



THE DEVELOPMENT OF SITE SPECIFIC RISK-BASED SOIL QUALITY GUIDELINES AS PART OF A SOIL AND GROUNDWATER MANAGEMENT AND REMEDICATION PLAN AT A PETROCHEMICAL FACILITY IN ALBERTA

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- **Introduction**
- **Background and Objectives**
- **Overall Approach**
- **Test Case Results**
- **Conclusions**

- **Critical to site management and remediation**
 - **problem definition**
 - **remedial design**
 - **performance monitoring**
 - **site closure**

Problem Definition

- **What** – individual chemicals or groups (fractions) brings focus to chemicals of concern
- **Where** – specific concentrations define spatial boundaries for various contaminants
- **Why** – risk-based helps understand controlling pathways and chemical concerns

Management Approach & Remedial Design Process

- **How** – evaluate expected endpoints for remedial technologies during selection process
- **When** – land use specific defines when endpoints are to be met. (i.e. as an operating industrial site versus an unrestricted land use)

Performance Monitoring

- **Who** – defines problem ownership
- Tracks progress and measures success.
(important to obtain stakeholder approval)

Background / Objectives



- 20 km east of Red Deer
- Several process plants on one site (ref map)
 - ethylene – three plants
 - polyethylene – two plants
 - cogeneration Plant
 - BP LAO
 - infrastructure and rail yards
- Plant and rail yards total area 720 acres
- Hundreds of chemicals/chemical mixtures are used/produced on site

- **All areas (except BP LAO) under one AENV approval**
- **1996 soil monitoring directive applies**
- **1999 soil test results compared to existing criteria, method detection limits or background**
- **Significant limitations in this approach**
 - **inconsistent**
 - **MDLs often very conservative**
 - **of limited use in developing management plans**

