



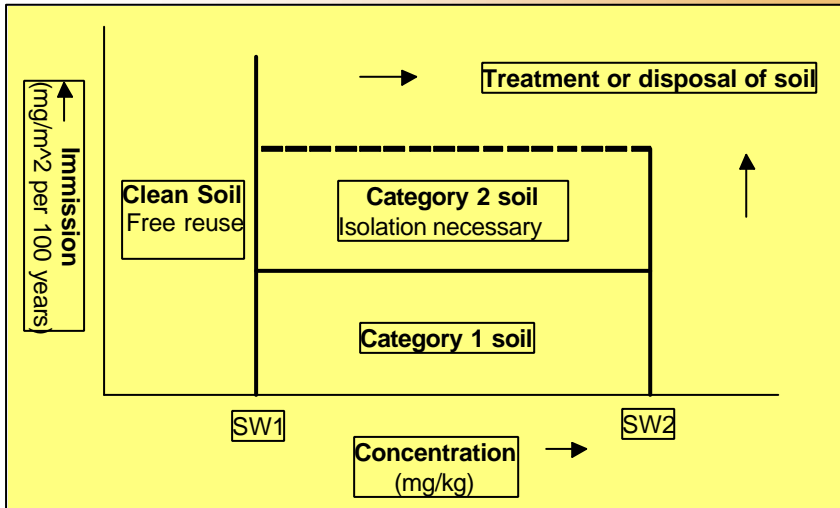
SAMPLING STRATEGIES IN NL - ASSESSING THE ENVIRONMENTAL QUALITY OF SOIL

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Centre for Soil Treatment - NL**

OUTLINE

- ◆ **SOIL QUALITY STANDARDS**
- ◆ **SAMPLING OBJECTIVES - IN/EX-SITU**
- ◆ **DEVELOPMENT / VALIDATION EX-SITU STRATEGY**
 - PROBLEM DEFINITION & APPROACH
 - MODELING
 - VALIDATION
 - PRACTICAL APPLICATION, COSTS AND QA/QC
- ◆ **“MISMATCH” IN-SITU VS EX-SITU**
 - DATABASE STATISTICAL ANALYSIS
 - COSTS / BENEFITS
- ◆ **EPILOGUE**

SOIL QUALITY STANDARDS



IN-SITU SAMPLING (1)

OBJECTIVE = SITE REMEDIATION

- IDENTIFICATION OF HOTSPOTS
- CONTAMINATION CONTOUR MAPS
- GROUNDWATER CONTAMINATION

AVAILABLE PROTOCOLS

- HISTORIC INVESTIGATION
- SITE REMEDIATION
- MIX OF REMEDIATION / REUSE (NEN 5740)

IN-SITU SAMPLING (2)

OBJECTIVE = REUSE

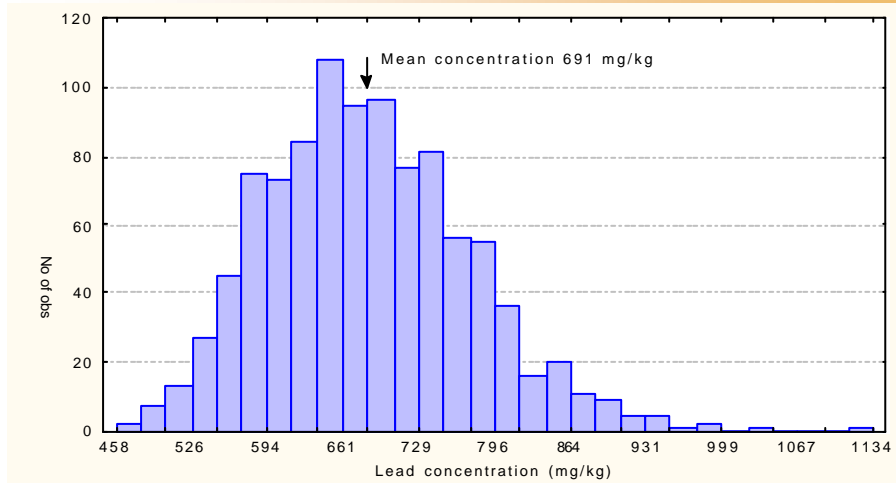
- ◆ **IN-SITU SOIL QUALITY MAPPING**
- ◆ **IN CITIES AND COUNTRYSIDE**
- ◆ **REUSE AS “SOIL” ONLY**
- ◆ **GENERIC FEATURES:**
 - **GREEN ZONE = UNRESTRICTED REUSE**
 - **YELLOW ZONE = OCCASIONAL EX-SITU SAMPLING**
 - **RED ZONE = COMPULSORY EX-SITU SAMPLING**

