« Salsigne » : the restoration of a contaminated site taking sanitary, environmental and economics objectives into account

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  - Conceptual model
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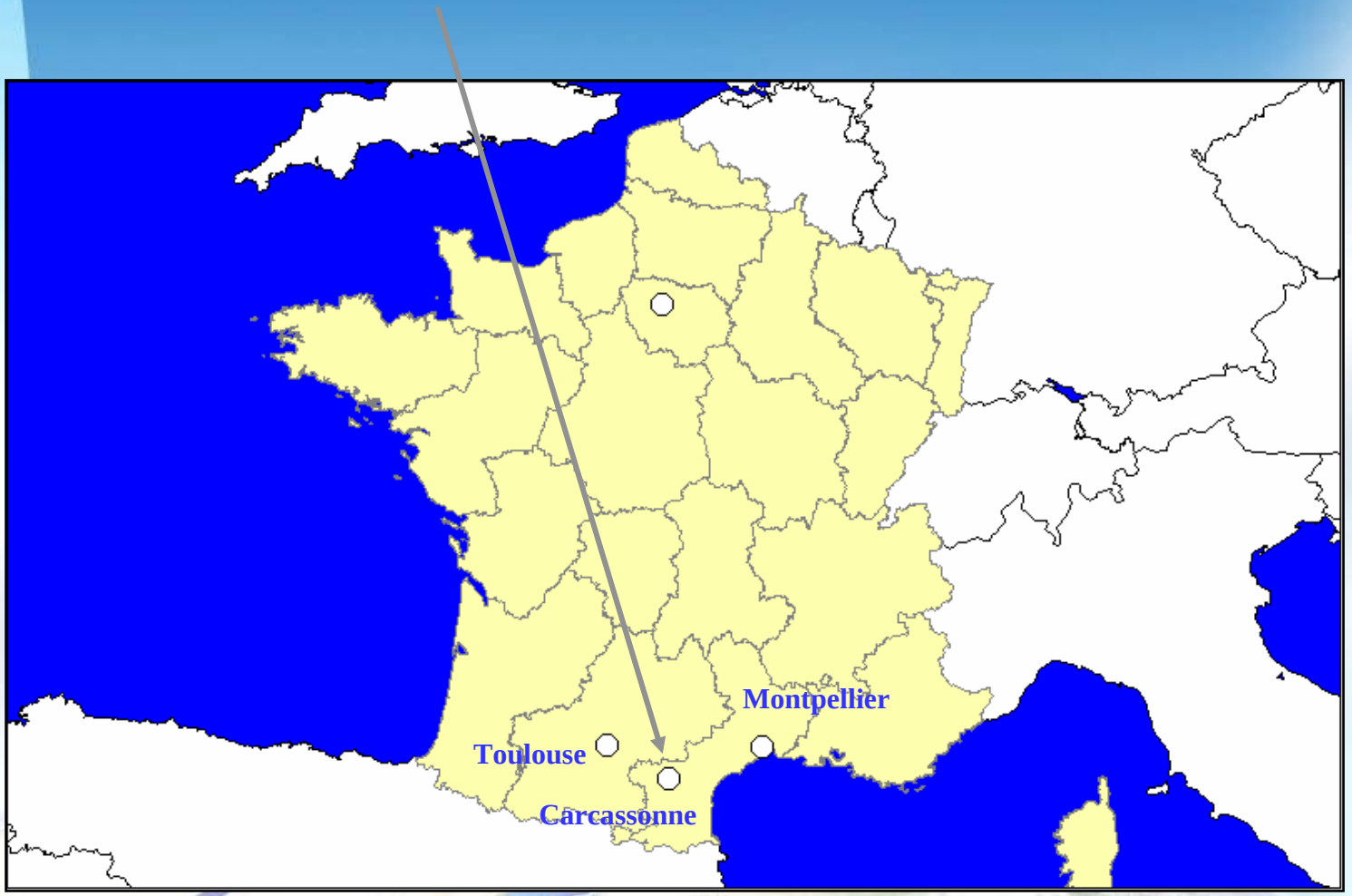
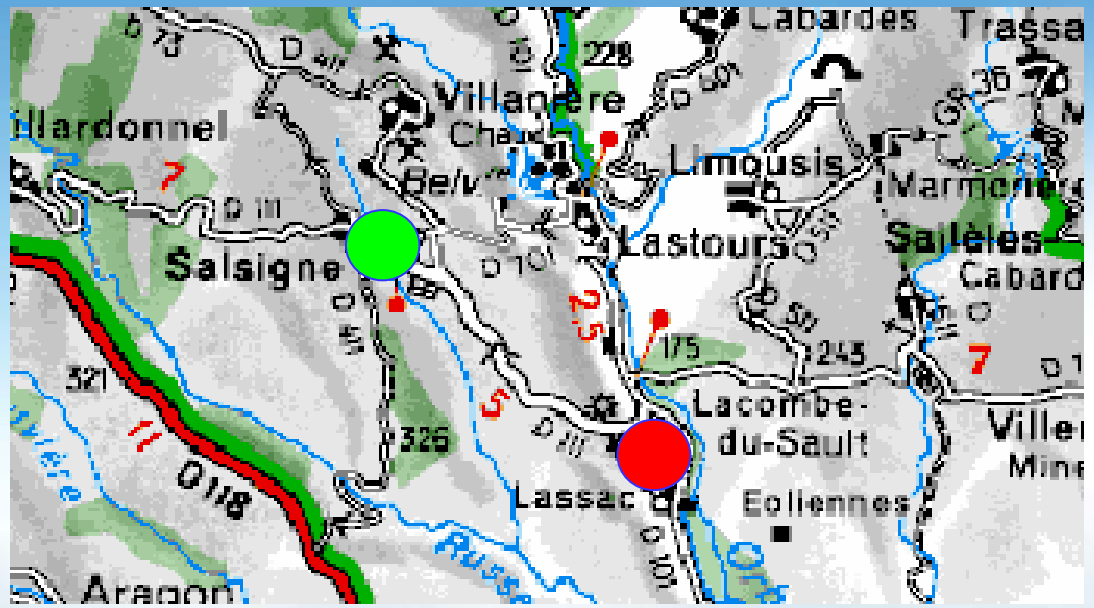
  - Why Phytostabilisation and how ?
- Conclusion

