ET-DSP™ Technology

(Electro-Thermal Dynamic Stripping Process™)

The 1st full-scale reference in Europe: a former creosote facility – SVOC Case

March 9, 2016

Guillaume GARCIA
France & Switzerland Manager

SUMMARY



1. Thermal & ET-DSP™

   Heating effects, ET-DSP™ overall, scope of application

2. Proximus Ostend project

   Site conditions investigations & results

3. ET-DSP™ "stepwise approach“

   Laboratory tests, numerical simulation, Formal offer

4. ET-DSP™ “Full Scale“

   construction , Operation & Maintenance, monitoring, demonstration phase : final results

5. Conclusion

GROUP VAN VOOREN

Independent entity

135

1972 — Laboratoria Eddy VAN VOOREN
ENVIRONMENTAL & GEOTECHNICAL : DRILLING, ANALYSIS, ENGINEERING

2005 — 3 — European Remediation Technologies — In Situ BIOLOGICAL — In Situ CHEMICAL — Geo-Cleanse® INTERNATIONAL, INC.

2006 — LVV → 85 GROUP VAN VOOREN Geo Measuring & Analysis — 25 GROUP VAN VOOREN Terra Engineering & Consultancy — Analysis Activity sold out to Agrolab in 2008

Environmental & Geotechnical

2010 — 20 GROUP VAN VOOREN Divoli Data Processing Belgium

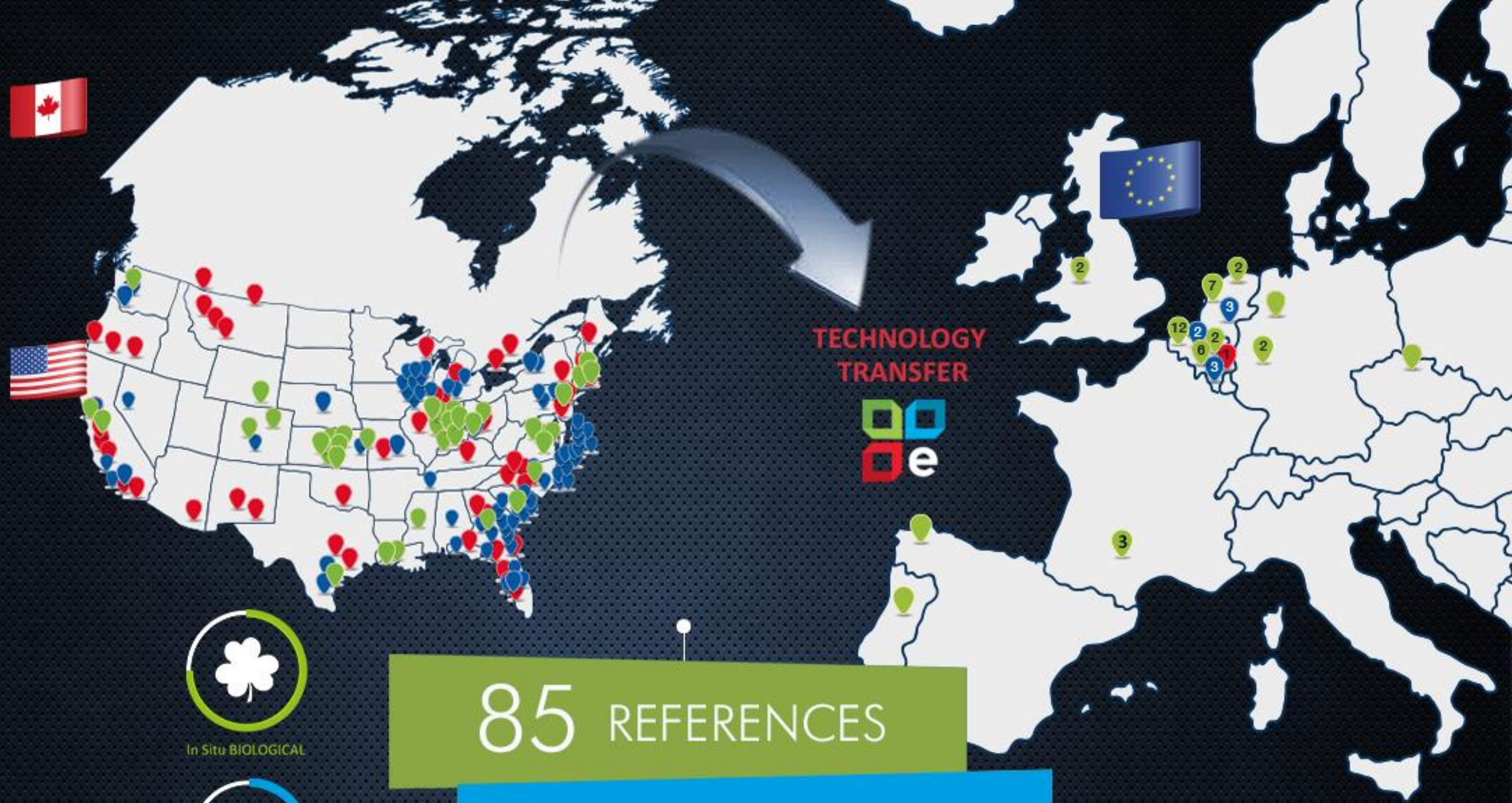
2014 — European Remediation Technologies → euremtech In Situ Specialists — 6 — In Situ BIOLOGICAL — In Situ CHEMICAL — In Situ THERMAL

2015 — McMILLAN-McGEE CORP.

SYSTEM CERTIFICATION QUALITY DNV·GL ISO 9001

SYSTEM CERTIFICATION SAFETY DNV·GL OHSAS 18001

OUR REFERENCES



In Situ BIOLOGICAL

In Situ CHEMICAL

In Situ THERMAL

85 REFERENCES

165 REFERENCES

80 REFERENCES

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Long term partnerships
WORLDWIDE LEADERS

McMILLAN-McGEE CORP.
Creators of ET-DSP™
Founded in 1991

In Situ THERMAL

Ph. D. Bruce Mc GEE
President
Inventor of "ET-DSP™", Patent US 6,596,142 B2 - 2003

Location : CANADA - CALGARY (Alberta)
80 references - 18 On-going projects
Proven track record : energy transfer
Queen's University Partnership

Creator of ET-DSP™
Electro-Thermal Dynamic
Stripping Process™

Mc² received the "project of the year" award in 2007 from NGA

Total Greensboro (CN)

23 YEARS OF EXPERIENCE

ET-DSP™ = an advanced ERH
Using Convection Heating Process

Oil Sand extraction using ET-DSP™
Alberta Oilfield

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Electro-Thermal Dynamic Stripping Process™

Patent - Description - Equipment

HOW HEATING IMPROVES MOBILITY AND EXTRACTION OF ORGANIC CONTAMINANTS ?

VAPORIZATION
STRIPPING / VAPOR RECOVERY
Vapor Pressure / Henry 's constant

SOLUBILITY
DISSOLVED PHASE RECOVERY

VISCOSITY
NAPL MOBILITY IMPROVEMENT

OTHER EFFECTS
INCREASED **PERMEABILITY**

THERMAL **HYDROLYSIS**

DECREASED **SORPTION BONDS :**

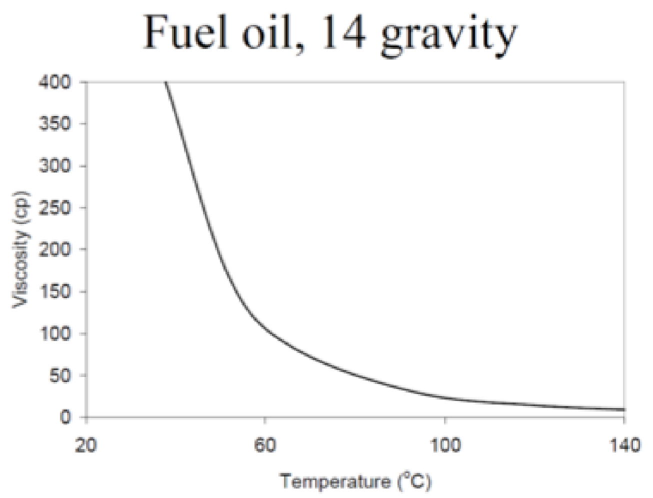
- AQUEOUS PHASE SORPTION : reduction by a factor of 2,2 from 20 to 90°C (Source: Heron)
- VAPOR PHASE SORPTION : reduction order of magnitude (TCE) from 20 to 90°C (Source: Heron)

PHYSICAL PROCESSES

Component property	Oil based LNAPL	Chlorinated solvents	Creosote	Coal tar	PCB	Comment
Vapor pressure increase factor	20-80	20-100	20-300	20-300	2000	Abundance of data in literature
Solubility increase factor	2-100?	1.5-3	10-1000	10-1000	10-1000	Chlorinated solvent less affected than larger hydrocarbons
Henry's constant increase factors		10-20	0-10	0-10	0-10	Data absent for most compounds, some decrease?
Viscosity reduction factor	2 to 100+	1.3-3	5-10	20-100+	3-100	The higher initial viscosity, the more reduction
Interfacial tension reduction factor	<2	<2	2-5	1-5	<5	Typically not dramatic effect (less than factor 2)
Density reduction (%)	10-20	10-20	10-20	10-20	10-20	Note that DNAPL may become LNAPL
K_d (reduction factor)	?	1-10	5-100	5-100	NA	Estimates based on limited data

MOBILITY IMPROVEMENT

- PHYSICAL DISPLACEMENT OF HIGH BOILING POINT NAPL'S ENHANCED WITH HEATING
- VISCOSITY REDUCTIONS OF SEVERAL ORDERS OF MAGNITUDE ARE POSSIBLE