EX-SITU SAMPLING OF SOIL STOCKPILES

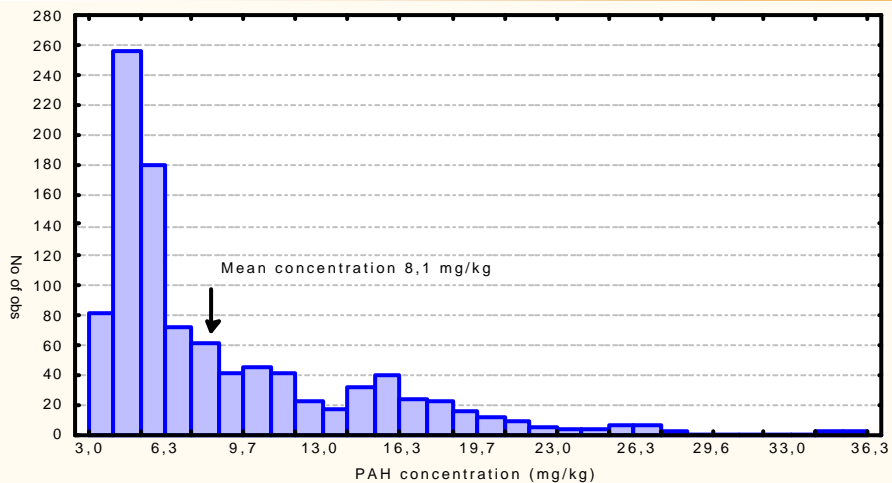
OBJECTIVES

- ◆ **REUSE IN CIVIL ENGINEERING WORKS
(DUTCH BUILDING MATERIALS DECREE)**
- ◆ **INPUT CONTROL FOR SOIL TREATMENT**
- ◆ **LANDFILLING (TAXATION)**

CONTAMINANT HETEROGENEITY 1



CONTAMINANT HETEROGENEITY 2



SAMPLING STRATEGY OPTIONS

GIVEN = CONTAMINANT HETEROGENEITY IS UNKNOWN

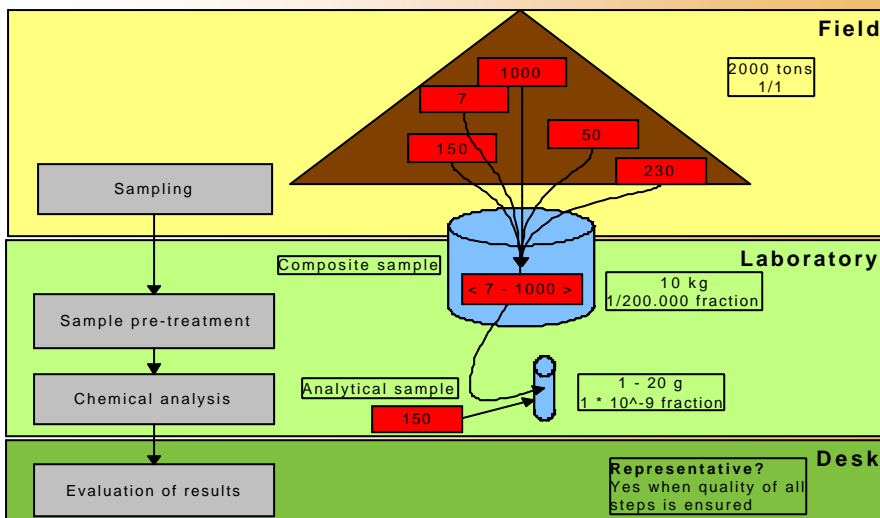
OPTION 1

- ◆ **SAMPLING AND ANALYSIS OF A LARGE NUMBER OF INDIVIDUAL SAMPLES**
(INFO ON MEAN, PERCENTILE VALUES)

OPTION 2

- ◆ **COMPOSITE SAMPLE**
(INFO ON MEAN VALUE ONLY)