Salsigne – La Combe du Saut

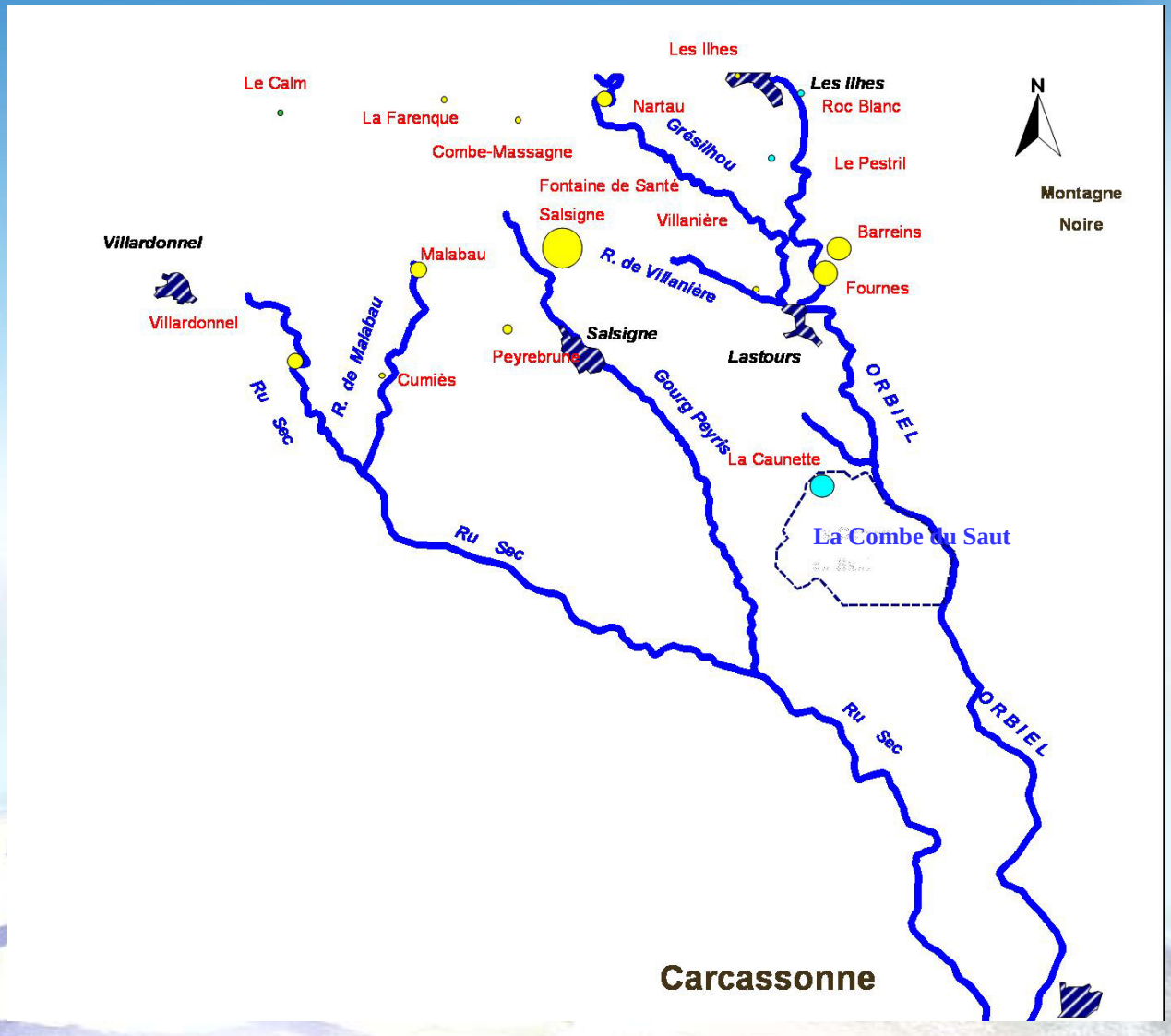


La montagne Noire



Carcassonne

Orbiel Valley



Historical background

- 1924 : SMUS
- 1966 : SMPCS
- 1980 : SMPCS (COFRAMINES)

The site is then divided in three parts :

- 1989 – 1996 : SNC Lastours (Tailings re-treatment)
- 1992 – 1996 : SEPS (Waste treatment company)
- 1992 – 2004 : Mine d'Or de Salsigne (MOS)
  (Gold Mine of Salsigne)

Production during XXth Century

- Pyrometallurgy and cyanuration
- 15 million tonnes of ore
- 110 tonnes of gold

Period	Arsenic trioxyde (tons/year)
From 1924 to 1927	150 to 900
From 1928 to 1938	3000 to 6000
From 1939 to 1954	1000 to 10 000
From 1955 to 1960	6000 to 7000
From 1961 to 1992	10 000 (in 1990)
TOTAL	200 000

Mission of ADEME

1998 : 30 million of euro

- **June 1999 :** Monitoring
  Waste management
  Demolition
  Studies

- **March 2004 :** Remediation project
  Monitoring plan

DIFPOLMINE

Diffuse Pollution from Mining Activities

Difpolmine demonstration project

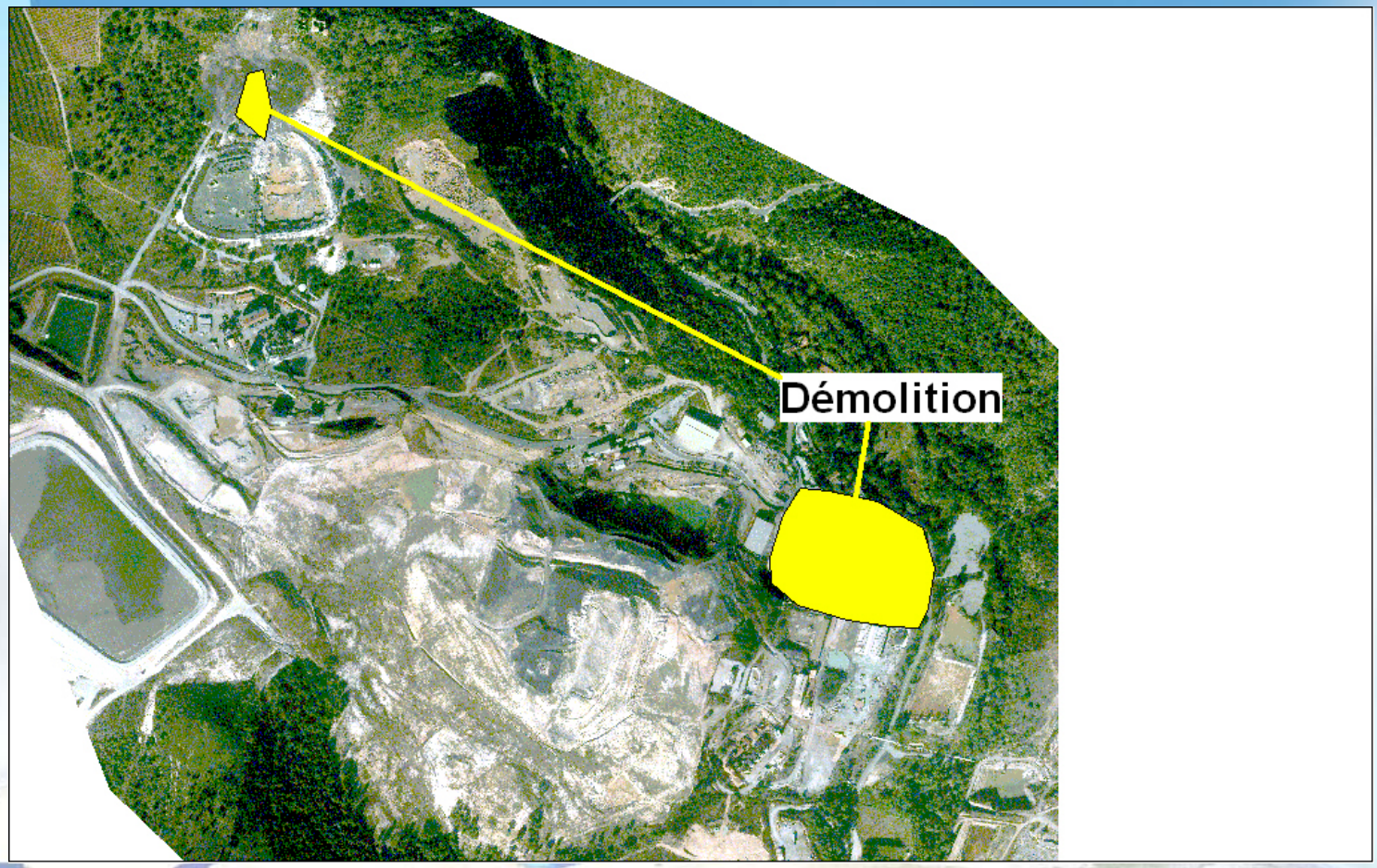
- Life Environment 2002
- Water management and phytostabilisation
- www.ademe.fr/difpolmine
  - IRH Environment
  - Limburg University
  - Budapest University (Mrs Gruiz)
  - Water Agency RMC