INCREASED SOLUBILITY

NAPHTHALENE

9 times more soluble by passing from 20°C to 80°C

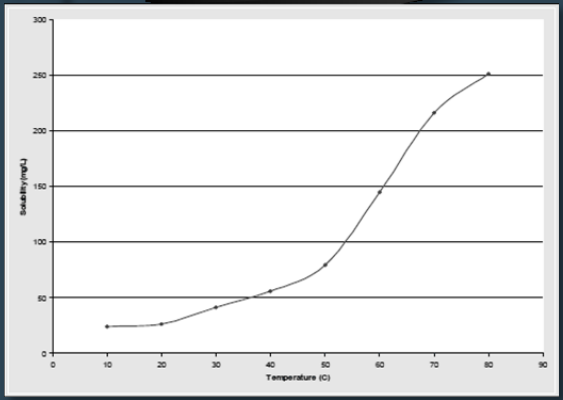
(26,6 mg/l to 252 mg/l)

BENZENE

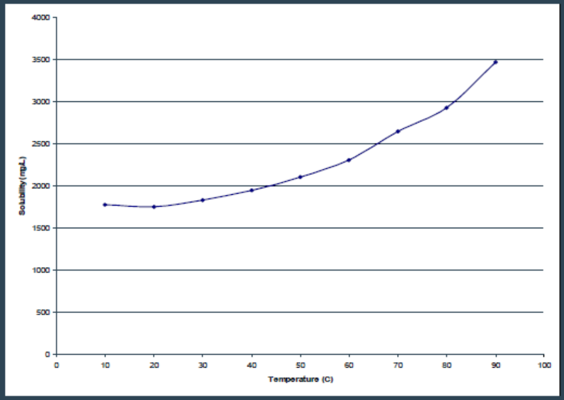
55% increase in solubility from 20°C to 80°C

(1750 mg/l to 2720 mg/l)

Naphthalene



Benzene



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DON'T CONFUSE!!

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THERMAL TECHNOLOGIES
FOR SOURCE CONTAMINATION

ET-DSP™ (ADVANCED ERH)

≠

IS THERMAL DESORPTION BY
CONDUCTIVE HEATING (TCH)

- ET-DSP™ is well adapted for **VADOSE** & **SATURATED** zones
- Temperature max **100 °C**
- Average required energy **250 kWh/m³**
- All **organic contaminants** : TPHs, PAH, HVOC, Creosote,…
- All geologies with electrical resistivity < **500 Ω.m**
- Ground water velocity **< 0,3 m/day**

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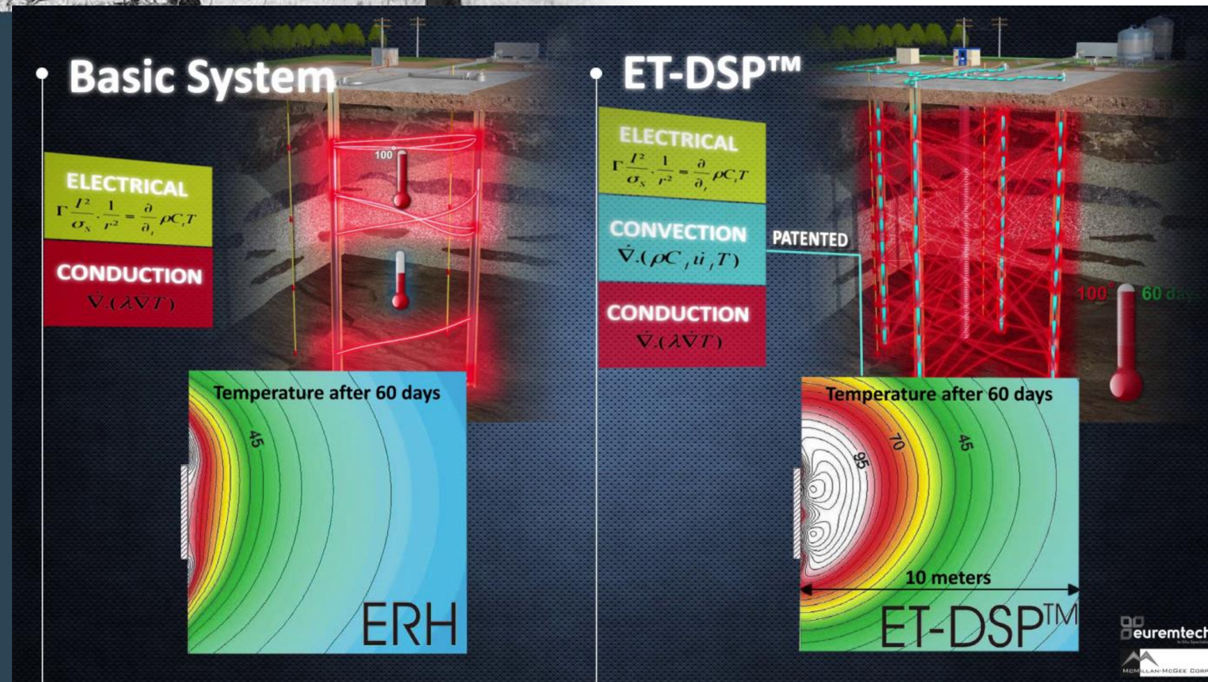
PATENT

… MAKES THE DIFFERENCE

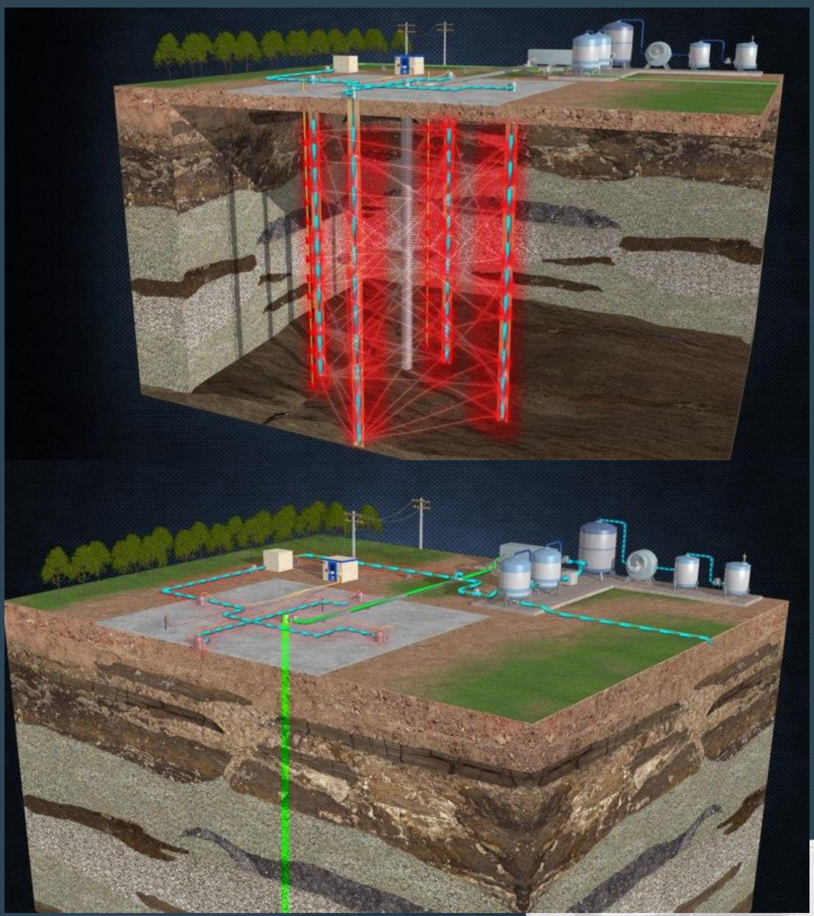


- ET-DSP™ avoid ends overheating by circulating cooled water into electrode
- Hot water + steam (10%) are injected into the aquifer : **HEATING BY CONVECTION**

Conduction	Convection	Electrical
$\vec{\nabla}\cdot\left(\lambda\vec{\nabla}T\right)+$	$\vec{\nabla}\cdot\left(\rho C_f\vec{u}_f T\right)+$	$\Gamma\frac{I^2}{\sigma_s}\frac{1}{r^2}=\frac{\partial}{\partial t}\rho C_t T$

DESCRIPTION

OVERALL SYSTEM DESCRIPTION



- A **THREE-PHASE** ELECTRICAL TECHNOLOGY
- USE ALL OF **HEATING ENERGY TRANSFER VECTORS** :
  - Electrical resistivity
  - Conduction
  - Convection (ET-DSP™ patent)
- **MULTIPHASE EXTRACTION SYSTEM** EXTRACTS RELEASED CONTAMINANTS

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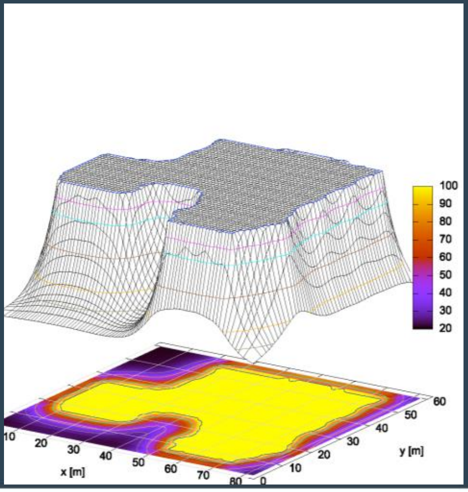
1[ST] ET-DSP™ in Europe former creosote site