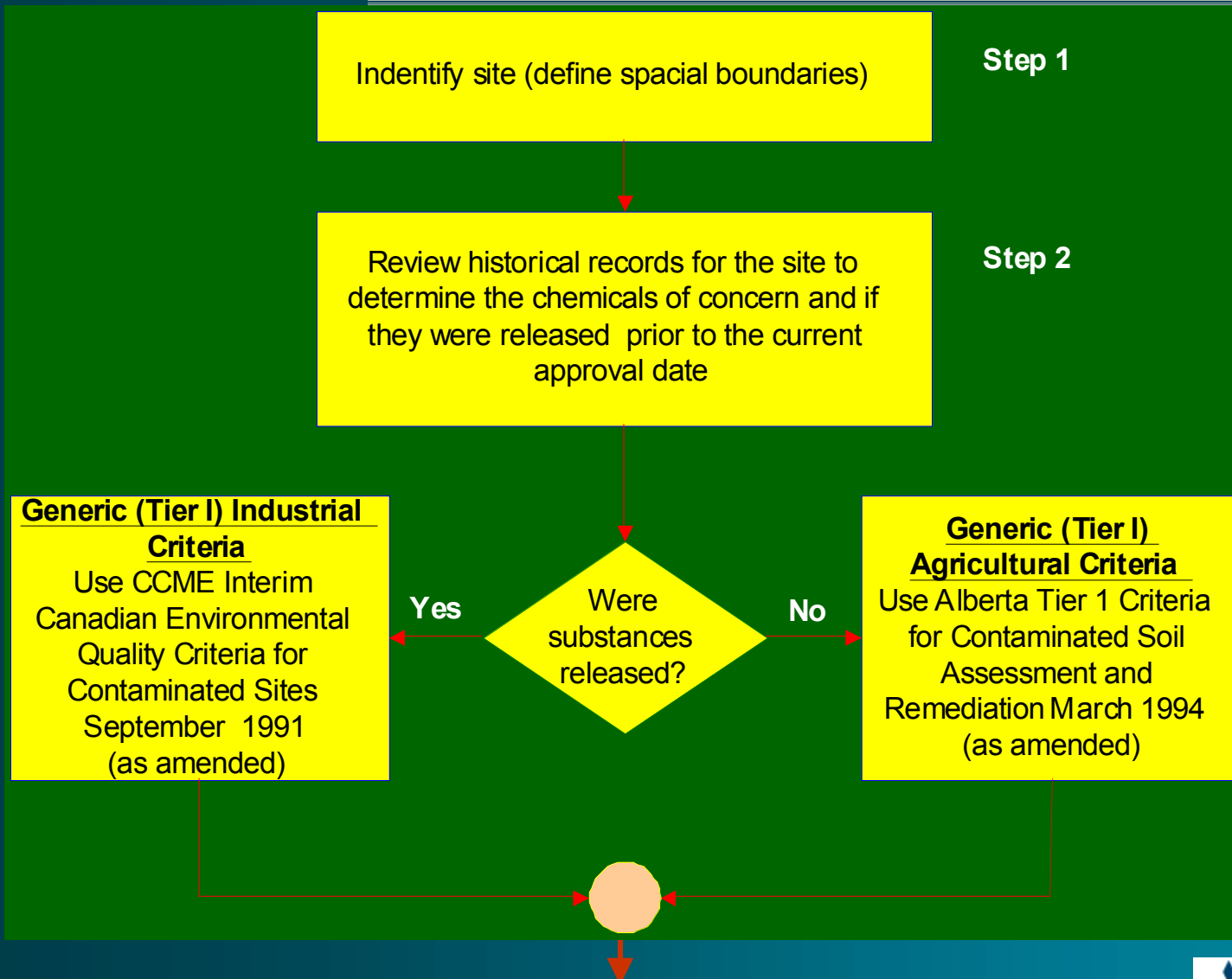
Scope of Work / Objectives

- **Define guidelines for all chemicals of concern for all site areas and obtain AENV approval**
- **Guideline expectations:**
 - **risk-based and scientifically defensible**
 - **balance efforts against benefits**
 - **consider different site physical conditions, different processes and business areas**
 - **add value to the overall management process**
 - **not be considered as pollute “up to” criteria**
 - **make sense...not be too high or low**

