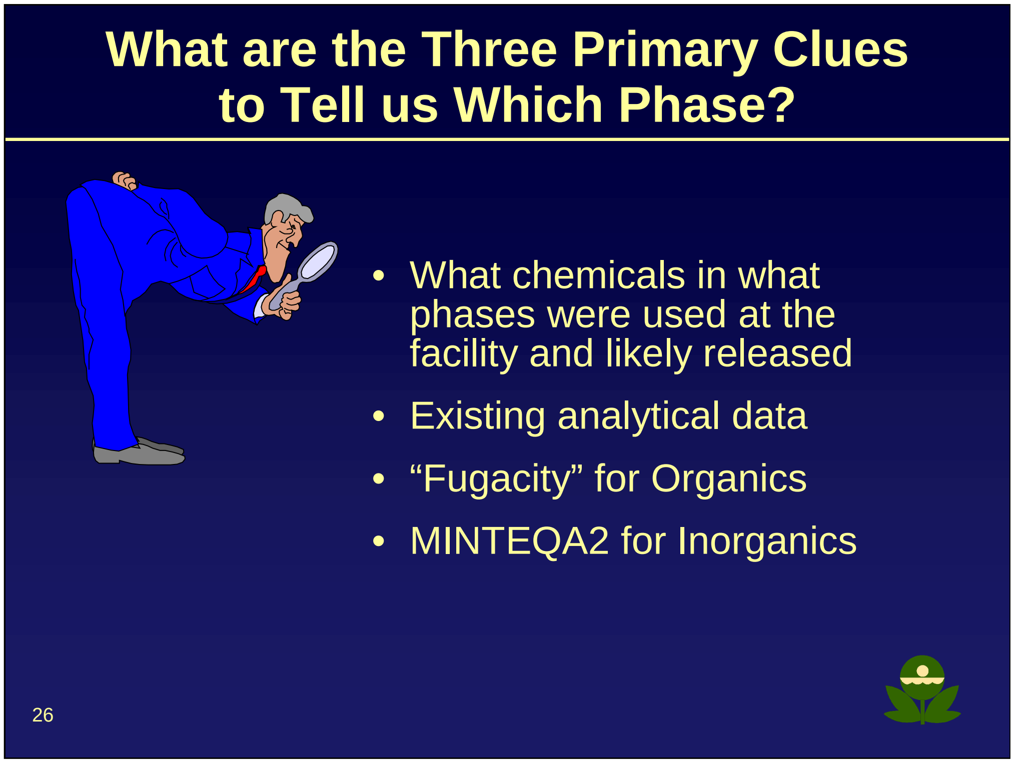

Notes:

Clue 1

A good file review and narrative history will often provide information about the phases of chemicals used and likely released at a facility. For example, processes that would lead one to believe that organics were likely to be mixed in water, as compared to organics being used and likely released as a separate phase, include petroleum wastewaters, MTBE (methyl tert-butyl ether), water soluble herbicides such as 2,4-dichlorophenol, and water soluble chemical feedstocks such as organic acids. Examples of organics likely to be released as a separate phase (NAPL) include chlorinated solvents, fuels, coal tars, etc.

Clue 2

Existing data can be useful in judging the phase of contamination. For example, past data confirming the presence of contaminants in soil gas would also confirm that the contaminant is available for transport and exposure via the air phase. However, existing data isn't always reliable because it depends on a number of factors such as where and how the sample was collected. In general, a positive detection in a phase confirms the chemical's existence and availability for transport and exposure in that phase; but not finding a chemical in a phase does not mean that it is not present in another phase. A potentially common example of this generality is when a certain concentration present in

Clue 2 (cont'd)

groundwater (or percentage of the solubility of a particular contaminant) is used to conclude the absence of an non-aqueous phase liquid (NAPL) phase. For example, finding contaminants in a water phase below a certain percent of the solubility does not negate the potential that they are also present in the soil and/or oil phases. Fugacity provides a tool to help us determine which phases of organic contaminants to expect at our facilities.

Note: For metals, there is no tool that can be used to evaluate phase partitioning. What is used are thermodynamic models such as GEOCHEM-PC, which is free and can be downloaded from the web site: http://envisci.ucr.edu/faculty/dparker/default.html. GEOCHEM-PC is written for metals in soil environments. MINTEQA2 for sediment-water systems is available, as well as U.S. EPA information about the model, at the web site: http://www.epa.gov/earth100/records/a00164.html.