Site conditions - Bench test - numerical simulation



PROJECT APPROACH

Client & Consultant

Investigation:

- Site characterization
- Contamination delineation
- Treatment goals
- Needs, constraints, …

1

FEASIBILITY Study
PREDESIGN & BUDGET

2

BENCH TEST
Electrical Resistivity profile of Geology
Optional : Full Bench Test

3

NUMERICAL SIMULATION

Final DESIGN (guaranteed)

- Electrodes / X-wells / Sensor wells GRID
- Energy requirement, Balance of extracted/injected water flow,
- Duration to reach the max temperature
- Contaminant mass removal simulation : remediation duration

4

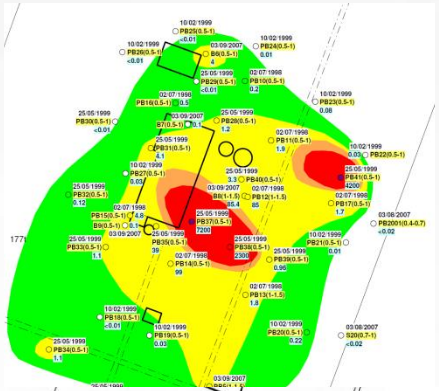
« FULL SCALE »
Remediation

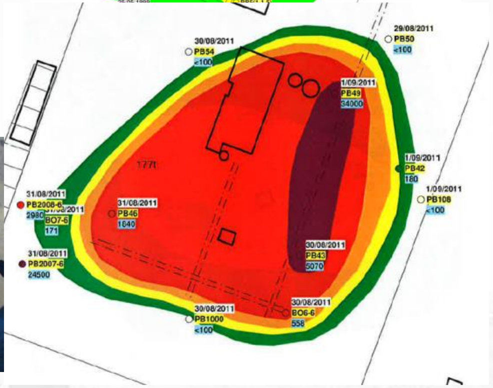
FORMER CREOSOTE FACILITY

SITE DESCRIPTION

SITE DESCRIPTION

- HISTORICAL POLLUTION : ACTIVITIES FROM 1845-1984
- INHERITOR OF REMEDIATION DUTY: BELGACOM NV (EX-PROXIMUS)
- CULTURAL HERITAGE : MONUMENT CLASSIFIED BUILDING
- COMPLEX CONTAMINANT : CREOSOTE (MIX OF CHEMICALS) - TPH
- UNPREDICTABLE DISTRIBUTION PATTERN IN THE SOIL : HETEROGENEOUS GEOLOGIES
- L&DNAPL, ABOVE AND BELOW GROUNDWATER LEVEL : SOURCE CONTAMINATION ZONE





TECHNICAL DATA

- AREA NEED TO BE TREATED: CA. 2.115 M^2
- VOLUME GROUNDWATER: CA. 20.600 M^3
- CONTAMINATED GROUND WATER THICKNESS : 0,5 M TO 15 M BGS
- ESTIMATED CONTAMINANT MASS: CA. 30,000 KG CREOSOTE
- COMPLEX GEOLOGY

0-2.0 m BGS	(Fine) sand	AQUIFER 1
2.0-4.8 m BGS	Clay	AQUITARD
4.8-6.6 m BGS	Peat	AQUITARD
6.0-7.0 m BGS	Clay	AQUITARD
7.0-15.0 m BGS	(Fine) sand	AQUIFER 2
15.0-17.2 m BGS	Silt	SEMI-AQUITARD
17.2-17.7 m BGS	Clay	SEMI-AQUITARD
17.7-24 m BGS	Coarse sand	AQUIFER 3
>24 m BGS	Clay	

ET-DSP™ LABORATORY TEST

RESULTS

ELECTRICAL RESISTIVITY PROFILE

- Peat lithology has a real different resistivity
- Overall is pretty conductive (<16 ohm.m)
- Stacked electrodes requirement

PERFORMANCE RESULTS

- Volatile compounds (BTEX , naphthalene, …) > 99 % reduction
- Non-volatiles compounds > 50 % reduction
- Main mass contaminant recovery : pure phase (NAPL) and water (dissolved contamination)

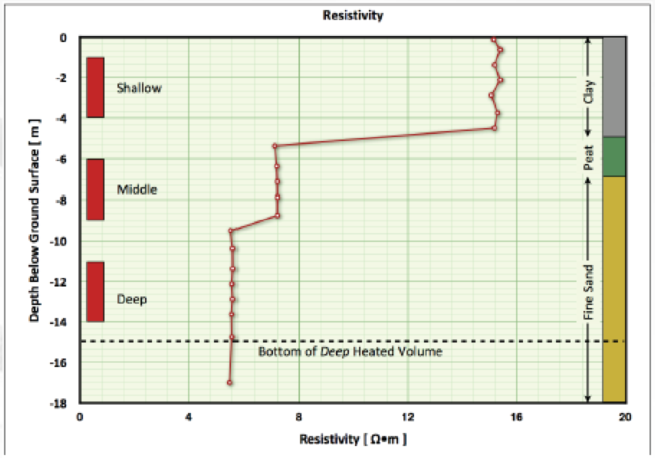
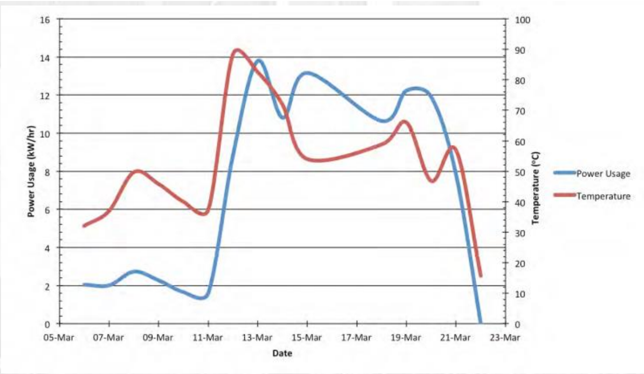
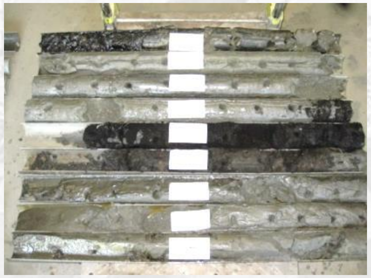
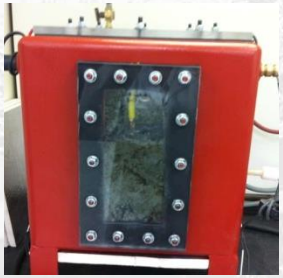


Figure 1.7: Resistivity profile for the site.







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EXTRA INVESTIGATIONS

ADDITIONAL DATA COLLECTION

EXTENSIVE KNOWLEDGE UPSTREAM TO INCREASE THE SUCCESS PROBABILITY
TEST OUT ANY METHOD BEFORE FULL SCALE !!

INVESTIGATIONS

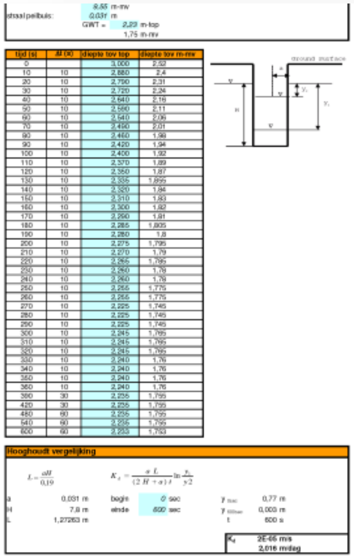
- DRILLING METHOD TESTING : **COST & EFFICIENCY**
  - JET-DRILLING OR HOLLOW-AUGER ?
  - SLUG TESTS : CHECK OUT THE BEST DRILLING METHOD
- DETERMINE AQUIFER CHARACTERISTICS
- ADDITIONAL SOIL & GROUNDWATER SAMPLING

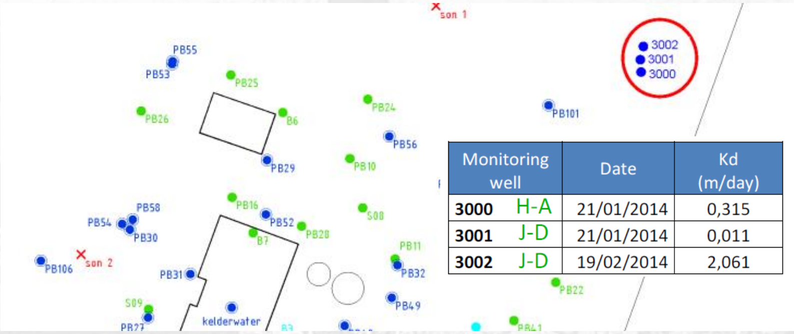
RESULTS

- JET-DRILLING IS FASTER THAN H-S-AUGER (2 TIMES)
- JET-DRILLING DOESN'T BRING UP CONTAMINATED SOIL (NO CONTACT RISK)
- H-A IS A MORE RELIABLE INSTALLATION METHOD : WITH JET-D THE HOLE CAN COLLAPSE BEFORE BEING EQUIPPED
- SLUDGE TESTS DEMONSTRATED :
  - H-A PROBABLY CLOGS PART OF THE BOREHOLE EDGE
  - BEST PERMEABILITY RESULT WITH JET-D N°3002
  - JET-D MUST BE IMPLEMENT BY A EXPERIMENTED TEAM

DECISIONS

- JET-DRILLING METHODS : ELECTRODES & EXTRACTION WELLS
- GEOPROBE : SENSOR WELLS (GEOLOGY)





Monitoring well		Date	Kd (m/day)
3000	H-A	21/01/2014	0,315
3001	J-D	21/01/2014	0,011
3002	J-D	19/02/2014	2,061