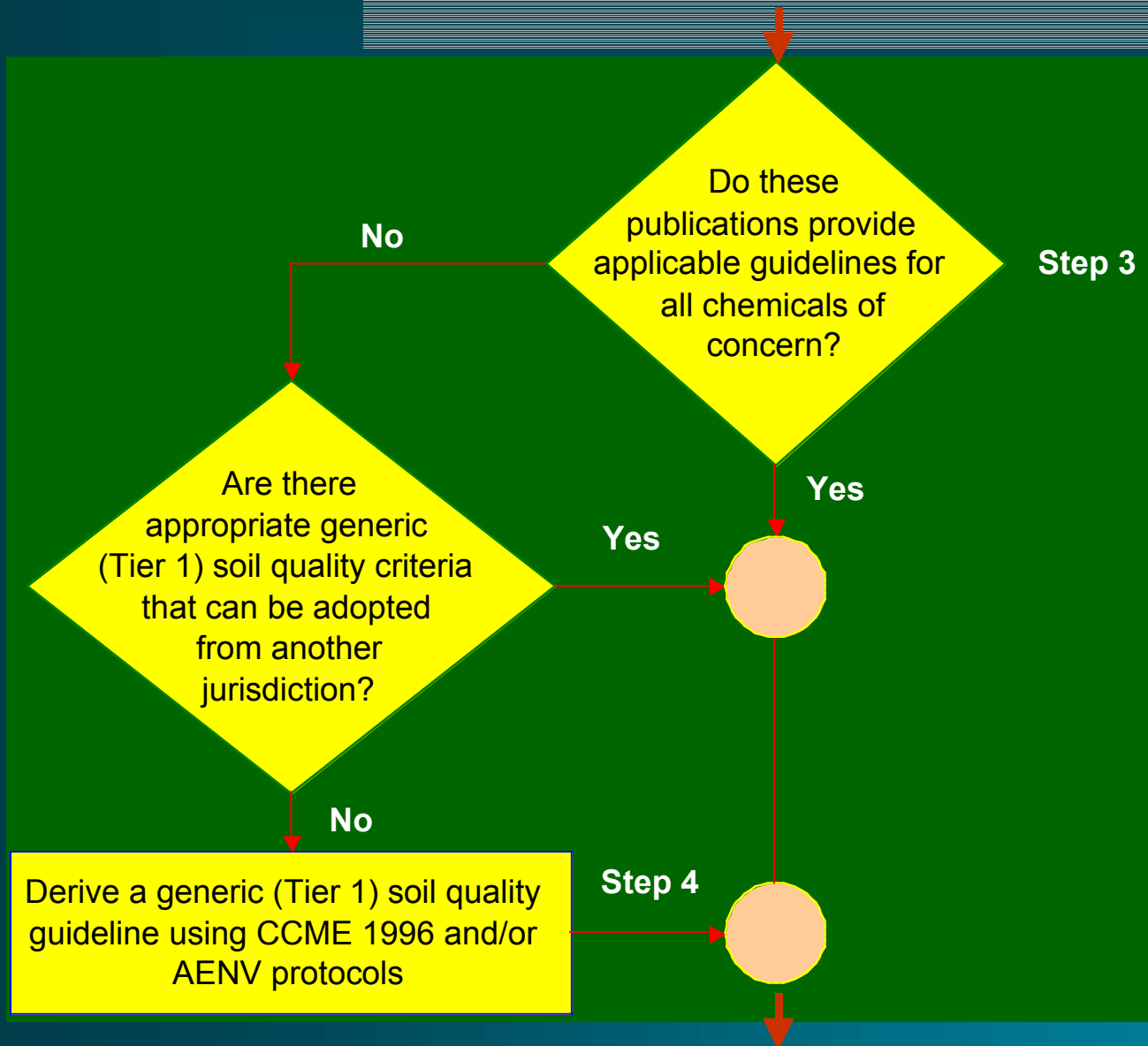
Overall Approach

- **Develop an approach that meets the requirements in the approval**
- **Refined/modified the approach considering AENV 2001 Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities**
- **Applied approach to a selected test case in which industrial guidelines were developed for the ethylene process areas**