Salsigne – La Combe du Saut

1999

Waste management

Demolition

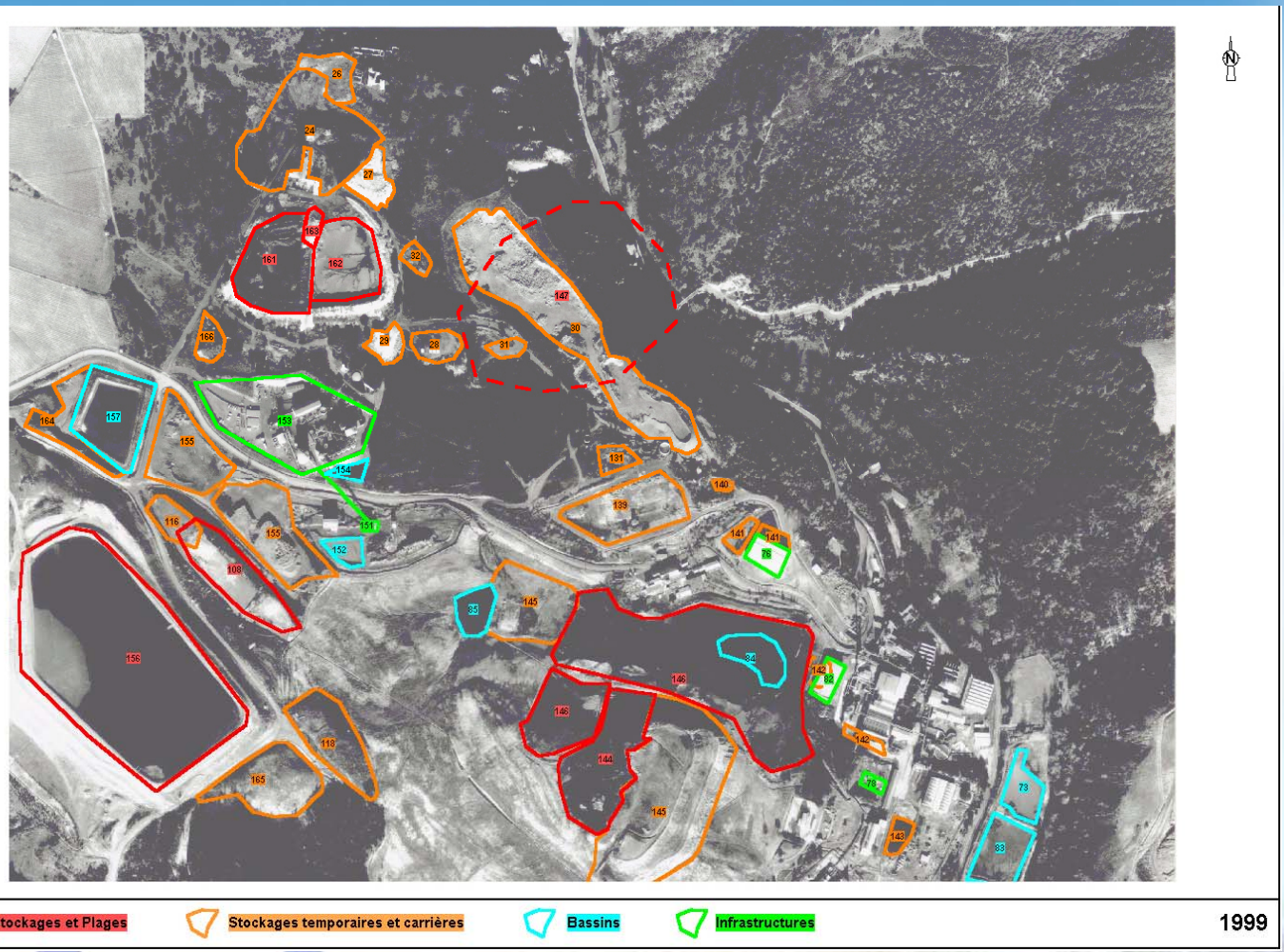


Demolition

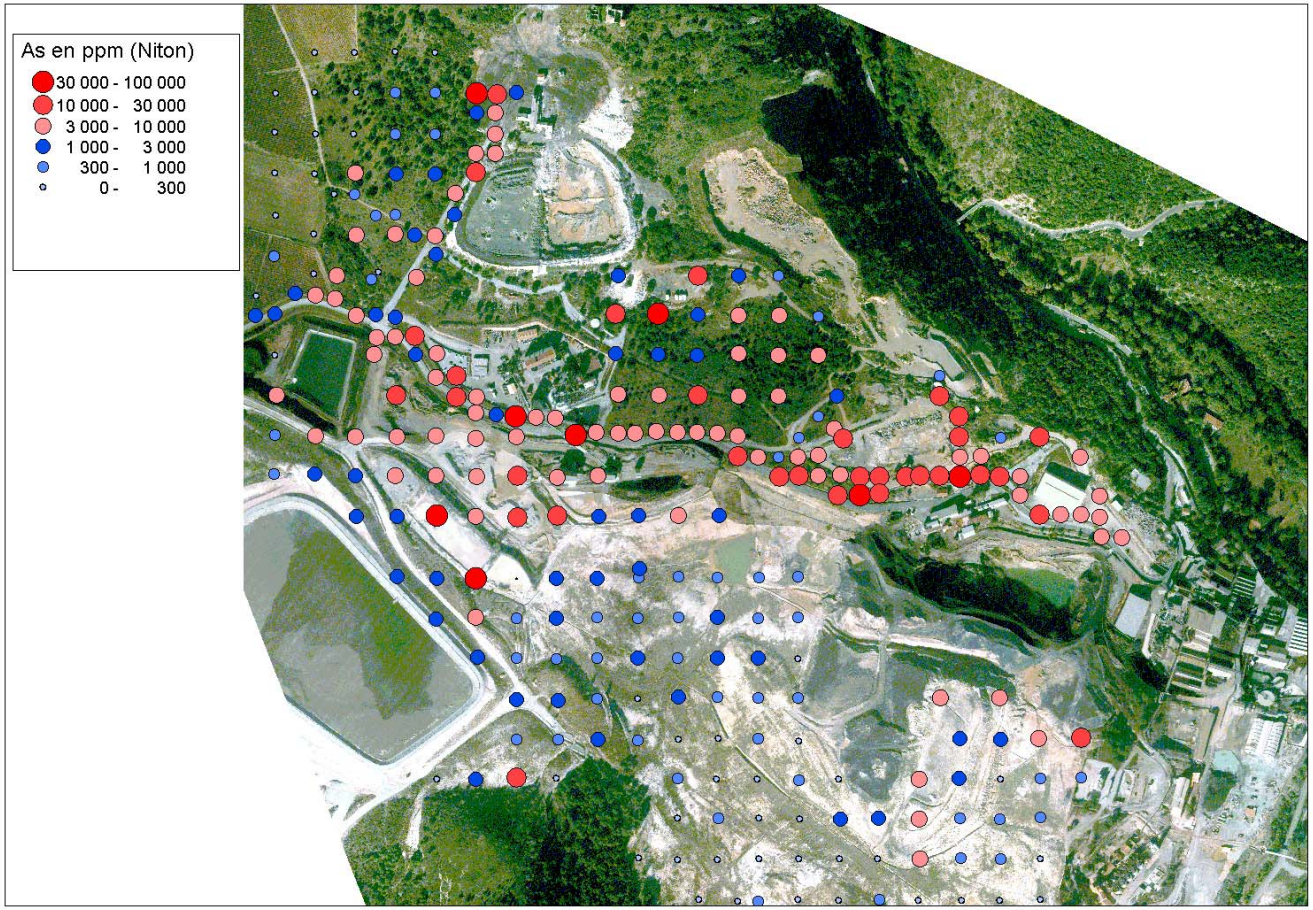
Watertight area

Watertight area

Source characterisation



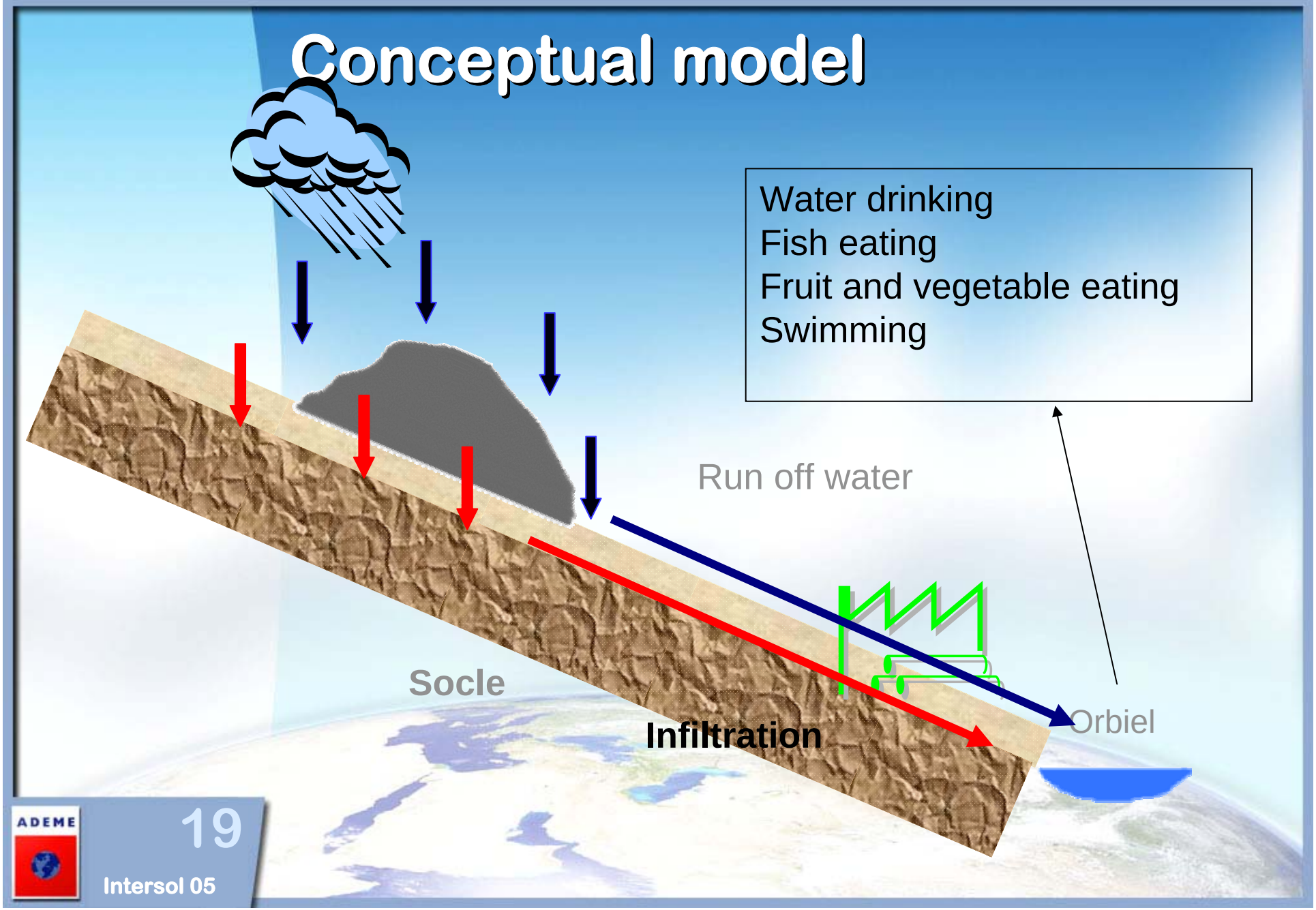
Arsenic soil concentration



Sources

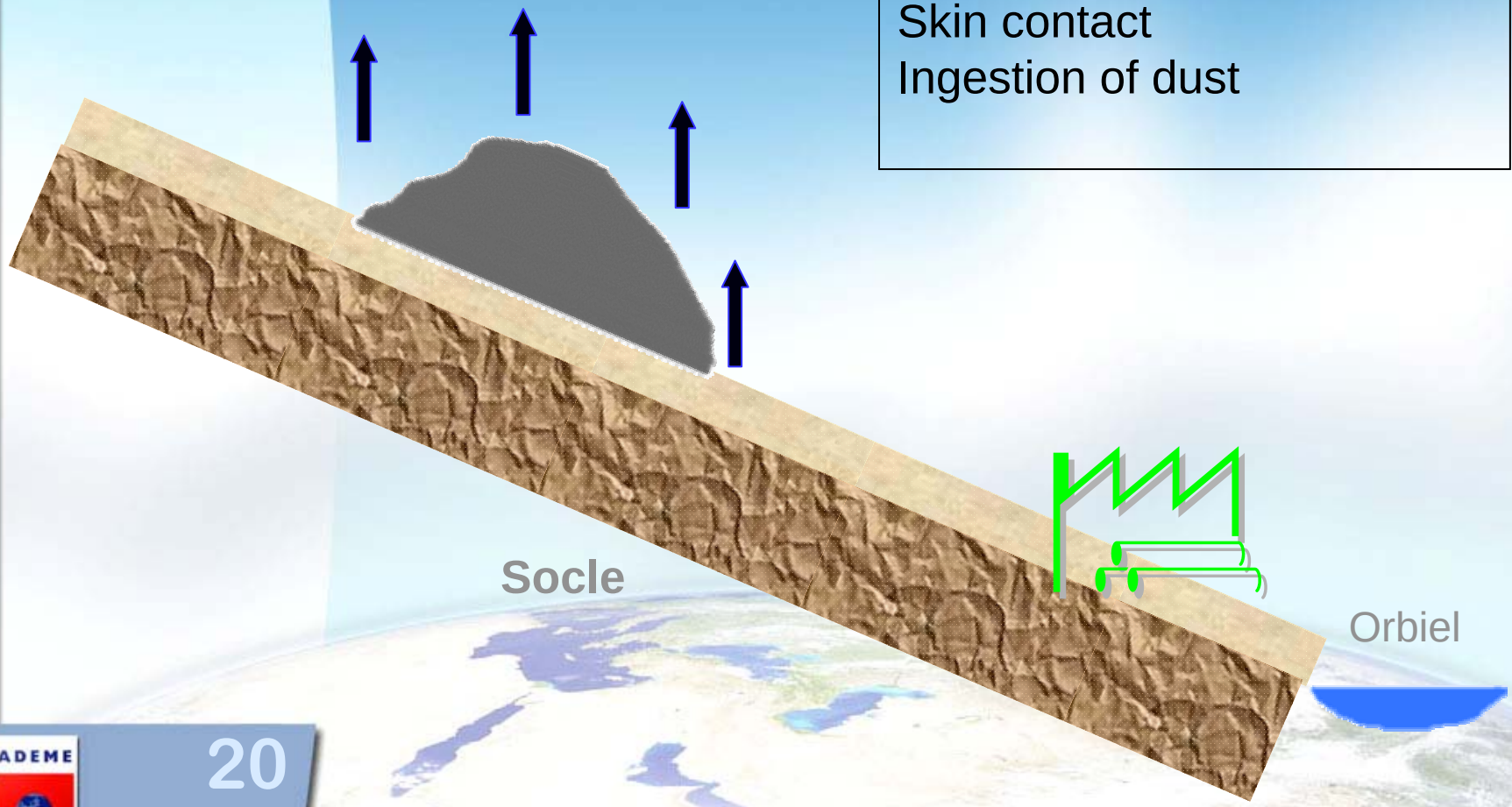
- 2,4 million m^3 of waste and polluted soil
- 53 hectares

Conceptual model



Conceptual model

Air breathing
Skin contact
Ingestion of dust



Transfer