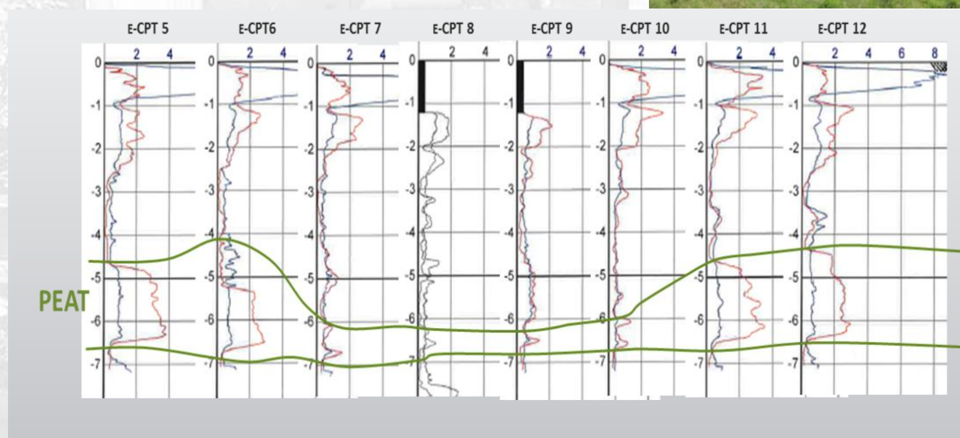
EXTRA INVESTIGATIONS

ADDITIONAL DATA COLLECTION

PEAT LAYER HAS TO BE OBSERVED AS A PRIMARY ISSUE : AVOIDING DESICCATION

PERFORMING **E-CPT** INVESTIGATIONS

- EXTENSIVE PROFILING OF THE LITHOLOGY THROUGHOUT THE TREATMENT AREA
  - GET THE MOST DETAILED GEOLOGY PROFILE
  - DEEPEN THE ELECTRICAL PROFILE
- DETERMINATE THE **PEAT LAYER THICKNESS** IN A SMALL SCALE
  - SPECIAL RANGE OF RESISTIVITY
  - ELECTRODES DEPTH INSTALLATION : water injection 1,2 times more to keep peat wet all the time



COMPLEX & HETEROGENEOUS GEOLOGIES MUST BE INVESTIGATED PROPERLY

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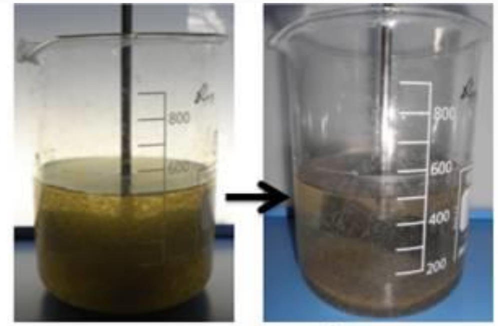
BENCH TEST-LABORATORY

LIQUID TREATMENT SYSTEM DESIGN

BENCH TESTING OF LIQUID EFFLUENT

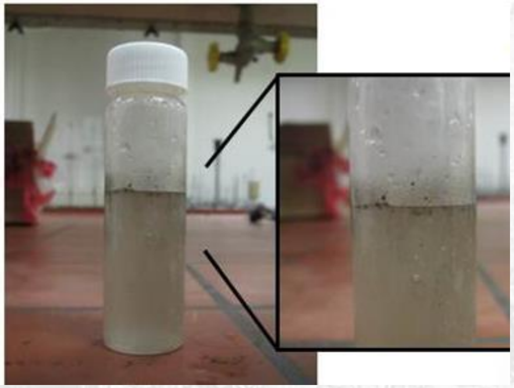
- **TEMPERATURE EFFECTS** ON EXTRACTED LIQUIDS
- DETERMINE THE **OPTIMAL PROCESS** CONFIGURATION
- CHECK THE **EFFICIENCY** OF EVERY TREATMENT STEP :
  - Air stripping / Active Sedimentation / Activated Carbon / Ozone
- BEHAVIOR OF **CREOSOTE NAPL** AT DIFFERENT TEMPERATURES :
  - Pipe fouling / Crystallization
  - Temperature to keep creosote in a non viscous state – avoid coating



Coagulation/floculation Décantation

THOROUGH KNOWLEDGE OF THE CONTAMINANT

- BETTER TREATMENT EFFICIENCY & COSTS
- MITIGATE TREATMENT SYSTEM DOWNTIMES



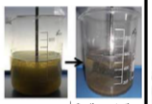
LIQUID EFFLUENT LABORATORY TEST

RESULTS

RESULTS & LEARNINGS

- OZONE TREATMENT : a bad efficiency on heavy compounds – affected AC performance
- NATURAL SEDIMENTATION : long (20 min) + still a lot of suspension particles + high [TPH]
- ACTIVE SEDIMENTATION : 10 ppm of cationic polymer FLOPAM EM640 (SNF supplier)
- ACTIVATED CARBON : 10-AA [3 gAC/gCOD] (DESOTEC)

N°	Technologies & combinations		Summary of Bench test Results				
	Symbols	Main bench test specifications	Main Results	Performance rates		Comments	Pictures
BENCH TEST - Phase A (February 2014) : water treatment technologies effectiveness							
A.1	**NSed**	10 minutes of sedimentation	- After 20 min, a decrease of 50% COD - After 1 hr, a decrease of 58% - After 3 hrs, a decrease of 63 % - The treated liquid is still colored (orangish) and unclear	- COD drop : **50 % at 20 min** [COD]= 385 mg/l		- Efficiency is too weak (40% COD reduction)	
A.2	**NSed**	30 minutes of sedimentation				- Sed time can be suitable with a full scale treatment : - **Design Separator tank volume** : 1700 L with a flow rate of 5 m^3/h	
A.3	**NSed**	60 minutes of sedimentation				- Too long time of Sed to get a low improvement of efficiency	
A.4	**NSed → Strip**	20 min of Sedimentation Strip : 3,5 min - 70L air/L water bubbling ratio – Column design	- NSed 20 min performed a reduction of COD at 385 mg/l (ca 50% reduction) - Based on COD performance indicator, Stripping exposed a limited positive effect: just **3 %** of COD drop. (385 mg/l → 374 mg/l).	- COD drop : **3 %** [COD]= 374 mg/l - BTEX drop : 83,5 % - PAH drop : 91,9% - TPH drop : 20,4%		- NSed has a limited efficiency on TPH CoC : a large part of this CoC is stuck (adsorption)on some very fine particles (mineral & organic) which mostly remain in suspension - Stripping appears to be useless but in looking at the laboratory analyses (see table 5), we notice that volatiles compounds (naphthalene, benzene, ..) are not enough addressed using just sedimentation even for Active sedimentation : Stripping has to be considered as an important step along the treatment line. - **Stripping design** : .3,5 min - 70L air/L water bubbling ratio is acceptable (increase the contact time up to 4 min)/ plate-aerator configuration	