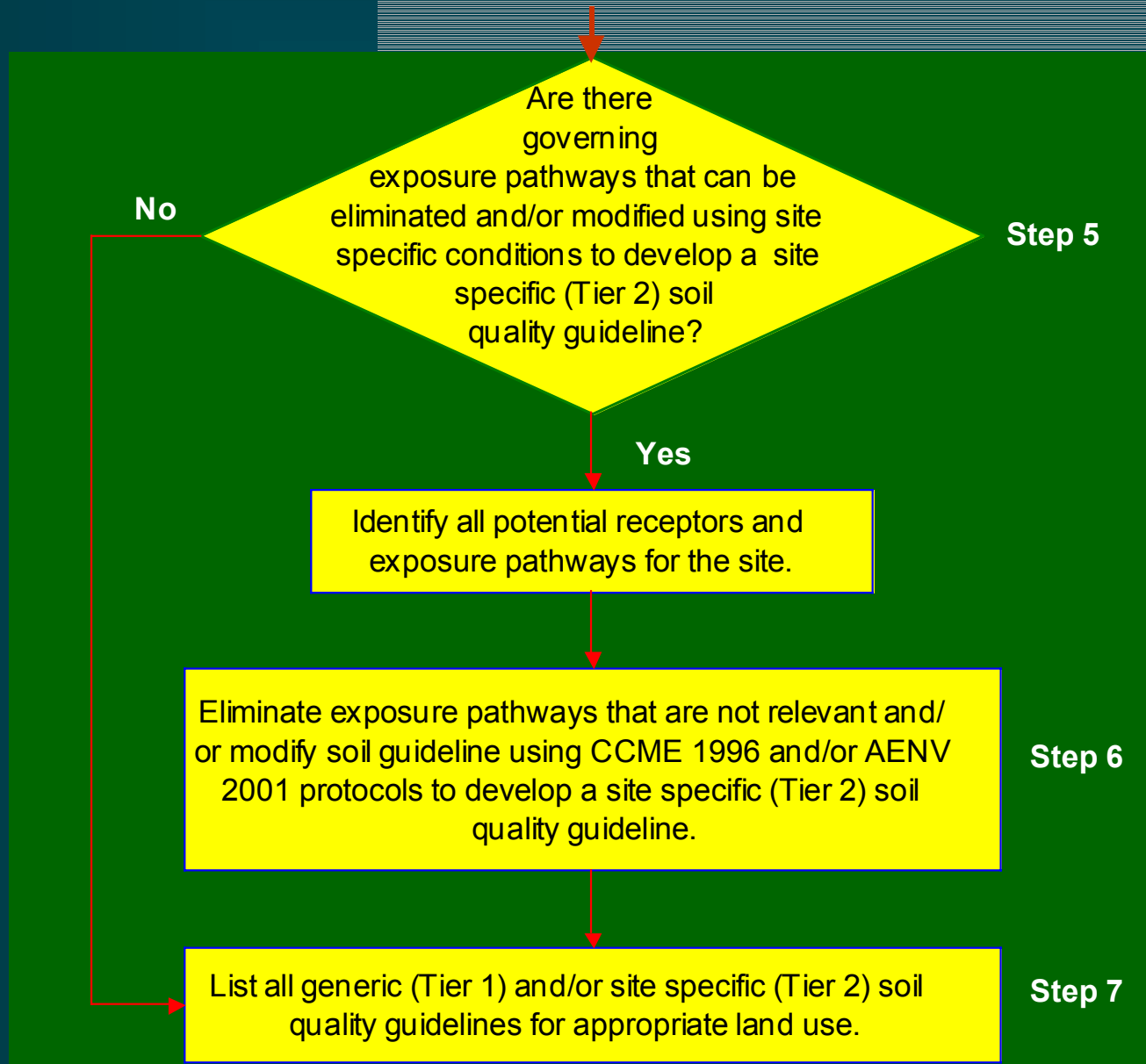
Development of Selection Guidelines

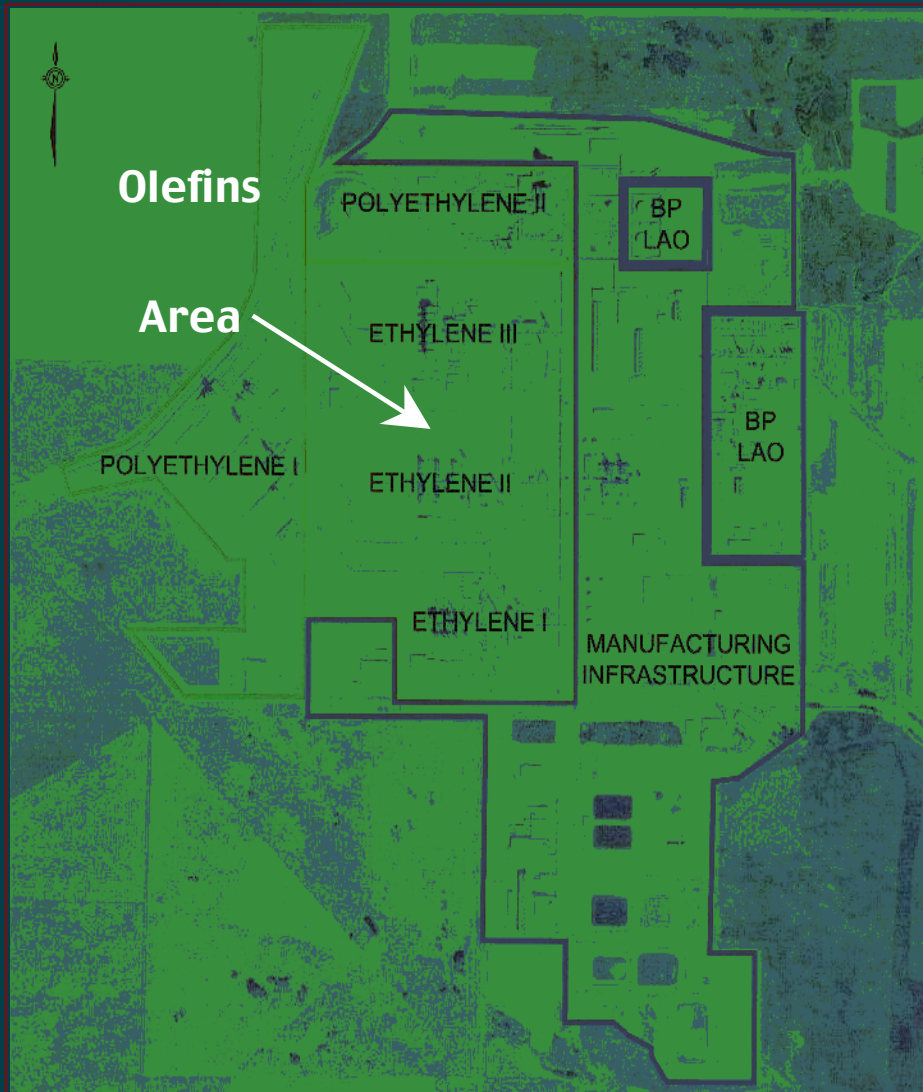


Development of Selection Guidelines



Development of Selection Guidelines





- **Identify Site – Olefins Area**
 - **3 ethylene plants and HOG plant**
 - **ethane from natural gas shipped via pipeline to the Joffre site are cracked to produce ethylene**
 - **co-product include hydrogen and other mixtures of hydrocarbon gases and liquids**

➤ Identify chemicals of potential concern (COPC)

- identify chemicals previously detected in soil and groundwater
- chemicals used in industrial processes retained for further consideration
- chemicals within natural background concentration excluded as a COPC
- chemicals considered to be nutrient or non-toxic excluded

- **Identification of published generic (Tier 1) guidelines**
 - **risk-based references used to compile appropriate guidelines for COPC's**
 - CCME 1999
 - 2001 AENV Guidelines
 - MOEE 1996
 - **generic (Tier 1) Guidelines for industrial land use are appropriate for the Olefins plant area**
 - **SQG's compiled where available (Table 1 lists chemicals requiring generic Tier 1 SQG's)**



COPCs Requiring Derivation of Generic (Tier 1) Soil Quality Guidelines

Inorganics	Organics