Run off water :

- **Arsenic Concentration > 10 mg/l**
- **Sediment in Orbiel river**

Underground water :

- **La Combe du Saut Thalweg**
- **Transfer in Orbiel via the water table**

Dust :

- **Arsenic concentration : 2 µg/m³**

Risk assessment

Cancer risk

	Oral route			Breathing route		
ERI	Resident	Farmer	Fisherman	Resident	Farmer	Fisherman
Adult	1,7.10-3	2,4.10-3	2,1.10-3	2,5.10-3	3,6.10-3	3,3.10-3
Children	3,3.10-3	3,4.10-3	3,6.10-3	1,9.10-3	1,9.10-3	1,9.10-3

Non Cancer risk

	Breathing route : toxic total			Breathing route : nervous system		
SRD	Resident	Farmer	Fisherman	Resident	Farmer	Fisherman
Adult	1,74	2,25	2,14	5,28	6,74	6,42
Children	2,17	2,17	2,17	6,55	6,55	6,55

Salsigne – La Combe du Saut

1999 / 2005

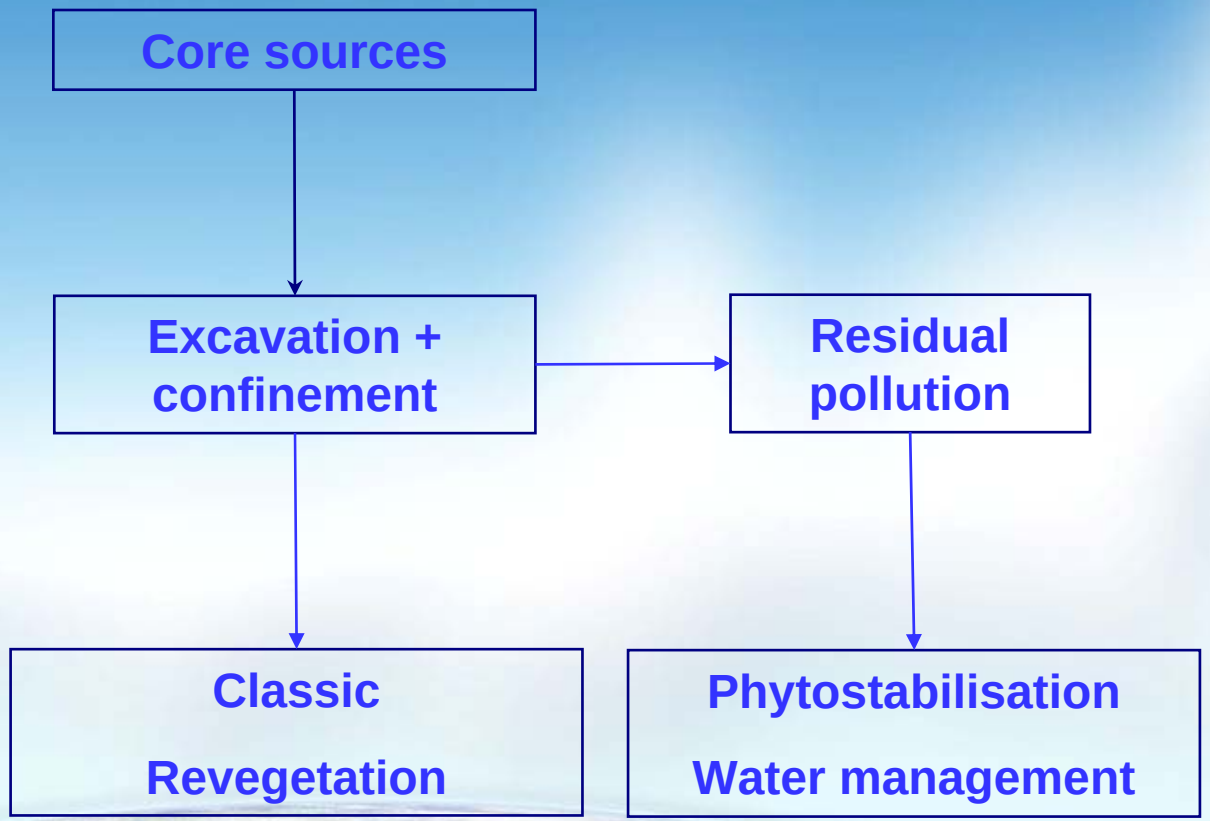
Total cost between 1999 and 2004 (millions of euro)

Operation	Cost
Monitoring and water treatment :	3.5
Waste management :	3.0
Demolition :	3.5
Watertight area :	1.0
Studies and prime constructor :	1.5
Total Cost :	12.5