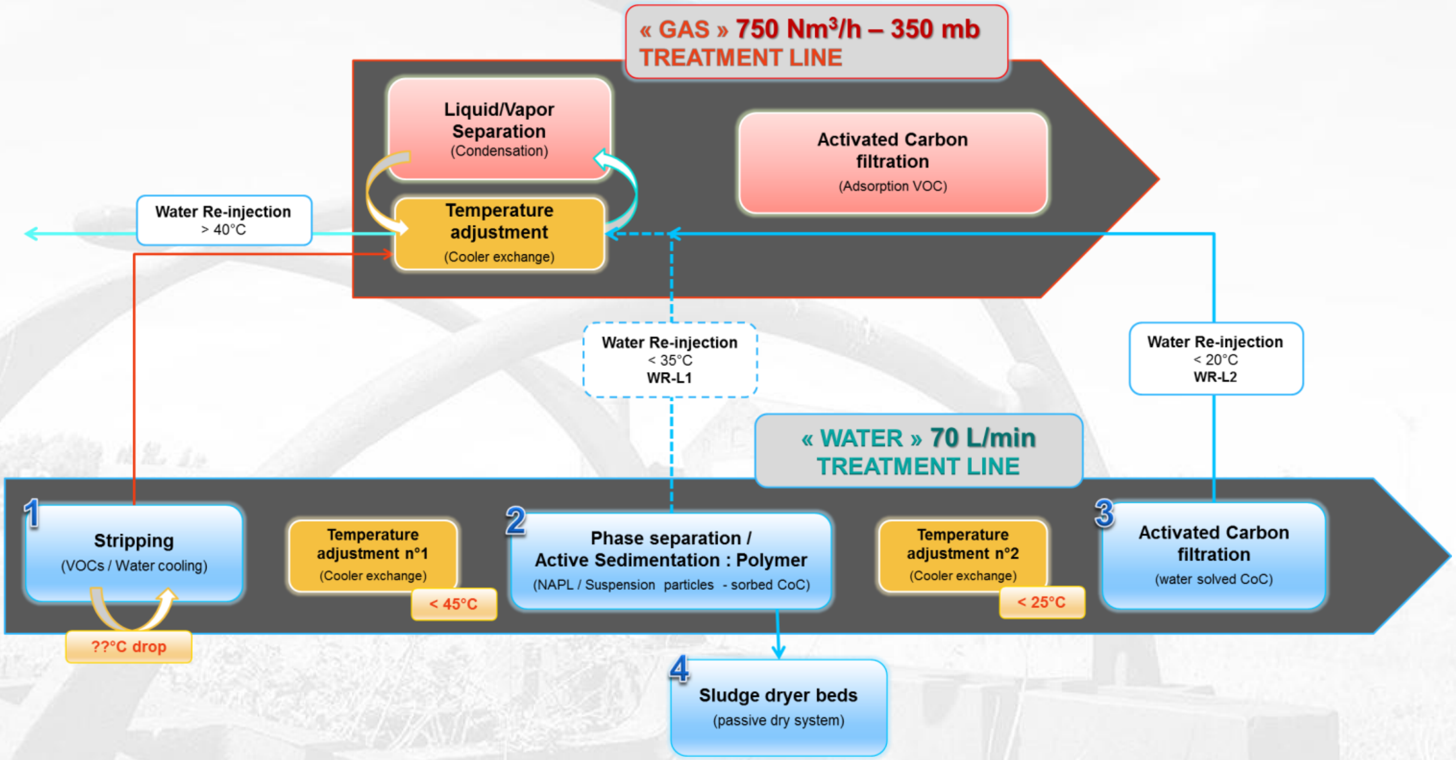
A.5	**ASed**	Coagulation $FeCl_3$ 40 mg/l
		Flocculation AS34VHM polymer 2 mg/l
		Sedimentation time : 5 min
			- Initial COD of raw sample was 696 mg/l
			- ASed time is enormously reduced in compare with NSed time : 4-fold
			- Just **5 min** is required to get a proper sedimentation
			- The COD dropped up to 209 mg/l : 70 % reduction
			- Sludge production: [sludge] = 30 g/l consists in producing 1,5% volume per treated water.
			- The treated liquid looks very clear and transparent that consists in all particles removal.
			- Chemicals injection requirement :
			  - $FeCl_3$ = circa 4,8 Kg/day
			  - AS34VHM polymer = circa 0,25 Kg/day
				- COD drop : **70 %**
				[COD]= 209 mg/l
				- BTEX drop : 66,4 %
				- PAH drop : 89,1%
				- TPH drop : 95,8 %
						- ASed has a very high efficiency on TPH mass reduction because chemicals help to make those compounds go down.
						- This high treatment efficiency of sedimentation proves that the largest part of CoC is sorbed on particles and not very much in solved status. The massive reduction of Total Solid Suspension material should also **prevent any Activated Carbon fouling/clogging + save up a lot of AC consumable**.
						- As any Stripping was applied after ASed, volatile compounds were partially treated (66 % of BTEX). By adding a stripping step, volatiles CoC will definitely be addressed and removed.
						- **Design Separator for ASed** : chemical injection point upstream - rapid configuration (mixing) cone-shaped tank – 10 min
						- **Chemicals dosing range** for injection : $FeCl_3$: 5-100 ppm / Polymer: 0,5-10 ppm
						- **Sludge production estimate** : 1,5 % of 120 m^3/day corresponds to circa 2 m^3 sludge/day
						- **Sludge concentrator** system will have to be considered by the water-treatment gears vendor.
							
							Coagulation Flocculation / Sedimentation

A.6	**NSed → AC-AA**	20 min of Sedimentation
		[AC] = **1** gAC/gCOD(treated)
			- Initial COD outing of NSed step was 420 mg/l
			- Filtration fouling was not readily mitigated by applying NSed pretreatment.
			- AC-AA :
			  - The best result was observed using 2 or 3 gAC/gCOD
			  - COD dropped under 50 mg/l
			- AC-10 & AC-CO :
			  - Still a yellowish colored liquid after treatment
			  - COD reduction is limited : low efficiency
				- COD drop : 82 %
				[COD]= 77 mg/l
						- This short treatment line process appears suitable to meet the demanded water treatment cleanup values before discharging.
						- A minimum of **2 gAC per gram of treated COD** is required to meet the cleanup values that corresponds about a COD indicator < 50 mg/l
						- The AC quality type is crucial : in this case the AC-AA quality is the best one (coal origin)
						- NSed is not able to mitigate the AC fouling which has 2 consequences:
						  ✓ Clogging the filters : significant O&M cost
						  ✓ Wasting a lot of AC consumable : high cost
							

		20 min of Sedimentation [AC] = **2** gAC/gCOD(treated)		- COD drop : **88 %** [COD]= **49,5 mg/l** - BTEX drop : 99,.9 % - PAH drop : 100% - TPH drop : 100 %			
		20 min of Sedimentation [AC] = **3** gAC/gCOD(treated)		- COD drop : 89 % [COD]= 44,8 mg/l			
		20 min of Sedimentation [AC] = **4** gAC/gCOD(treated)		- COD drop : 90 % [COD]= 88 mg/l			
A.7	**NSed → AC-10**	20 min of Sedimentation [AC] = **2** gAC/gCOD(treated)		- COD drop : 85% - [COD]= 67 mg/l			
A.8	**NSed → AC-CO**	20 min of Sedimentation [AC] = **2** gAC/gCOD(treated)		- COD drop : 75% [COD]= 105 mg/l			

MPE & TREATMENT SYSTEM DESIGN

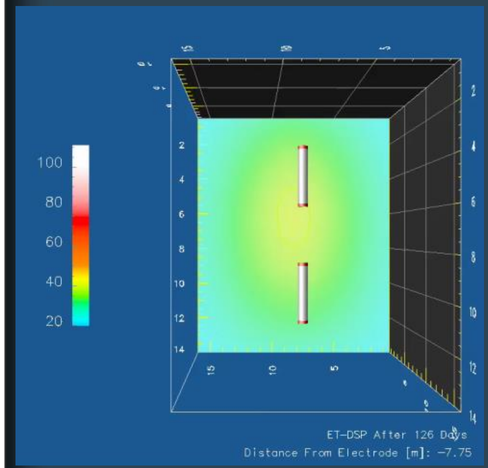
VAPOUR & LIQUID TREATMENT FLOW SHEET

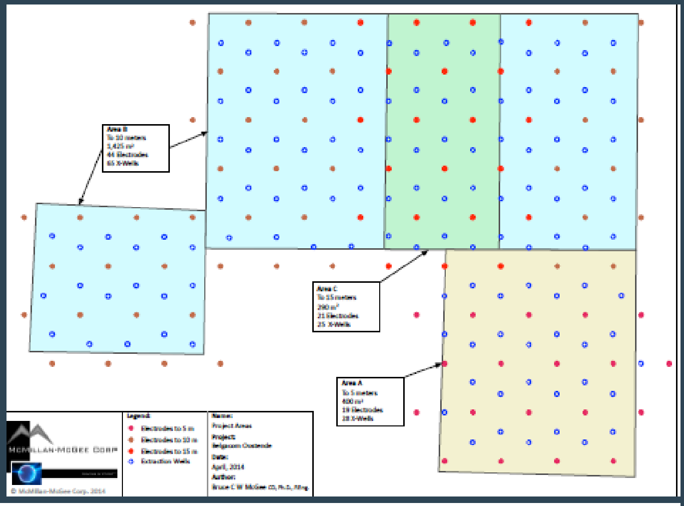


PROCESS FLOW DIAGRAM & PIPING & INSTRUMENTATION DIAGRAM WERE DONE BASED ON THOSE LAB TESTS + MK ENVIRONMENTAL EXPERIENCES

NUMERICAL MODELING

A KNOW-HOW OF OVER 15 YEARS
NO PLACE FOR LUCKINESS





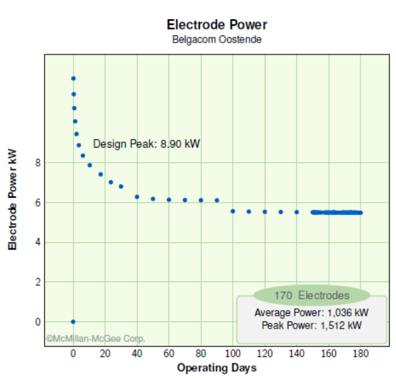


Figure 3.6: Typical electrode input power [kW].

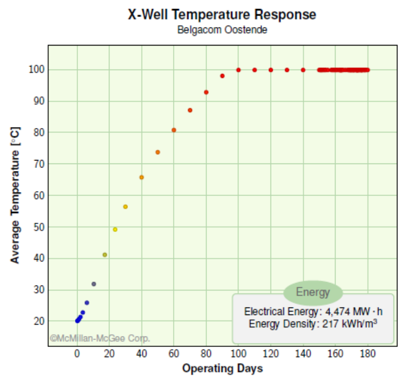


Figure 3.7: Average temperature response at the extraction wells [°C].