What is Fugacity?

- Fugacity uses partition coefficients to describe the distribution of chemicals in a multi-phase site with regard to:
  - Sources;
  - Transport and transformation; and
  - Exposure
- User-friendly computer software available

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Notes:

We are spending more time on this third clue because understanding a chemical's inherent properties helps us focus investigations on the most likely problems.

The fugacity tool for conducting a mass-balance analysis is readily available through publications in books, in scientific journal articles, and electronic publication via the internet.

Fugacity

Donald Mackay, Professor of Chemical Engineering at the University of Toronto, Canada, introduced the concept of fugacity in the 1970's to express the distribution of organic pesticides among various phases of the environment. His book *Multimedia Environmental Models - The Fugacity Approach*, 1991, Lewis Publishers, Inc., describes the basis and applications of fugacity for handling chemical reaction, advective flow, and diffusive and nondiffusive transport in multimedia environments.

Fugacity was introduced by G.N. Lewis in 1901 and has been widely used in chemical process calculations. Its convenience in environmental partitioning calculations became apparent only after 1980.

Results of Mass Balance Analysis Using Fugacity

Physical Phase	% Chemical Associated with each Phase
Air	
Aqueous	
Solid	
NAPL	

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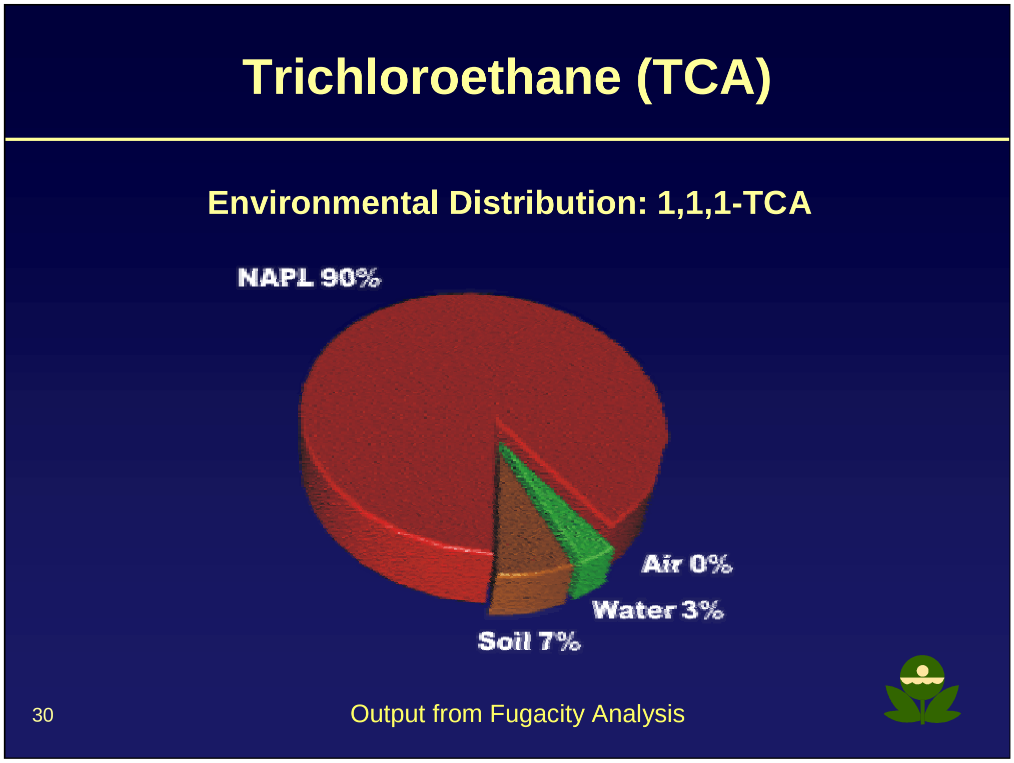
Notes:

Mass Balance in a Four-Phase Physical System

NAPL, Water, Solid, Gas (Air)



Notes:

TCA with NAPL PHASE

CHEMICAL CHARACTERISTICS

Enter the compound name: TCA

Enter the molecular weight: 133.4

Enter water solubility (mg/L): 9.50E + 02

Enter vapor Pressure (mmHg): 1.00E + 02

Enter Log Kow: 2.49

Enter Log Koc : 2.18

SITE CHARACTERISTICS

Enter the following:

Volume of air (m^3): 2.50E + 01

Volume of Water(m^3): 2.30E + 01

Volume of Soil(m^3): 5.00E + 01

Volume of NAPL(m^3): 2

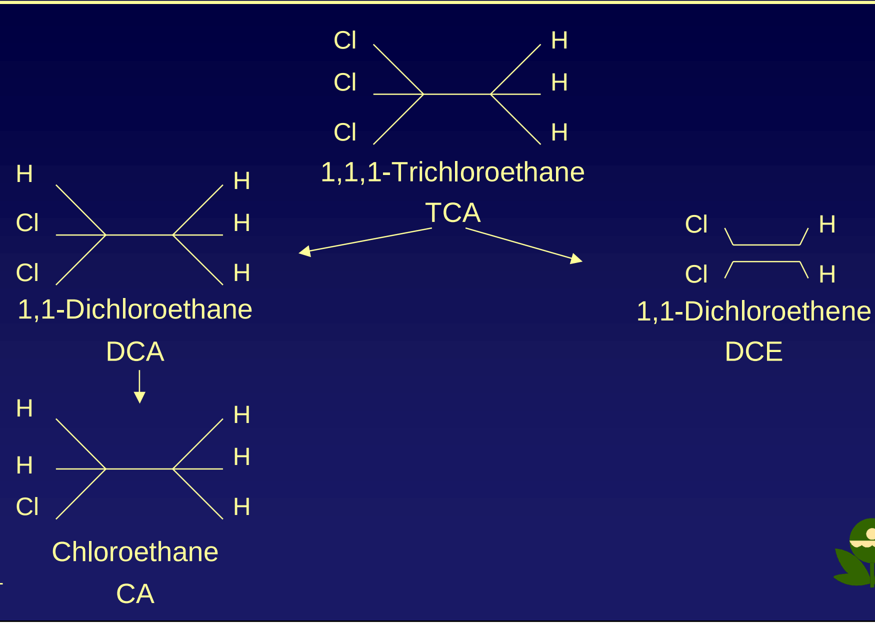
Total volume (m^3) is : 100

Enter the % organic carbon in the soil phase: 0.5

Enter the Bulk Density of the Soil (Kg/m^3): 1325

Enter the total mass of the compound in the system (g): 1.00E + 00

Pathways for the Anaerobic Transformation of TCA



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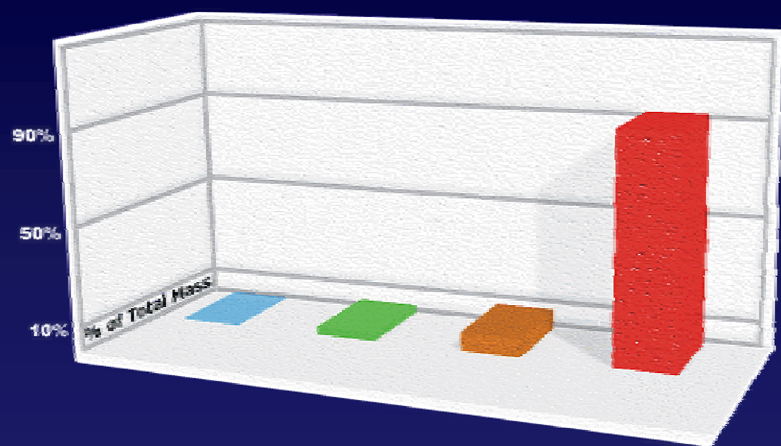
Trichloroethane (TCA)