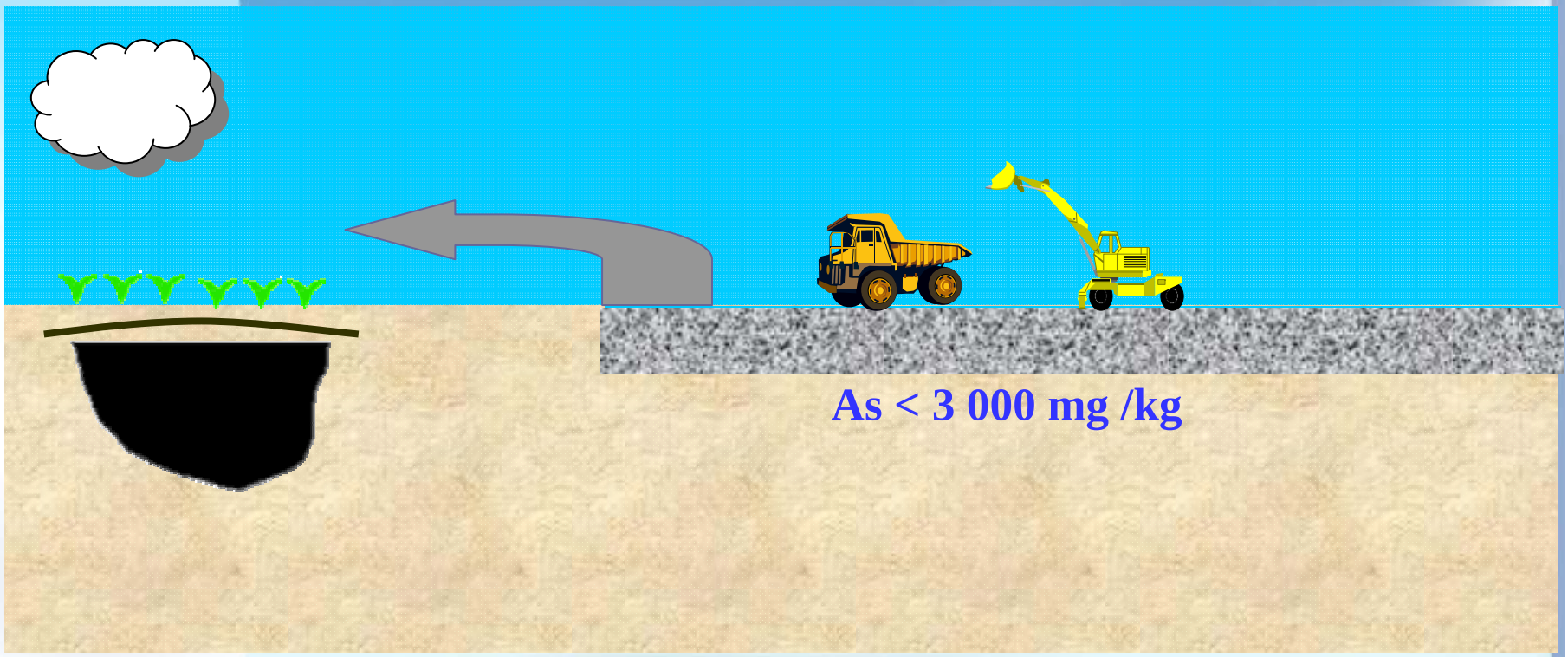
Evaluation of total cost / quantity of polluted soil with conventional techniques (Million of euro)

Type of treatment	euro/m3	500 000 m3
Excavation	3	1,5
Confinement Min	15	7,5
Confinement Max	30	15
Stabilisation	300	150
Landfilling (stabilisation)	500	250

Remediation project



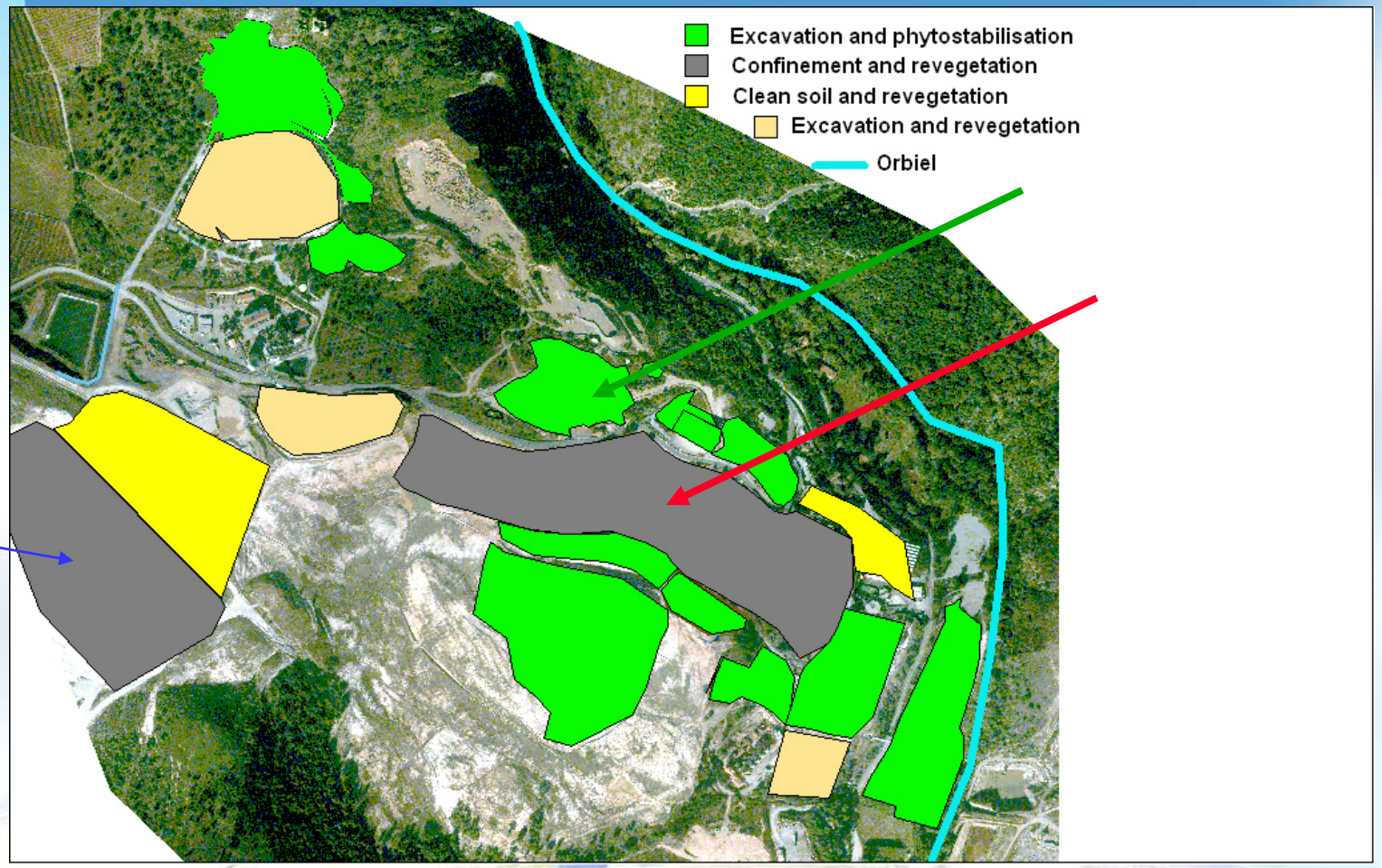
1. Excavation



Confinement area

2. Phytostabilisation

Remediation programme



Confinement by MOS

Remediation programme (million of euro)