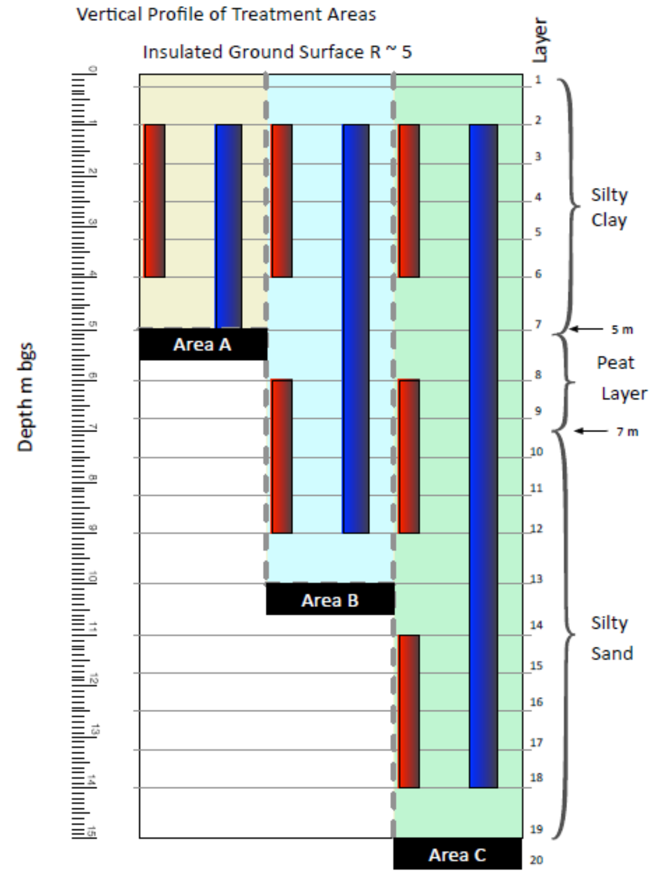


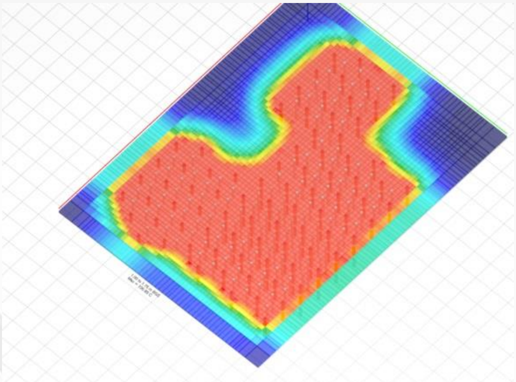
Figure 1.6: Vertical extent of the Treatment Volume.

NUMERICAL MODELING

A KNOW-HOW OF OVER 15 YEARS
NO PLACE FOR LUCKINESS

KEY NUMBERS OF DESIGN

- 170 ELECTRODES AT 84 LOCATIONS
- TARGET TEMPERATURE: ~100°C
- TIME TO REACH TARGET TEMPERATURE: 95 TO 105 DAYS
- DURATION OF THE ACTIVE REMEDIATION WORK: 180 DAYS
- AVERAGE POWER PER ELECTRODE: 6,09 KW
- TOTAL SIMULATED ENERGY REQUIREMENT PER M^3 OF SOIL : 217 KWH/M^3
- THERMAL INSULATION « VAPOUR CAP » R VALUE >5
- 325 TEMPERATURE SENSORS AT 25 LOCATIONS
- 117 VERTICAL AND 38 HORIZONTAL MULTI-PHASE EXTRACTION WELLS
- TOTAL LIQUID EXTRACTION FLOW RATE: 70 L/MIN
- VAPOUR EXTRACTION FLOW RATE PER FILTER: 10,4 M^3/H
- TOTAL WATER INJECTION FLOW RATE FOR CONVECTION HEATING PROCESS : 66,8 L/MIN
- INJECTION FLOW RATE IN THE **PEAT LAYER** IS 1,2 TIMES GREATER THAN ELSEWHERE.



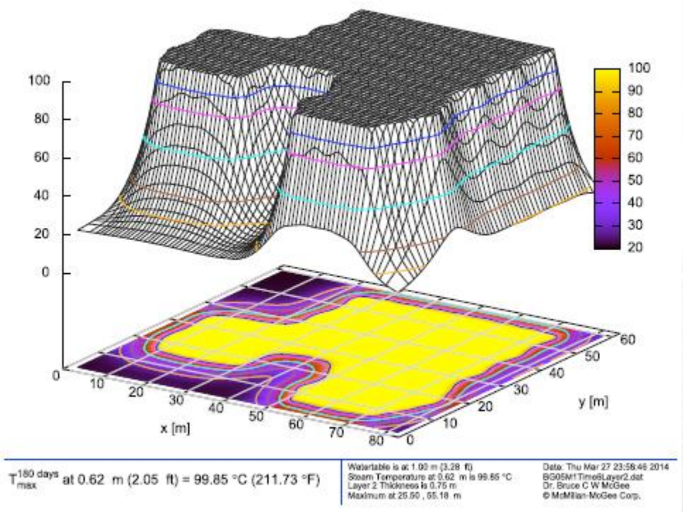


Figure A.2: Temperature distribution after 180 days of operations.

FORMAL OFFER – FIXED PRICE : 3,5 M€ (170 €/M^3)

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In Situ THERMAL

1st ET-DSP™ in Europe former creosote site

Full Scale construction – Monitoring - Results

euremtech
In Situ Specialists

FULL SCALE OPERATIONS

CONSTRUCTION PHASE

TIME LAPSE FILM : 1 MINUTE = 6 MONTHS

7 MONTH DURATION

FROM JUNE, 2014 UNTIL JANUARY,2015

THE 1ST IS ALWAYS A CHALLENGE

- MANUFACTURING EQUIPMENT FOR EU
- EQUIPMENT FLEET SHIPPING FROM CANADIAN & USA
- FIND OUT THE SAME MATERIALS THAN NORTH-AMERICA
- LEARN WORKING TOGETHER
- ….

DRILLINGS
Electrodes & wells installation
90 days

VAPOUR CAP
2 500 m² - 25 cm
5 days

PIPING – WELL HEADS
Steel 2 500 m - 117 heads
20 days

CABLING – ELECTRODES
Cable 8000 m – 170 electrodes
20 days

SYSTEMS INSTALLATION
ET-DSP & MPE Treatment
25 days

CHECKOUT & ACCEPTANCE PHASE
10 days

ESTIMATE OF **25 %** LESS TIME FOR THE NEXT PROJECT

ET-DSP™ & MPE TREATMENT

START-UP

26TH FEBRUARY, 2015

- BASELINE SUBSURFACE TEMPERATURES :
  - 0-5 M BGS : 8°C
  - 5-10 M BGS : 11°C
  - 10-15 M BGS : 10°C
- DAYS TO REACH 100 °C : 90 -105 DAYS
  - VERY CONDUCTIVE GEOLOGY (USUALLY 60 DAYS)
  - FIRST, SET-UP A HYDRAULIC & THERMAL CONTAINMENT CONTOUR
  - SETTINGS OF MPE –TREATMENT LINES : 15 DAYS
  - A TEAM 100 % IN THE FIELD
- A 1ST CASE IS ALWAYS A BIG CHALLENGE : WE WERE FOCUSED !!

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ET-DSP™ & MPE TREATMENT - O&M

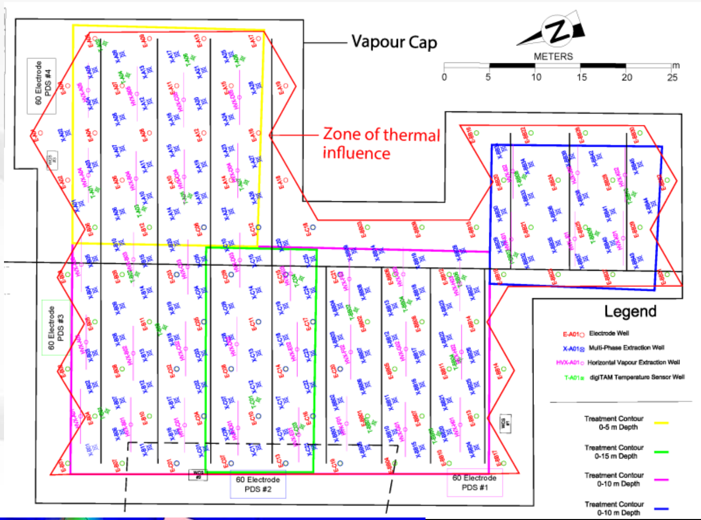
PROCESS MONITORING

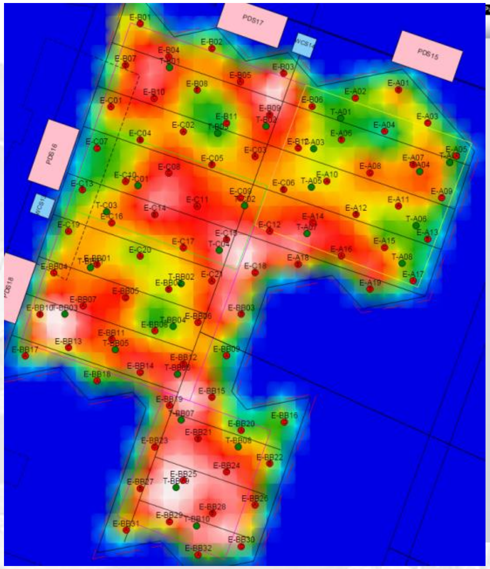
POCESS MONITORING

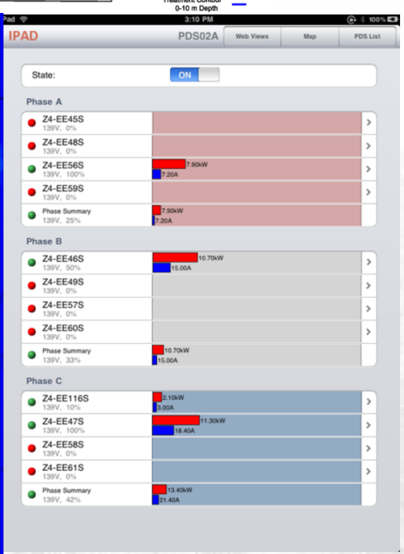
CRUCIAL FOR PROJECT ACHIEVEMENT

- REAL TIME TEMPERATURES : 325 DIGITAM™
  - VERTICALLY SPACING : CA. 1 SENSOR / M
  - PATTERN : DISTRIBUTION THROUGH THE ENTIRE ZONE – COLDEST SPOTS ESTIMATION
  - UPLOADED ANALOGIC DATA : DATABASE
  - WIRELESS SYSTEM – SOLAR PANEL POWER FEED
- ELECTRODES SYSTEM GIVES A LOT OF REAL TIME DATA :
  - CURRENT/VOLTAGE – CONDUCTIVITY OF THE SOIL
  - POWER DENSITY MEASUREMENTS : W/M³
  - TEMPERATURE AT THE ELECTRODE LOCATION
- WEBPAGE INTERNET DATABASE -
  - CLIENT'S DIRECTLY ACCESS – IPAD
  - REMOTE SETTINGS IN REAL-TIME – MC²