CHOSEN SAMPLING STRATEGY



150 Concentration in an individual increment, composite sample or analytical sample

APPROACH

TECHNICAL QUESTIONS

- ◆ ADEQUATE SAMPLE PRETREATMENT PROCEDURES
- ◆ NUMBER OF INCREMENTS AND SIZE OF COMPOSITE SAMPLE

APPROACH

- ◆ TESTING OF SAMPLE PRETREATMENT PROCEDURES
- ◆ MODELING
- ◆ PRACTICAL VALIDATION

SAMPLE PRETREATMENT PROCEDURES

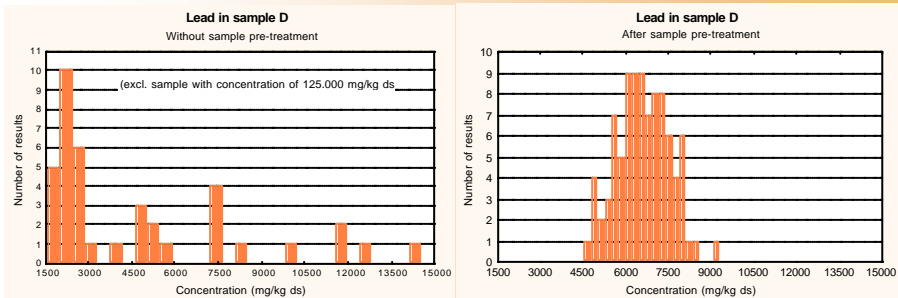
INORGANICS

- ◆ DRYING AND INTENSIVE GRINDING
- ◆ SUB-SAMPLING BY ROTATING DIVIDERS

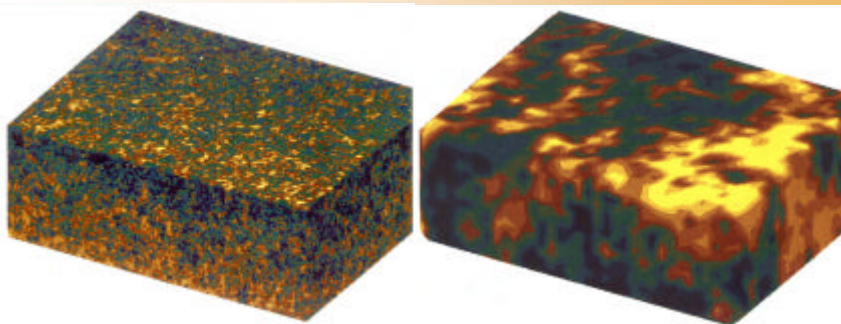
ORGANICS

- ◆ CRYOGENIC GRINDING
- ◆ ETC

IMPACT OF SAMPLE PRETREATMENT FOR LEAD



DIGITAL MODELS OF SOIL STOCKPILES



MODELING OBJECTIVES

TO OBTAIN A “RELIABLE” ESTIMATE OF THE TRUE MEAN CONTAMINANT CONCENTRATION

“RELIABILITY” RELATES TO THE WIDTH OF THE SAMPLING DISTRIBUTION CURVE

“RELIABILITY” DEPENDS ON:

- ◆ CONTAMINANT HETEROGENEITY
- ◆ NUMBER OF INCREMENTS

MODELING FEATURES

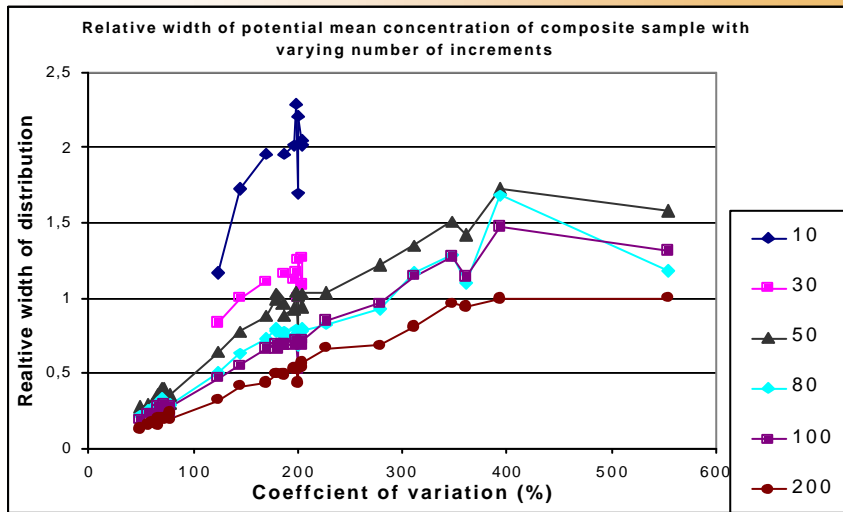
INPUT

- ◆ SPATIAL DISTRIBUTION OF CONTAMINANTS IN 3 STOCKPILES
- ◆ CONVERTED TO 30 MODELS WITH DIFFERENT HETEROGENEITIES

TESTING

- ◆ NUMBER OF INCREMENTS (10-200)
- ◆ NUMBER OF COMPOSITE SAMPLES

MODELING EXAMPLE



MODELING RESULTS

- ◆ 50 INCREMENTS PER COMPOSITE SAMPLE (9kg)
- ◆ 2 COMPOSITE SAMPLES PER STOCKPILE

VALIDATION PROCESS

INPUT

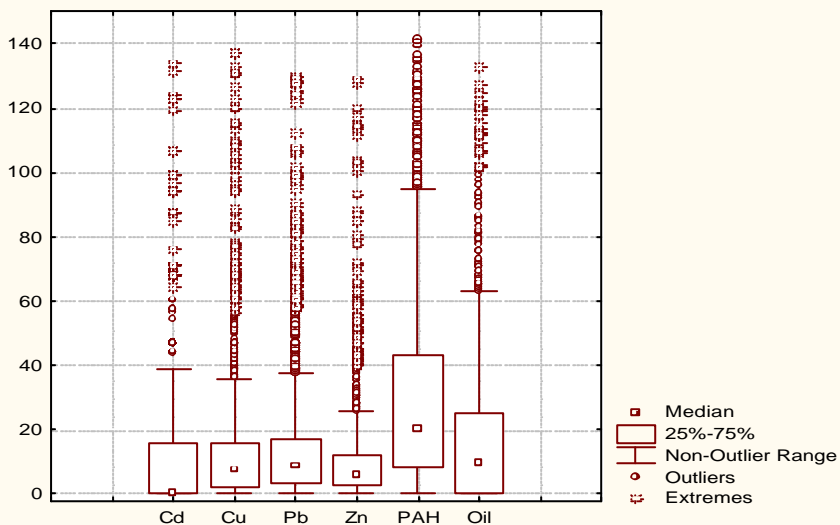
- ◆ 2600 SOIL STOCKPILES
- ◆ PER STOCKPILE 2 SETS OF DATA
- ◆ FOR 8 HEAVY METALS, MIN.OIL, SUM-PAH's AND HALOGENATED ORGANICS

OUTPUT

- ◆ MEAN CONCENTRATION
- ◆ COEFFICIENT OF VARIATION



EXAMPLES CV



STRATEGY RELIABILITY

	Inorganic contaminants		Organic contaminants	
<i>Estimated analytical error</i>	5 %	10 %	5 %	20 %
Strategy 2 x 50	97%	98%	75%	82%
Strategy 2 x 6	79%	85%	48%	69%

PRACTICAL APPLICABILITY

- ◆ BOTH FOR EX-SITU AND IN-SITU APPLICATION
- ◆ COMPOSITE SAMPLE = 50 INCREMENTS
- ◆ SAMPLING AND CHEMICAL ANALYSIS FOR 1 COMPOSITE SAMPLE = 500 EURO

SAMPLING REGIMES

QTY	INFORMATION	ACTION	# SAMPLES
< 200 ton	QUALITATIVE	LUMPING 200 ton	2
< 2000 ton	QUANTITATIVE	LUMPING 2000 ton	2
2-50 kton	IN-SITU	-	2-11
> 50 kton	IN-SITU	PROTOCOL	STATISTICS

- USE OF CERTIFICATION SCHEMES COMPULSORY
- EXPERT SYSTEM AVAILABLE (DUTCH ONLY)

MARKET ACCEPTANCE

PROCES	COSTS [Euro/ton]
Sampling & analysis	0.5-1.5
Reuse	2-7
Thermal treatment	35-60
Soil washing	20-45
Biological treatment	20-40
Landfilling	40-70

QUALITY ASSURANCE & CONTROL

AUDITED CERTIFICATION SCHEMES FOR:

- ◆ SAMPLING
- ◆ CHEMICAL ANALYSIS AND LEACHING TESTS
- ◆ REUSE
- ◆ TREATMENT
- ◆ LANDFILLING
- ◆ SITE REMEDIATION

ADVANTAGES:

- ◆ STAKEHOLDERS AGREE ON WHAT TO DO
- ◆ KNOW HOW TO DO IT
- ◆ KNOW THE VALUE OF WHAT'S BEING DONE



EPILOGUE

A CONCERTED EFFORT OF STAKEHOLDERS HAS RESULTED IN A:

- ◆ TECHNICALLY SUBSTANTIATED
- ◆ COST-EFFECTIVE
- ◆ AUDITED

SAMPLING AND CHEMICAL ANALYSIS PROCEDURES FOR:

- ◆ CLEAN
- ◆ REUSABLE
- ◆ TREATABLE/DISPOSABLE SOIL

WHICH IS:

- ◆ WIDELY ACCEPTED

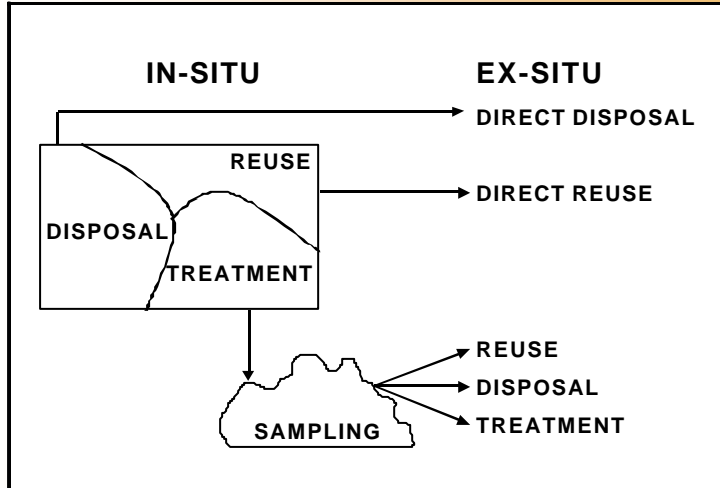


SAMPLING



“MISMATCH” BETWEEN IN-SITU AND EX-SITU COMPARISON BETWEEN IN-SITU QUALIFICATION WITH PROTOCOLS FOR REMEDIATION AND EX-SITU “2 x 50” PROTOCOL

