STATUS AND APPLICATION OF DTSC'S VAPOR INTRUSION GUIDANCE

Petroleum Vapor Intrusion Workshop

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Vapor Intrusion Guidance Document

Guidance released as interim final on

January 5, 2005

(http://www.dtsc.ca.gov/ScienceTechnology)

Public comment period ended on August 15, 2005

Comments may always be sent to:

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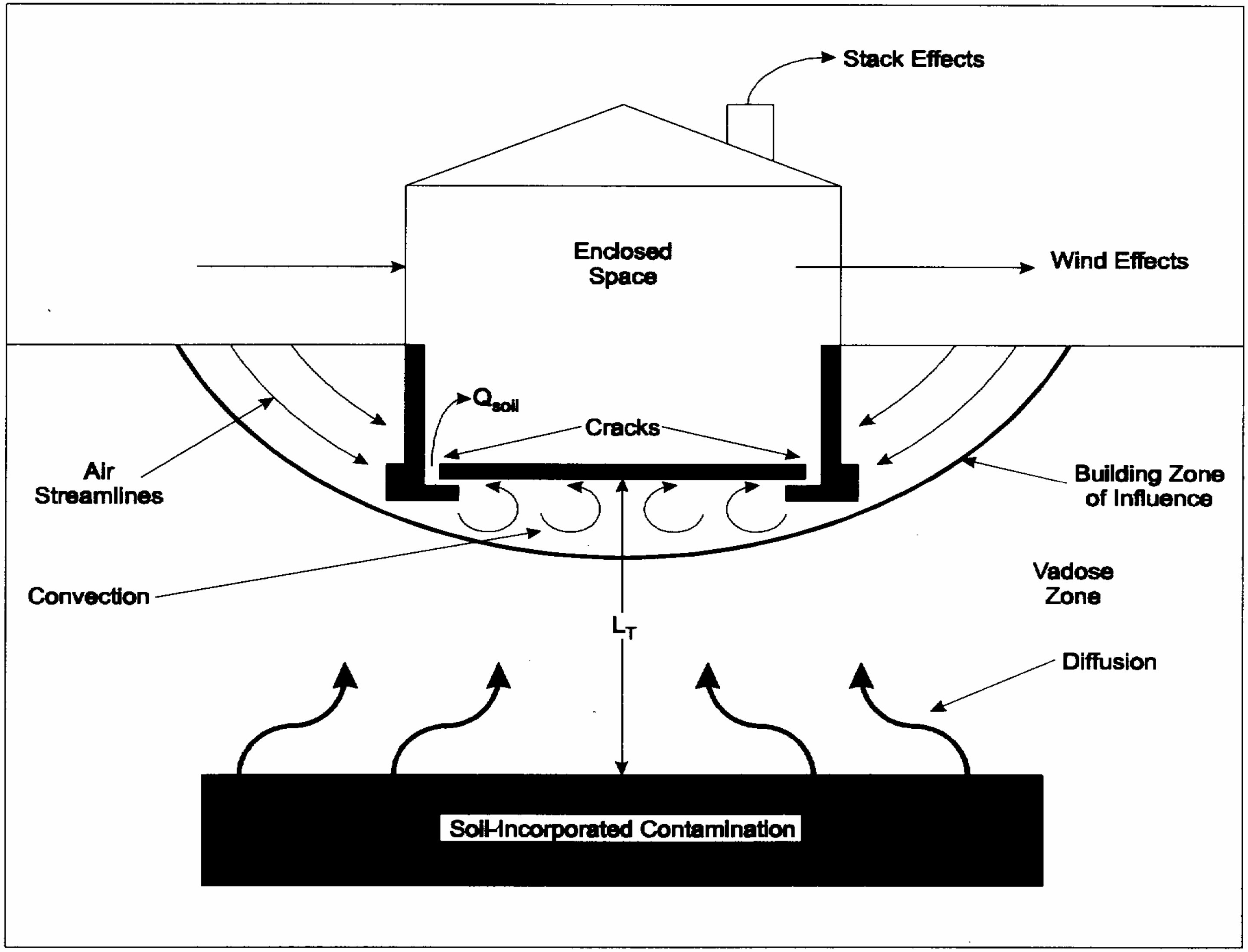
Vapor Intrusion –Conceptual Model



Taken from USEPA User's Guide for Subsurface Vapor Intrusion (2003)

Definition of Attenuation Factor

$$\text{attenuation factor } (\alpha) = \frac{\text{indoor air concentration}}{\text{soil gas concentration}}$$

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Guidance is Presented as a Series of Steps

Step 1: Identification of a Spill or Release

- Knowledge of site history, and past and present industrial practices

Step 2: Site characterization

- Site inspection (receptors and buildings)
- Three dimensional definition of contamination

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Step 3: Is the Site a Candidate for Vapor Intrusion?