https://data2.mcmillan-mcgee.com/ertbel





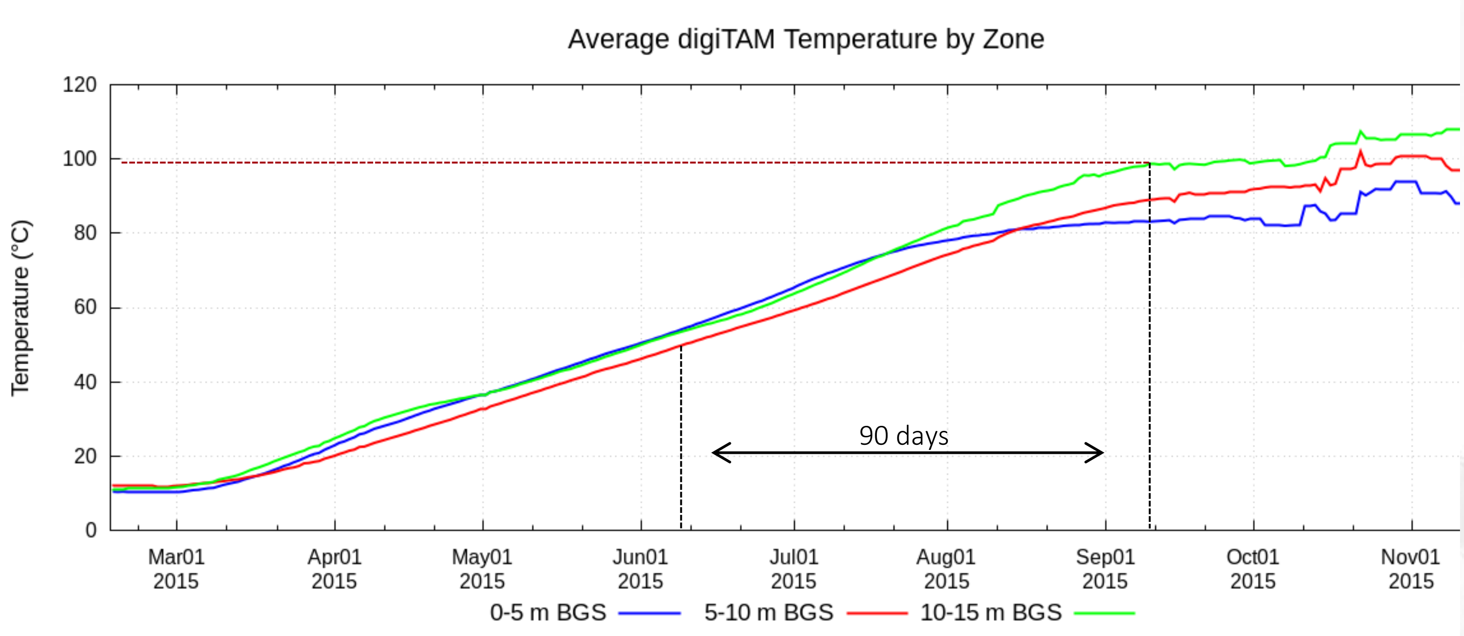


ET-DSP™ & MPE TREATMENT - O&M

RESULTS - HEATING TO 100 °C

HEATING

LONGER TIME TO REACH 100°C



- SUBSURFACE IS SIGNIFICANTLY MORE CONDUCTIVE THAN EXPECTED < 1 OHM.M (LAB TEST: < 16 OHM.M)

  This resistivity (<1 ohm.m) is very exceptional and close to the technology limit

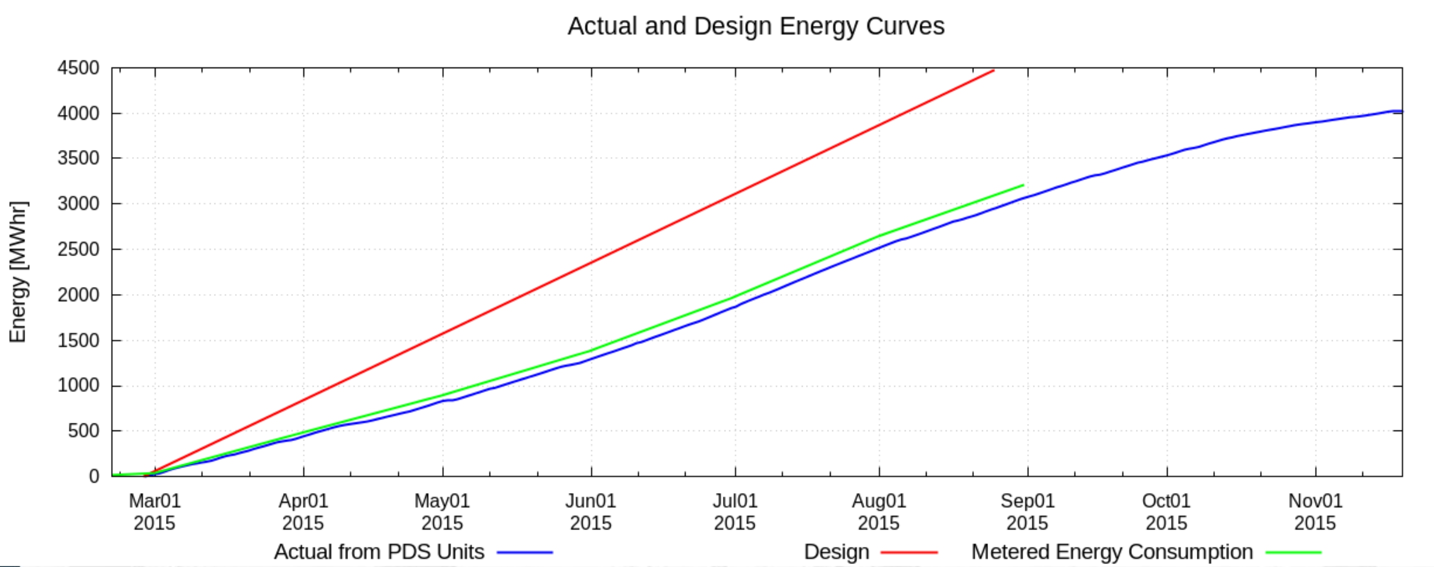
  Mc² had to find the best settings to heat up the site as quick as possible

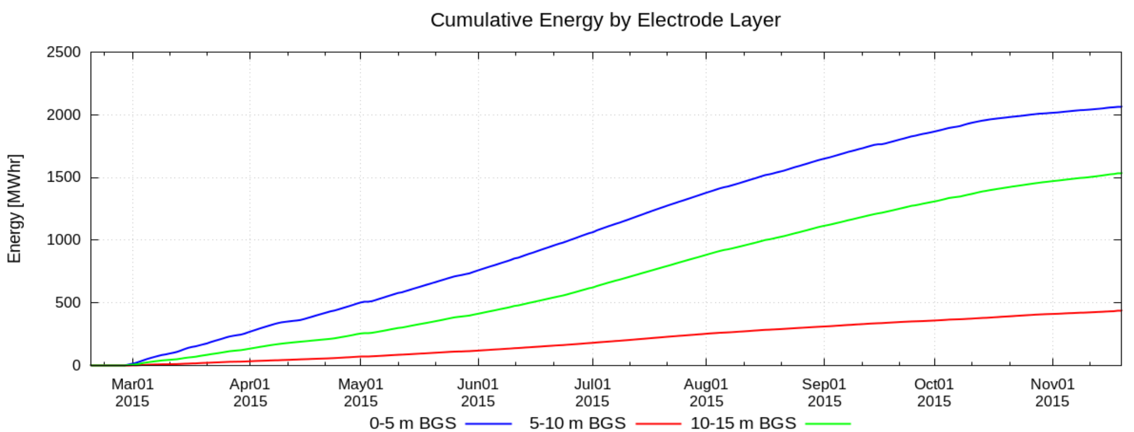
- TIME TO REACH 100°C HAD EXTENDED TO THE DOUBLE : 160 DAYS

- EUREMTECH-MC² MANAGED THIS PROBLEM EVEN IF THE LONGER TIME IS MORE EXPENSIVE (FIXED PRICE) : OUR RESPONSIBILITY

ENERGY CONSUMPTION

LOWER ENERGY CONSUMPTION THAN DESIGNED : BETTER INSULATION OF VAPOR CAP (R>10)