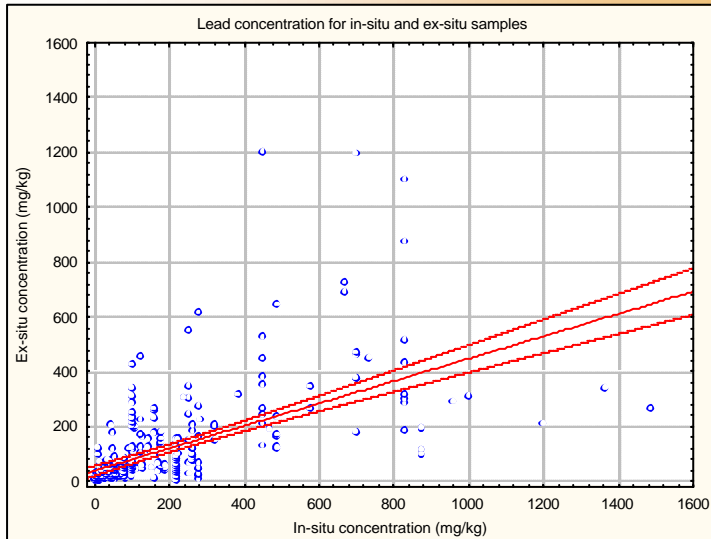
APPROACH



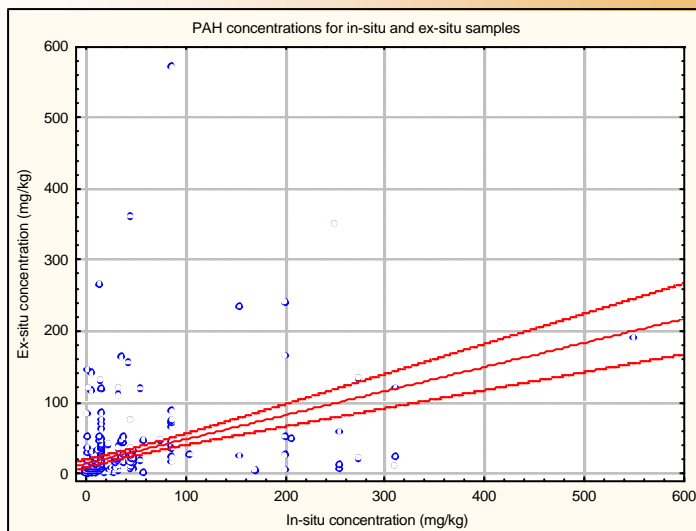
IN/EX-SITU DATABASE

FEATURE	NUMBER
REMEDICATION PROJECTS	119
# IN-SITU QUALIFIED LOTS	189
# EX-SITU QUALIFIED LOTS	506
TONS IN-SITU QUALIFIED	439 kton
TONS EX-SITU QUALIFIED	468 kton

“MISMATCH” FOR LEAD



“MISMATCH” FOR PAH's



IN/EX-SITU DIFFERENCES

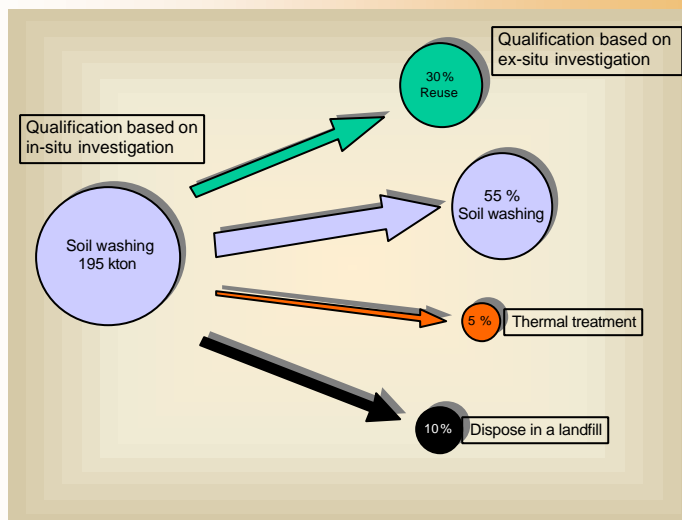
OBSERVED

EX-SITU CONCENTRATIONS <
IN-SITU CONCENTRATIONS

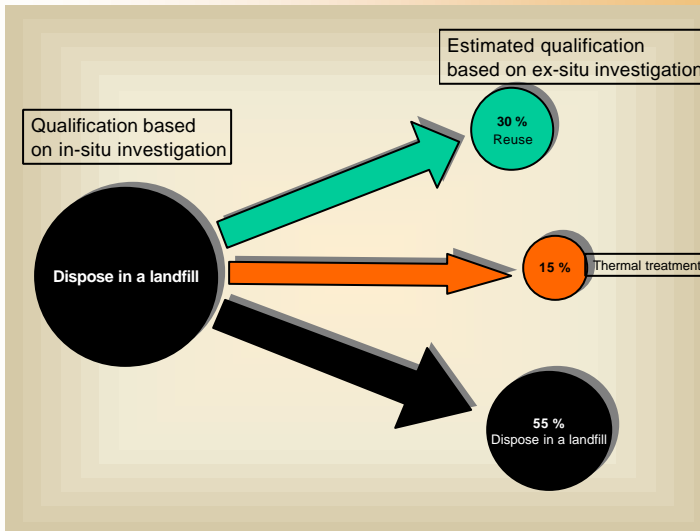
REASONS

- ◆ DILUTION EFFECT DUE TO EXCAVATION
- ◆ IN-SITU PROTOCOLS => HOTSPOT IDENTIFICATION
EX-SITU PROTOCOLS => MEAN CONCENTRATION

IMPACT ON SOIL QUALIFICATION (1)



IMPACT ON SOIL QUALIFICATION (2)



ACTIONS TAKEN

- ◆ COSTS REUSE << COSTS TREATMENT/LANDFILLING
- ◆ FULL ECONOMIC ASSESSMENT BY KPMG
- ◆ POLITICALLY UNACCEPTABLE TO LANDFILL REUSABLE/TREATABLE SOIL

EX-SITU QUALIFICATION OF SOIL
OPTED FOR LANDFILLING
COMPULSORY
SINCE 2001