Environmental Distribution: 1,1,1-TCA



Output from Fugacity Analysis

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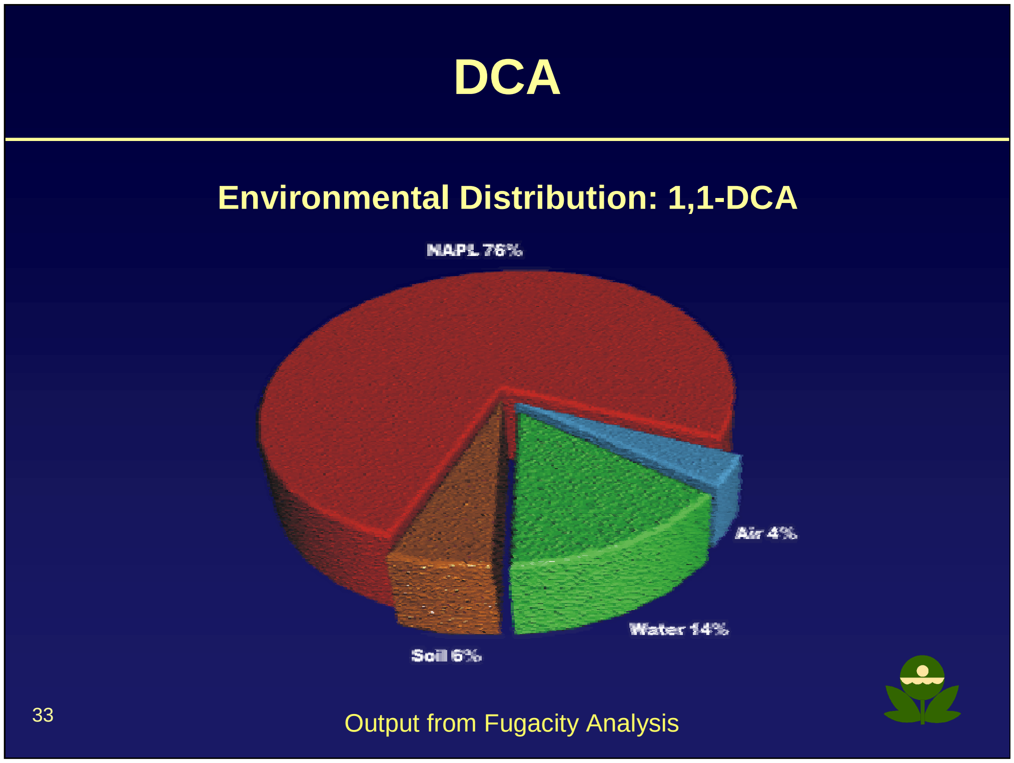


Notes:

DCA WITH NAPL PHASE

CHEMICAL CHARACTERISTICS

Enter the compound name: DCA

Enter the molecular weight: 99

Enter water solubility (mg/L): 5.50E + 03

Enter vapor Pressure (mmHg): 1.82E + 02

Enter Log Kow: 1.79

Enter Log Koc: 1.48

SITE CHARACTERISTICS

Enter the following:

Volume of air (m^3): 2.50E + 01

Volume of Water(m^3): 2.30E + 01

Volume of Soil(m^3): 5.00E + 01

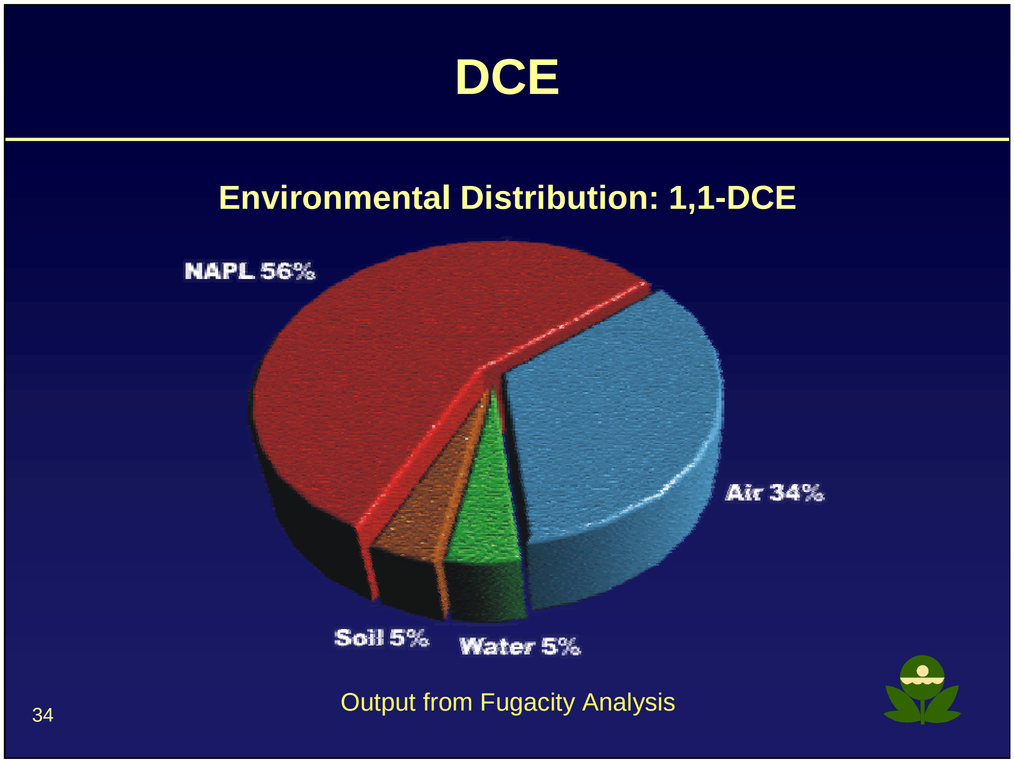
Volume of NAPL(m^3): 2

Total volume (m^3) is : 100

Enter the % organic carbon in the soil phase: 0.5

Enter the Bulk Density of the Soil (Kg/m^3): 1325

Enter the total mass of the compound in the system (g): 1.00E + 00



Notes:

DCE WITH NAPL PHASE

CHEMICAL CHARACTERISTICS

Enter the compound name: DCE

Enter the molecular weight: 96.94

Enter water solubility (mg/L): 4.00E + 02

Enter vapor Pressure (mmHg): 5.00E + 02

Enter Log Kow: 2.13

Enter Log Koc1: 1.81

SITE CHARACTERISTICS

Enter the following:

Volume of air (m^3): 2.50E + 01

Volume of Water(m^3): 2.30 + 01

Volume of Soil(m^3): 5.00E + 01

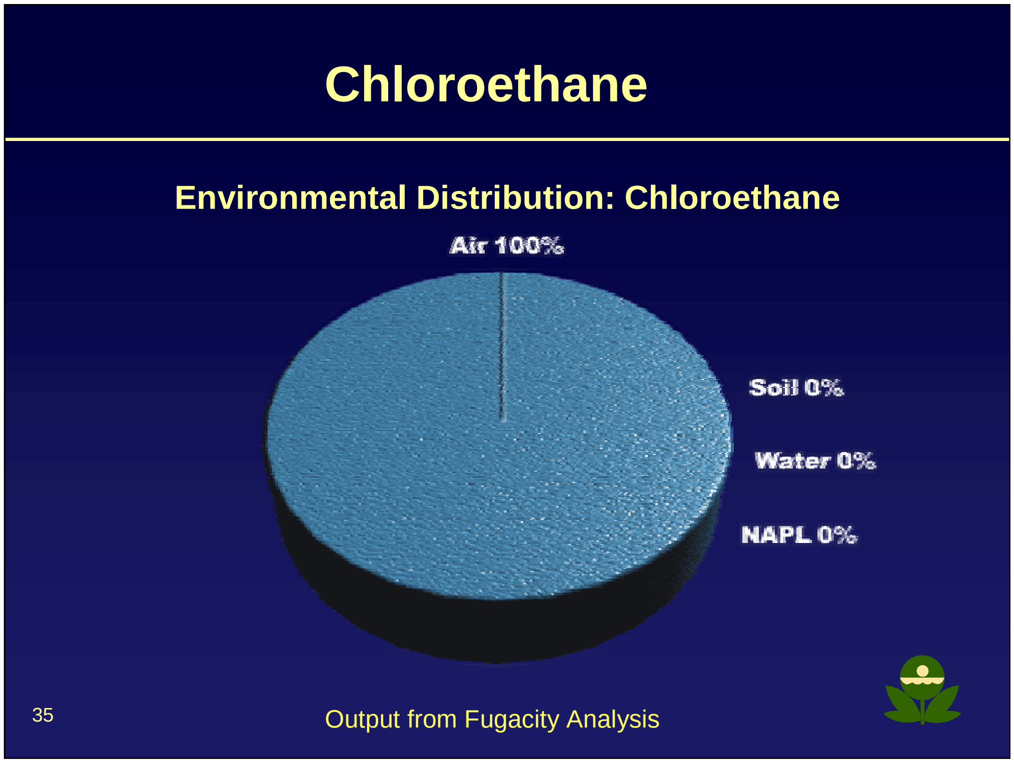
Volume of NAPL(m^3): 2

Total volume (m^3) is : 100

Enter the % organic carbon in the soil phase: 0.5

Enter the Bulk Density of the Soil (Kg/m^3): 1325

Enter the total mass of the compound in the system (g): 1.00E + 00



Notes:

CHLOROETHANE WITHOUT NAPL PHASE CHEMICAL CHARACTERISTICS

Enter the compound name: Chloroethane

Enter the molecular weight: 64.52

Enter water solubility (mg/L): 5.70E + 03

Enter vapor Pressure (mmHg): 1.00E + 03

Enter Log Kow: 1.43

Enter Log Koc1: 1.17

SITE CHARACTERISTICS

Enter the following:

Volume of air (m^3): 2.50E + 01

Volume of Water(m^3): 2.30E + 01

Volume of Soil(m^3): 5.00E + 01

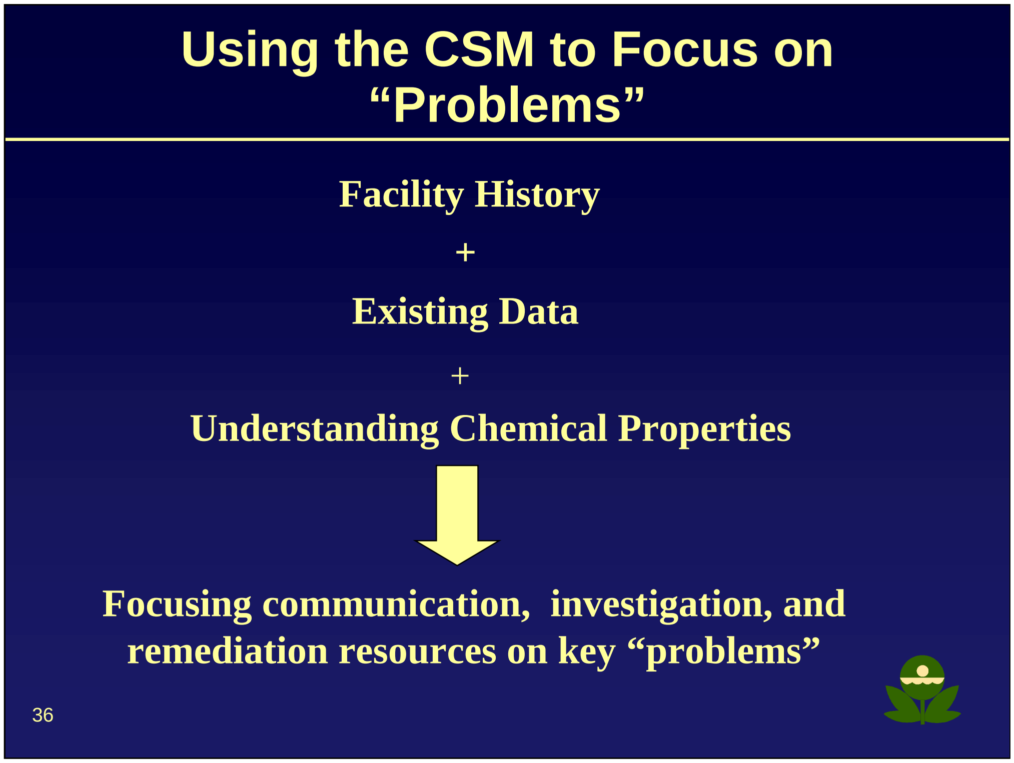
Volume of NAPL(m^3): 2

Total volume (m^3) is : 100

Enter the % organic carbon in the soil phase: 0.5

Enter the Bulk Density of the Soil (Kg/m^3): 1325

Enter the total mass of the compound in the system (g): 1.00E + 00



Notes:

CSM can help focus responses to problems. For example, if a response is needed, decision makers should be asking as early as possible:

What are the most likely responses?

What additional data are needed, if any, to evaluate/select responses?

What is the preferred response that will achieve interim or final Corrective Action results?

Has the response achieved the desired results?

Data Needs Exercise

- Work in small groups to discuss data needs to support EI evaluation (15 minutes)
- Volunteer table report back to large group (5 minutes)

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Notes:

Use available information from case study and information developed from fugacity exercises to predict the phases of contaminants that could represent a "problem."

Make sure to think of primary sources (i.e., original release location), release mechanism (e.g., leaching, volatilization, etc.), secondary sources (e.g., high concentration areas that represent continued subsurface source), exposure mechanism (e.g., ingestion, inhalation), and actual or potential receptors.

Large Group Discussion of Focused Data Needs

- Keep in mind "necessary and sufficient" concept with EI focus

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