- Volatile organic compounds (VOCs) at the site (list provided in the guidance)?
- Are buildings located near the VOCs (100 lateral feet)?

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Step 4: If Pathway is Complete, Evaluate Imminent Hazard

- Receptor symptoms
- Odors
- Wet basements
- Evaluate for fire and explosive conditions

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Step 5: Conduct Preliminary Screening for the Building

- Use the Office of Environmental Health Hazard Assessment (OEHHA) screening numbers (Senate Bill 32), or other approaches
- Use the OEHHA attenuation factors if screening number does not exist
- Use maximum contaminant concentrations

Office of Environmental Health Hazard Assessment

Mandated to develop screening numbers for California per Senate Bill 32

- SB 32 document contains screening numbers for vapor intrusion: California Human Health Screening Levels (CHHSLs)
- OEHHA screening numbers can be used to "estimate the degree of effort" for site cleanup – but the numbers are risk-based
- Cal-EPA recently published a user's guide for the screening numbers (www.calepa.ca.gov)

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Step 6: Collect Additional Field Data

- Collect air samples from crawl spaces
- Collect soil gas samples directly under the building foundation (subslab)
- Measure the physical properties of the soil, such as:
  - porosity
  - air permeability
  - moisture content
  - bulk density

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Step 7: Conduct a Site-Specific Modeling Evaluation for the Building

- Use the Johnson and Ettinger Model (JEM)
- Use site-specific geotechnical and building input parameters for modeling
- Use appropriate contaminant concentrations
- Attenuation factors should be reasonable (<0.00001 are probably unrealististic for shallow soil)

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Step 8 and 9: Building Pathway Evaluation and Indoor Air Sampling

- Building occupancy survey
- Identify sources of indoor contamination with field analytical equipment
- Sample indoor air twice to evaluate human exposure (autumn and spring) using TO-14A / TO-15 [SIM]

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Step 10: Evaluation of Indoor Air Data

Indoor Air Sampling Results (minimum of two sampling events needed)	Response	Activities
Risk: <10^{-6} **HQ: <1.0**	**Minimal**	**Determine that the soil vapor plume is stable**
Risk: 10^{-4} to 10^{-6} **HQ: 1.0 to 3.0**	**Monitoring**	**Install subslab monitoring points and/or vadose zone monitoring points and collect samples semi-annually**
Risk: >10^{-4} **HQ: >3.0**	**Mitigation**	**Institute engineering controls to mitigate exposure and collect indoor air samples semi-annually**

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Step 11: Mitigate Indoor Air Exposure

– Remediate the subsurface contamination

– Land use covenants to restrict property use

– Engineering controls to eliminate exposure

Long-term monitoring may be required

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DTSC Approach to Biodegradation of Petroleum Hydrocarbon

Empirical Assessment of Sites
Roggemans et al., 2001 (API Bulletin No. 15)

Four General Categories of Soil Gas Profiles

- Behavior A: Transport Limited Biodegradation Setting (degradation in Upper Portion of vadose zone)
- Behavior B: Aerobic Biodegradation Rate Limited Setting (degradation over entire vadose zone)
- Behavior C: Oxygen Deficient Subsurface Setting (minimal oxygen in vadose zone)
- Behavior D: Near-Source High Diffusion Resistance Setting (rapid degradation immediately above contaminant source)

Empirical Assessment of Sites
Roggemans et al., 2001 (API Bulletin No. 15)

Conclusions of the Study

- 6 of 28 soil profiles yielded no indication of biodegradation
- Collection of soil gas data (hydrocarbon and oxygen) is an important component for any biodegradation vapor study
- No correlation of soil gas profiles with site characteristics (surface cover, depth, soil type, hydrocarbon concentration)

Factors Influencing Biodegradation
CONTAMINANT CONCENTRATION

- Second-order degradation kinetics for pore water concentrations over 0.2 mg/L (DeVaull et al., 1997)