Operation	Cost
Excavation and transportation of waste and soil into the confinement area	2,5
Stabilisation of waste	1
Protection with a geomembrane (110 000 m^2)	4
Water management systems	1,5
Phytostabilisation	0,5
Prime constructor	1
Monitoring and water treatment	1
Other	1
TOTAL	12,5

	2005			2006			
	TR2	TR3	TR4	TR1	TR2	TR3	TR4
Excavation	■	■					
Call for tender (Phase 2)	■	■					
Capping			■	■	■		
Phytostabilisation					■	■	

Phytostabilisation (Difpolmine)

Laboratory experiments

Selection of seed mixture

↓

Field plots 100 m^2

↓

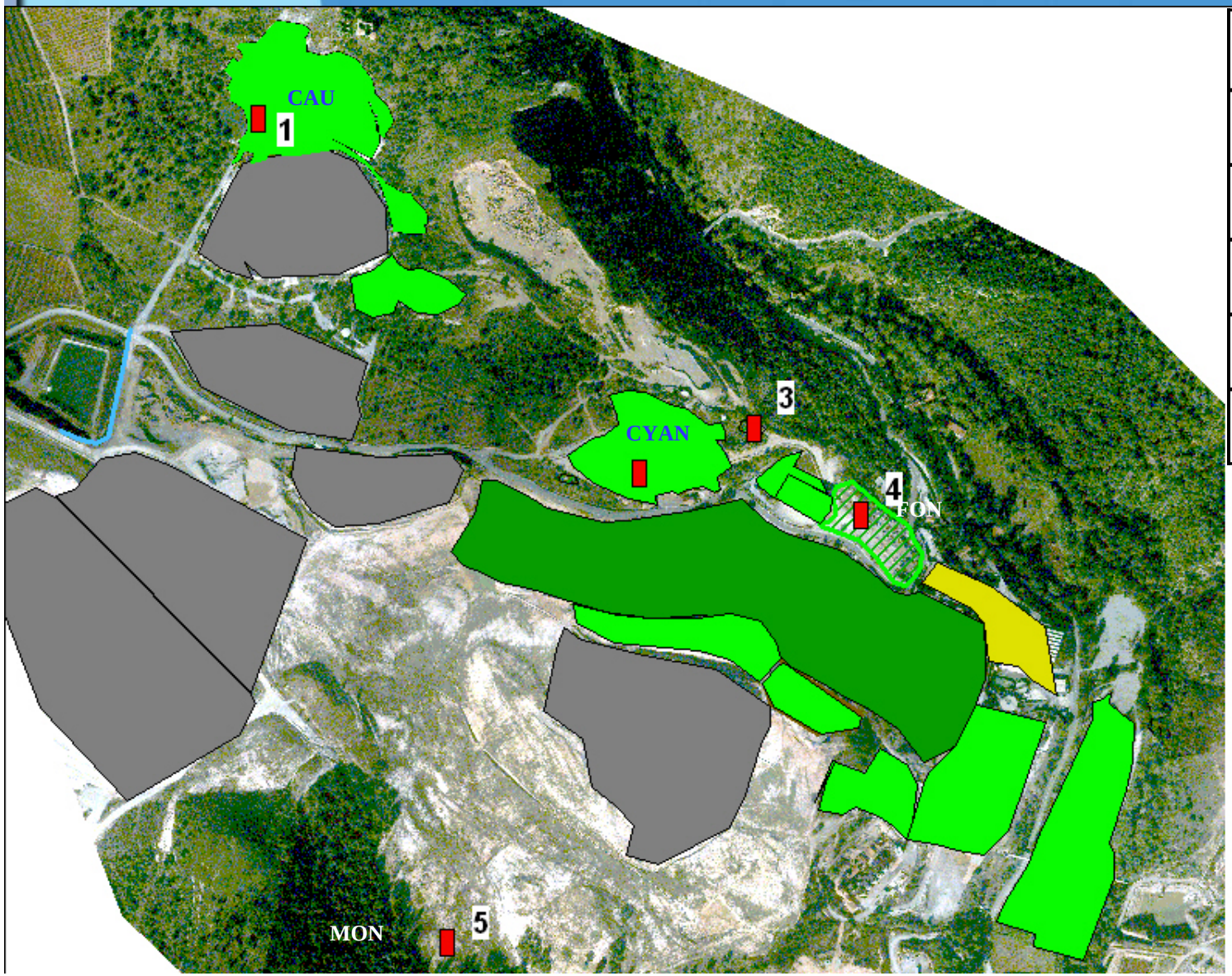
Large scale phytostabilisation

20 ha

Laboratory experiments

Location	Steel shots addition	Water soluble As (mg/kg DM)	% reduction
Control		<0.25	
Caunette	no	584 ± 112	
	yes	360 ± 44	39%
Cyanuration	no	1.6 ± 0.1	
	yes	0.29 ± 0.07	82%
Cyanuration2	no	7.1 ± 0.3	
	yes	4.5 ± 0.4	36%
Fonde	no	17.6 ± 0.4	
	yes	3.6 ± 0.6	79%
Monitoring	no	8.3 ± 0.2	
	yes	0.4 ± 0.1	95%