chromium	dicyclopentadiene
nickel	1, 3-butadiene
arsenic	ethylene glycol
zinc	diethanolamine
manganese	chloromethane
mercury	hexachlorobutadiene
barium	dichlorodifluoromethane
	1, 2, 3-trichloropropane
	methly phenols
	chloropropane
	C₅+ pyrolysis liquid

GC-FID Analysis of Joffre Aromatic Concentrate 1

Component	Wt %	Component	Wt %
benzene	45.2	1-pentene	2.15
dicyclopentadiene	16.1	t-1, 3-pentadiene	2.09
toluene	5.7	cyclopentene	1.96
cyclopentadiene	4.52	isoprene	1.34
styrene	2.52	c-1, 3-pentadiene	1.28

GC-FID Analysis of Joffre Aromatic Concentrate 1

Component	Wt %
C3	0.003
C4	1.21
C5	14.4
C6	52
C7	6.1
C8	4.3
c8+ (by diff)	5.3

F1 Fraction

$C_6 - C_{10}$

GC-FID Analysis of Joffre Aromatic Concentrate 1

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toluene	5.7	cyclopentene	1.96
cyclopentadiene	4.52	isoprene	1.34
styrene	2.52	c-1, 3-pentadiene	1.28

- **Derivation of generic (Tier1) guidelines for a chemical of potential concern**
 - exposure pathway guidelines for vapour inhalation, protection of aquatic life and protection of potable groundwater were derived assuming coarse grained soil

- **Evaluate potential for site specific (Tier 2) guidelines**
 - **receptor screening (adults)**
 - **exposure pathway screening**