(degradation rate decreases with increasing contaminant concentration)

Factors Influencing Biodegradation OXYGEN

- Depth of atmospheric oxygen penetration into vadose zone is function of moisture content; seasonal variation noted by Davis et al. (2000)
- Seasonal variation in precipitation and infiltration have an effect on oxygen diffusion (Hers et al., 2000)
- Potential limitation to oxygen migration from surface due to presence of building foundation or slab (DeVaull et al., 2002)

Factors Influencing Biodegradation
MOISTURE

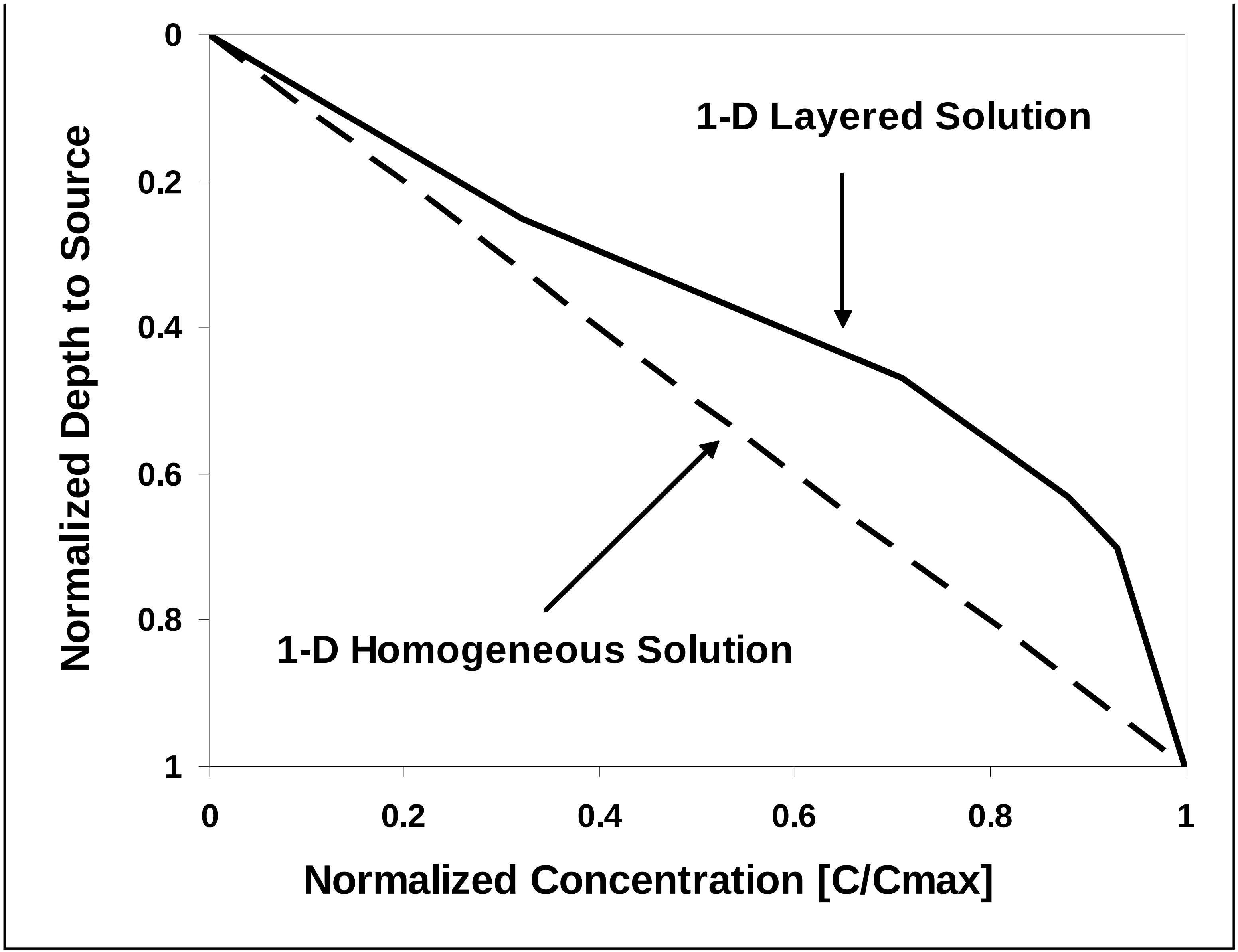
- Significant reduction in biodegradation occurs for soil moisture lower than the wilting point of soil (Zwick et al., 1995; Holden et al., 1997)