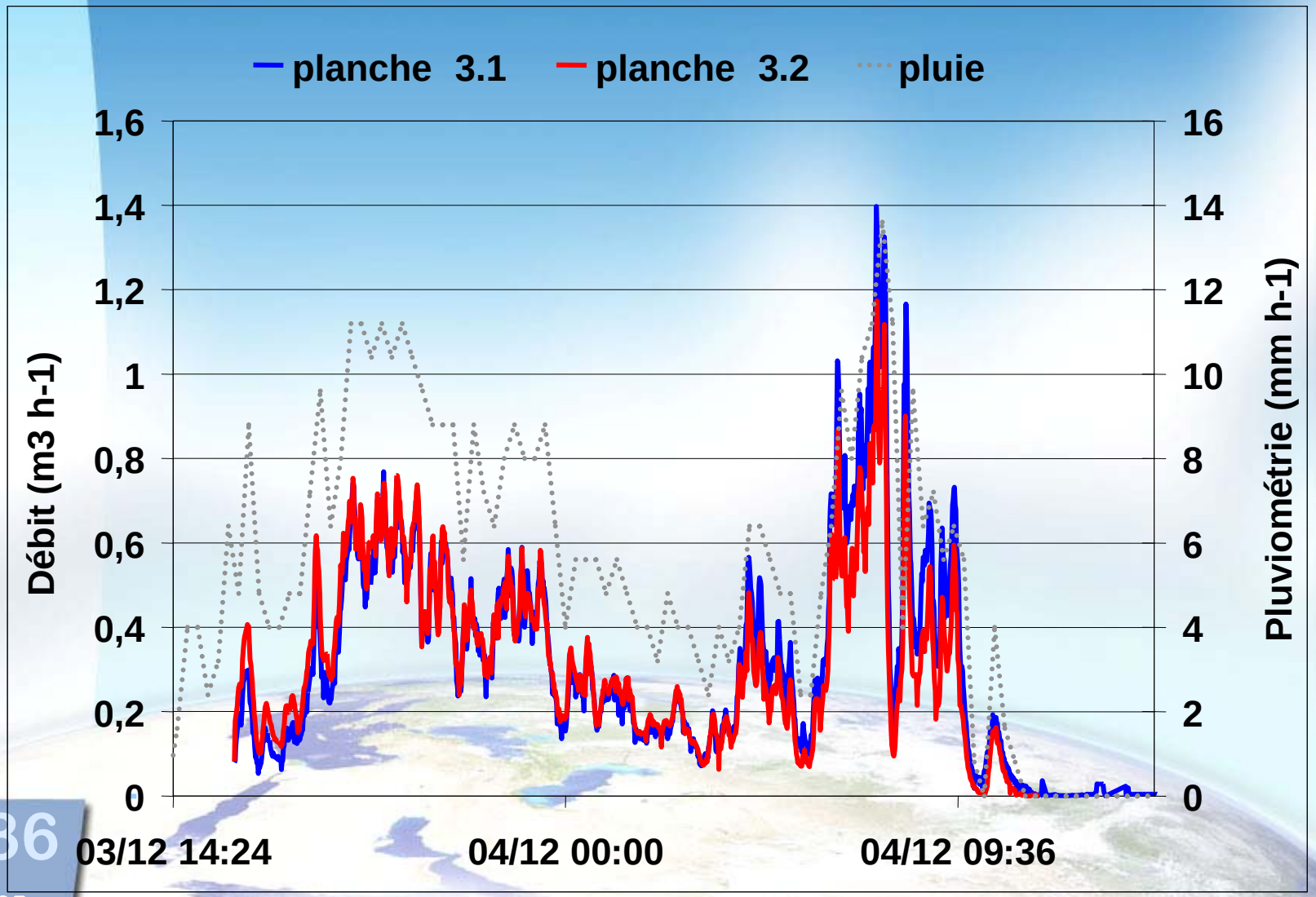
Location of the field plots



Field plot	[As total] (mg kg^{-1})	[As total] (mg.l^{-1})
1.1	7872	22.48
1.2	4136	6.12
2.1	1373	0.86
2.2	3193	1.65
3.1	2883	3.36
3.2	2111	2.99
4.1	3076	1.20
4.2	2828	1.63
5.1	69	0.33
5.2	102	0.21

Phytostabilisation field plots

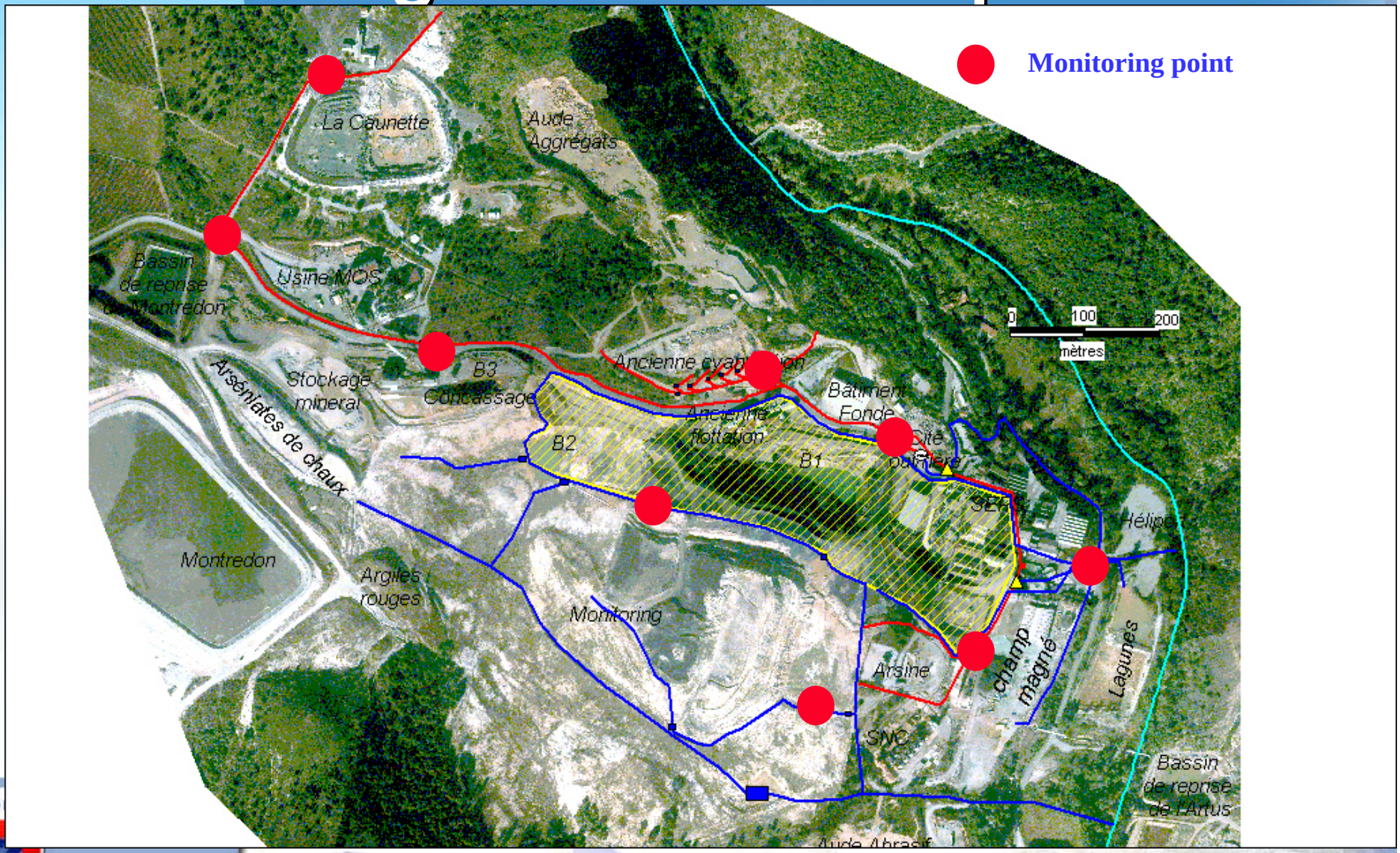
Follow up of the waterflow



Field plots 4 in April 2005

Field plots 1 in April 2005

Large scale follow up



Comparison between confinement and phytostabilisation

	Confinement		Phytostabilisation	
	Efficiency	Limiting factors	Efficiency	Limiting factors
Contact with the soil	+++	Soil use restriction Long-term monitoring	-	Soil use restriction Long-term monitoring
Dust emission	++		- /+	
Water concentration	++		- /+	
Global warming gas	- 1 litre gas oil / m^3 of excavated soil		+++ Avoidance of soil excavation	
Cost / m^2 / 20 cm depth	- /+ (6 euros)		+++ (2 euros)	

Conclusion

- Large metal polluted site remediation is very costly
- Phytostabilisation can be a compromise between technical and financial stakes
- The demonstration project in La Combe du Saut is an opportunity to evaluate the advantages and limiting factors of the application of phytostabilisation

Announcement

"DIFPOLMINE"

Training Course and Conference

- ***Budapest University of Technology and Economics***

4th to 7th July 2005 - 8th July 2005

- **Website: http://envirobiotech.mkt.bme.hu**

Salsigne – La Combe du Saut

Thanks to :

- ICF Environment (Mr Ferrer and Mr Ferrando)
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- And the other partners of ADEME