Olefins Plant Area

Generic (Tier 1) Industrial Land Use Exposure

- **Human Health**
 - soil ingestion
 - dermal contact
 - vapour inhalation (source beneath a building)
- **Off-site migration**
- **Groundwater protection**
 - potable
 - aquatic life
 - **wildlife**
- **Ecological Health**
 - Soil contact (plants & invertebrates)
 - **Soil ingestion (wildlife)**



Site Specific (Tier 2) Industrial Land Use Exposure Pathways

- **Human**
 - soil ingestion
 - dermal contact
 - vapor inhalation (source beneath a building)
- **Groundwater protection**
 - aquatic wildlife (300m from source)
 - wildlife
- **Ecological Health**
 - Soil contact (plants & invertebrates)
 - Soil ingestion (wildlife)

- **Develop site specific (Tier 2) soil quality guidelines for industrial land use**
 - **applying the problem formulation (Step 5)**
 - **exposure pathway guideline related to protection of potable water was eliminated**
 - **exposure pathway guideline for the protection of groundwater for aquatic life was modified (300 m)**

- **Documentation of generic (Tier 1) and site specific (Tier 2) guidelines**
 - **identify controlling pathway(s)
(have lowest guideline)**

Olefins Plant Area



Tier 1 and Tier 2 Soil Guidelines for Dicyclopentadiene for Olefins Area

Exposure Pathway	Tier 1	Tier 2
Human soil ingestion	RES	RES
Human dermal contact	RES	RES
Human vapour inhalation	74	74
Off-site migration	NA	EXC
Protection of potable groundwater	348	EXC
Soil contact (plants and invertebrates)	NA	NA
Protection of groundwater for aquatic life	18.4	RES
Protection of groundwater for wildlife	13008	13008
Soil ingestion (wildlife)	27006	27006
Final (limiting) guideline	18.4	74

RES - calculated value exceeds 30,000 mg/kg (saturated limit)

NA - pathway not calculated due to insufficient data or methodology

EXC - Excluded for Tier 2 guidelines





Tier 1 and Tier 2 Soil Guidelines for Ethylbenzene for Olefins Area

Exposure Pathway	Tier 1	Tier 2
Human soil ingestion	RES	RES
Human dermal contact	RES	RES
Human vapour inhalation	630	630
Off-site migration	NA	EXC
Protection of potable groundwater	0.36	EXC
Soil contact (plants and invertebrates)	200	200
Protection of groundwater for aquatic life	79	RES
Protection of groundwater for wildlife	16000	16000
Soil ingestion (wildlife)	3400	3400
Final (limiting) guideline	0.36	200

RES - calculated value exceeds 30,000 mg/kg (saturated limit)

NA - pathway not calculated due to insufficient data or methodology

EXC - Excluded for Tier 2 guidelines





Tier 1 and Tier 2 Soil Guidelines for Ethylene Glycol for Olefins Area

Exposure Pathway	Tier 1	Tier 2
Human soil ingestion	RES	RES
Human dermal contact	RES	RES
Human vapour inhalation	NA	NA
Off-site migration	NA	NA
Protection of potable groundwater	11.46	EXC
Soil contact (plants and invertebrates)	NA	NA
Protection of groundwater for aquatic life	0.27	RES
Protection of groundwater for wildlife	399	399
Soil ingestion (wildlife)	RES	RES
Final (limiting) guideline	0.27	399

RES - calculated value exceeds 30,000 mg/kg (saturated limit)

NA - pathway not calculated due to insufficient data or methodology

EXC - Excluded for Tier 2 guidelines



- **Application of process for selection of soil quality guidelines for the Olefin's Plant Area was completed and is currently being applied to other areas of the plant site**
- **AENV 2001 protocol successfully used to develop soil quality guidelines (SQG) to manage impacted soil at an industrial site**

Conclusions cont.

- **Success depends on separation of large complex sites into smaller manageable areas**
- **Risk-based frameworks can lead to increased operator understanding of risk and appropriate implementation of remedial/risk management plans**
- **AENV 2001 guidelines for petroleum hydrocarbons can be used to assess other organic mixtures**
- **Involve AENV early in the process**