DTSC Approach to Petroleum
Johnson et al., 1999

Documentation of Biodegradation in the Field

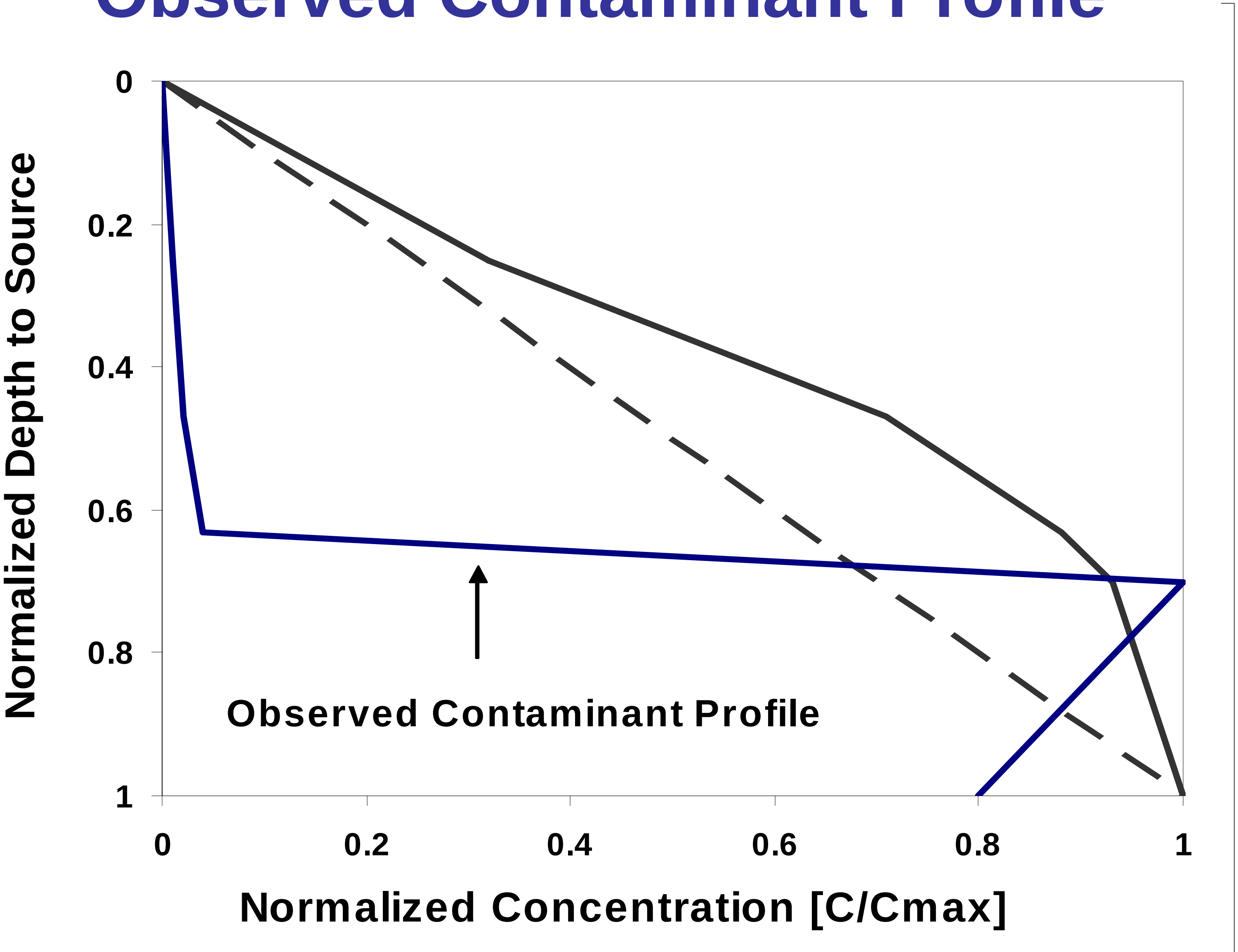
- Collect contaminant, oxygen, and carbon dioxide data with depth
- Develop site conceptual model (layer thickness, porosity, moisture, and depth to source
- Calculate the ‘expected’ or ‘theoretical’ contaminant profile

