



# SGI GUIDANCE ON NATURAL ATTENUATION FOR PETROLEUM RELEASES IN SWEDEN



**MONITORING NATURAL ATTENUATION (MNA)  
IN GROUNDWATER**



## OBJECTIVES OF THE GUIDANCE



- to introduce MNA as a remedial alternative for petroleum contaminated aquifers in Sweden
- to provide a Swedish technical guidance for evaluating natural attenuation processes in remediating groundwater contaminated with petroleum products
- assist responsible parties, consultants, environmental agencies in the site-specific evaluating processes.



## CONTENT OF THE GUIDANCE INFLUENCED BY



- SWEDISH FIELD EXPERIENCE
- INFORMATION FROM INTERNATIONAL EXPERTISE
- INFORMATION FROM SIMILAR INTERNATIONAL DOCUMENTS



## FUNDAMENTALS of MNA Source control and monitoring!



- ”Reliance on natural attenuation processes to achieve site-specific remedial objectives.”
- ”The natural attenuation processes act, under favorable conditions, without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater.”
- ”These in-situ processes include: biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants.”

US AFCEE, 1999



## MNA is appropriate



- only when protective of human health and the environment
- at sites with low potential for plume generation and migration
- where leaching source / free product have been removed
- where contaminants are biodegradable
- when achieving site-specific remediation objectives within a time frame that is reasonable compared to alternatives.



## MNA is not appropriate when



- consistent expanding groundwater plume exists
- contaminants are present which do not readily biodegrade
- mobile free product is present at the site and removal not proposed
- one or more of the exposure pathways (basis of Swedish guideline values) exists to a non-acceptable level, no active remediation method proposed
- the contaminated media is difficult to assess.

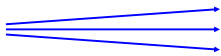
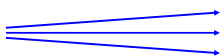



## THE GUIDANCE IS BASED ON 3 MAJOR LINES OF EVIDENCE SUPPORTING NATURAL ATTENUATION



### Major lines of evidence

### Sub-lines

- **First**  A  
B  
C etc.
- **Second**  A  
B  
C etc.
- **Third**  A  
B  
C etc.



## THE THREE MAJOR LINES OF EVIDENCE



- Trends of retracting (or stable) contaminant plume in groundwater.
- Geochemical data indicative of biodegradation processes in the plume.
- Microcosm studies, degradation products in field, TeMB versus BTEX, fate & transport modelling etc.



**THE GUIDANCE PARTLY BASED ON PARALLEL  
OBTAINED FIELD EXPERIENCE**



**OLD CLOSED PETROL STATION**



**MEADOW**

**PETROL STATION**



**THE MEADOW**

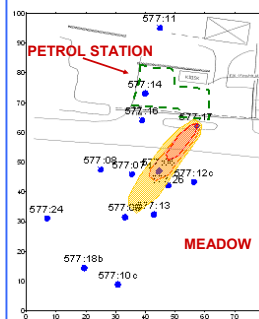


**PETROL STATION**

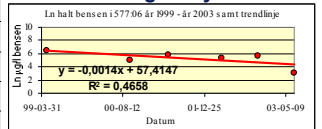


**FIRST LINE OF EVIDENCE, example**

*Trends of retracting plume of Benzene, BTEX etc.*



**Sampling up to 6 times  
during 3- 4 years**



**Significant variation.  
For better prognosis:  
4 - 6 consecutive quarterly  
sampling recommended.  
1 - 2 more sampling  
events for this site**

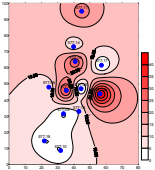


## SECOND LINE OF EVIDENCE, example

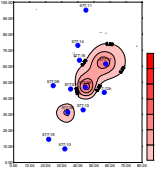
Geochemical indications of biodegradation.



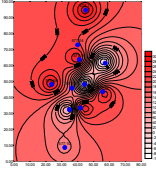
Depletion of nitrate



Methane production



Low redox



Similar trends for  $O_2$ ,  $SO_4$ ,  $Fe^{2+}$ , alkalinity, etc., from all sampling events.



## THIRD LINE OF EVIDENCE, example

Biodegradation products / intermediates from BTEX.



- 4-Methylbenzoate (from p-xylene) in one of two contaminated wells, not in non-contaminated area
  - Dimethylphenols (from xylenes) and ethylphenols (from ethylbenzene) in the two contaminated wells, not in non-contaminated area
- (In future include benzy succinate, methyl-benzy succinates).

*Fate/Transport modelling.*

- Bioscreen (Bioplume III, GMS etc.)



## CONCLUSIONS

Biodegradation may occur naturally in Sweden to a rate and degree which may give potential for MNA at Swedish petroleum contaminated sites.

The obtained site-specific first, second and third lines of evidence => MNA can be applied at the tested site provided that prognosticated remediation time is accepted.

Significant site-specific yearly variation in concentration => 4-6 consecutive quarterly sampling events recommended to be included in total sampling plan for evaluation and prognosis.