Expected or Theoretical Contaminant Profile



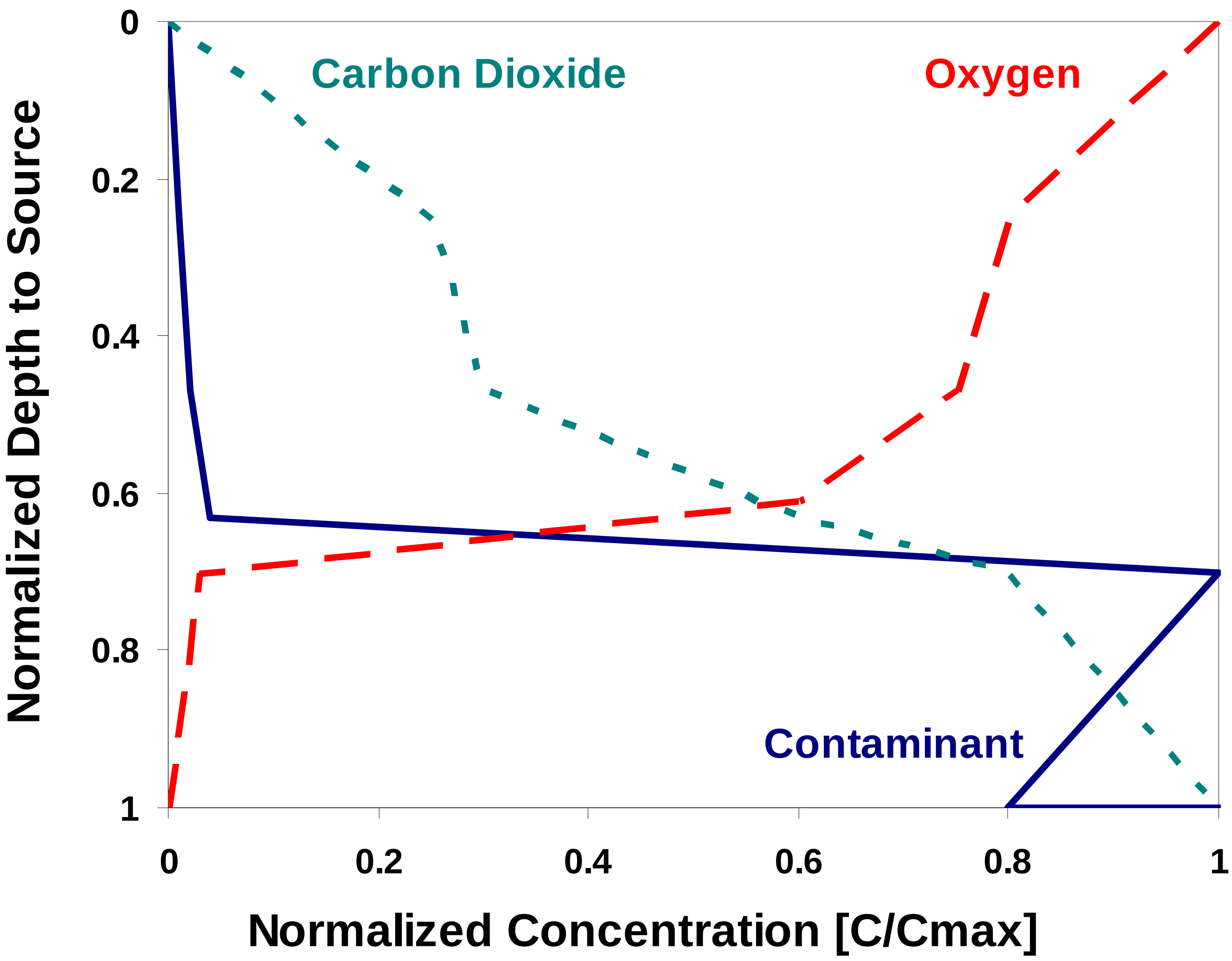
Taken from Johnson et al., 1999

Observed Contaminant Profile



Taken from Johnson et al., 1999

Evidence of Biodegradation



Taken from Johnson et al., 1999

DTSC Approach to Petroleum
Johnson et al., 1999

Verification of Biodegradation Occurrence

- Soil gas profiles are consistent
- Soil gas monitoring indicates stable subsurface profiles

Hence, a “dominant layer” exists in the subsurface where significant biodegradation occurs