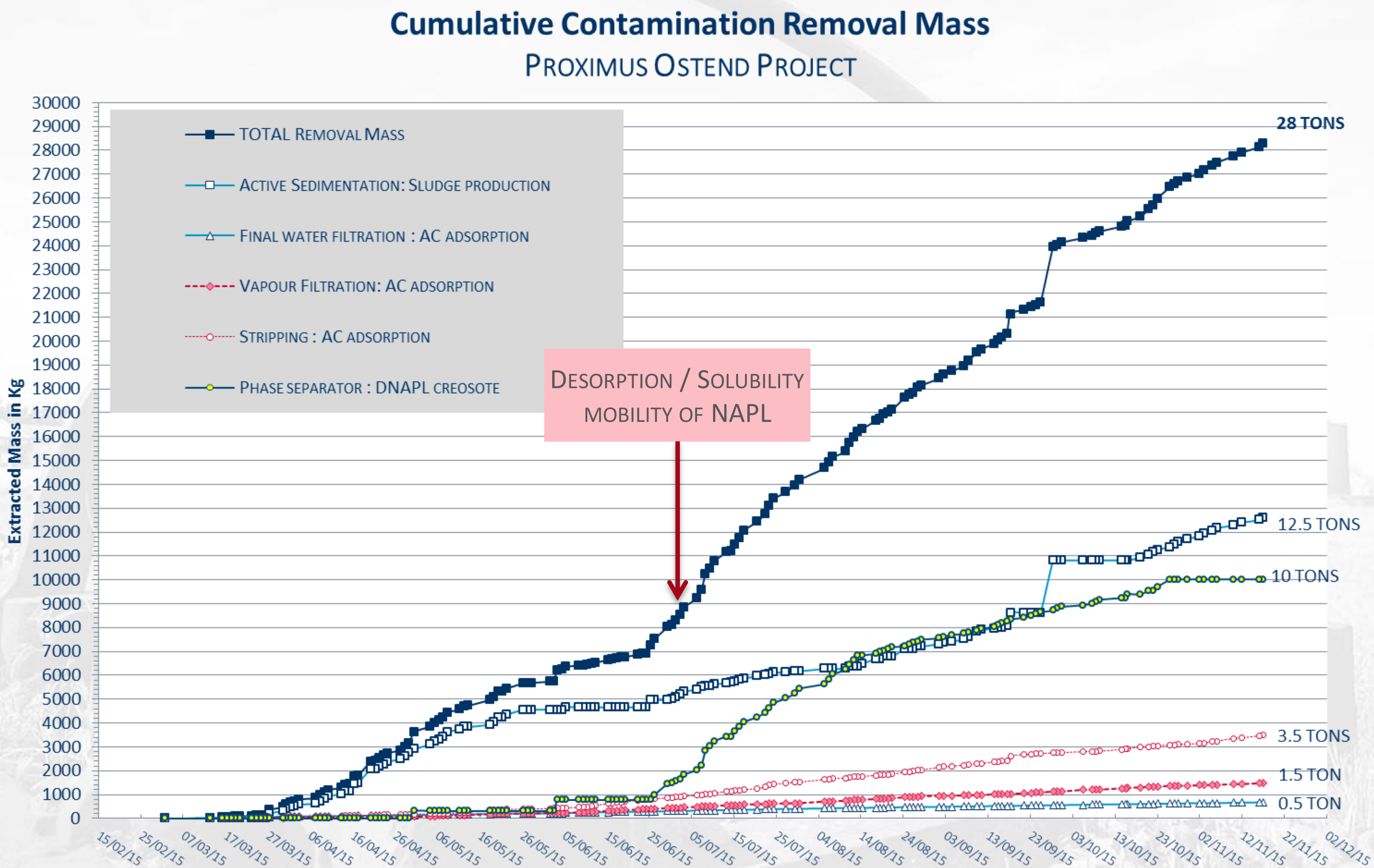
- SAVE UP 470 MWH : 10 % LOWER CONSUMPTION
- THE UPPER LAYER REQUIRES MUCH MORE ENERGY THAN INTERMEDIATE & DEEP ONES : THERMAL INSULATION AT GROUND SURFACE IS A PARAMOUNT ITEM (VAPOR CAP)

ET-DSP™ & MPE TREATMENT - O&M

RESULTS - CONTAMINATION MASS REMOVAL

CONTAMINATION MASS REMOVAL

28 TONS IN 9 MONTHS



SOIL & GWT SAMPLING PLAN

BEFORE HEATING:

- In the treatment area
- 1 sample every 500 m^3
- 11 locations, 36 samples
- PAHs, BTEX, mineral oil, phenols

DURING HEATING: INTERMEDIATE CAMPAIGN

- 2,5 months after start
- 2 weeks before stop
- 11 locations, 36 samples
- **Hot sampling** using Geoprobe®
- PAHs, BTEX, mineral oil, phenols

AFTER HEATING:

- After cooling of subsurface
- 5 locations, 25 samples
- Bore location used as groundwater monitoring well
- PAHs, BTEX, mineral oil, phenols

SOIL CONCENTRATIONS

AVERAGE REDUCTION MASS:

- BTEX : 89% (85 to 98 %)
- PAH : 75% (32% to 88%)
- NAPHTHALENE 55% (-20 % to 97%) : **BIG MASS**
- TPH : 73% (45 to 92%)

Rem Goals (risk based)

Standard Rem goals (Flanders)

		SW	RW	BSN	TSW
BTEX					
benzeen	mg/kg ds	0,1	0,3	1,82	2,21
tolueen	mg/kg ds	0,1	1,6	145,6	164
ethylbenzeen	mg/kg ds	0,1	0,8	140,14	184
xyleen	mg/kg ds	0,1	1,2	300,3	286
PAH					
naftaleen	mg/kg ds	0,1	0,8	288,576	235
benzo(a)pyreen	mg/kg ds	0,1	0,3	7,2	>1000000
fenantreen	mg/kg ds	0,08	30	1650	>1000000
fluoranteen	mg/kg ds	0,2	10,1	276,3936	>1000000
benzo(a)antraceen	mg/kg ds	0,06	2,5	30	>1000000
chryseen	mg/kg ds	0,15	5,1	320	>1000000
benzo(b)fluoranteen	mg/kg ds	0,2	1,1	30	>1000000
benzo(k)fluoranteen	mg/kg ds	0,2	0,6	30	>1000000
benzo(ghi)peryleen	mg/kg ds	0,1	35	4690	>1000000
indeno(123-cd)pyreen	mg/kg ds	0,1	0,55	30	>1000000
antraceen	mg/kg ds	0,1	1,5	4690	>1000000
fluoreen	mg/kg ds	0,1	19	4690	>1000000
dibenz(a,h)antraceen	mg/kg ds	0,1	0,3	3,6	>1000000
acenafteen	mg/kg ds	0,2	4,6	339,528	497,5
acenfatyleen	mg/kg ds	0,2	0,6	54,176	111
pyreen	mg/kg ds	0,1	62	3150	>1000000
TPH	mg/kg ds	50	300	2730	20000

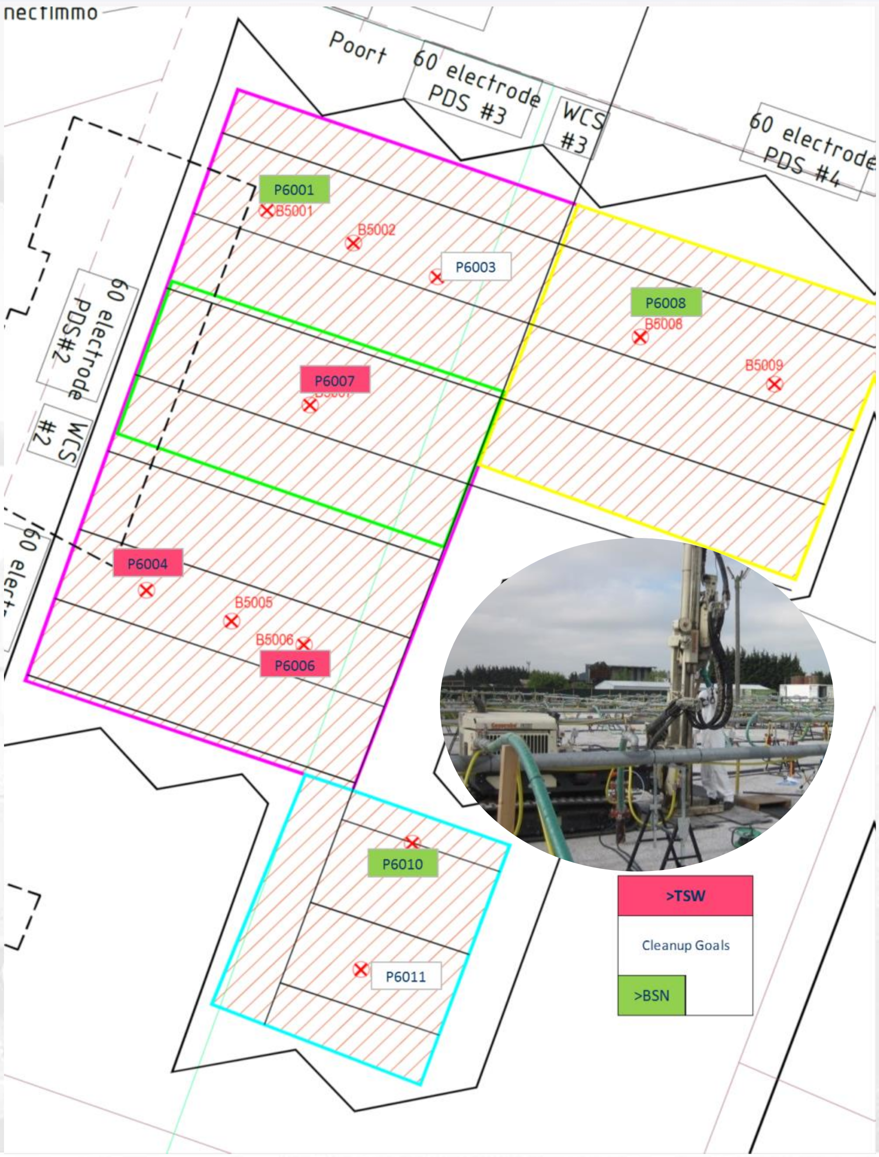
GW CONCENTRATIONS

- Goals are met regardless depth in zones Yellow ; Pink North ; blue
- Still high concentrations in green & south pink zones

Rem Goals (risk based)

Standard Rem goals (Flanders)

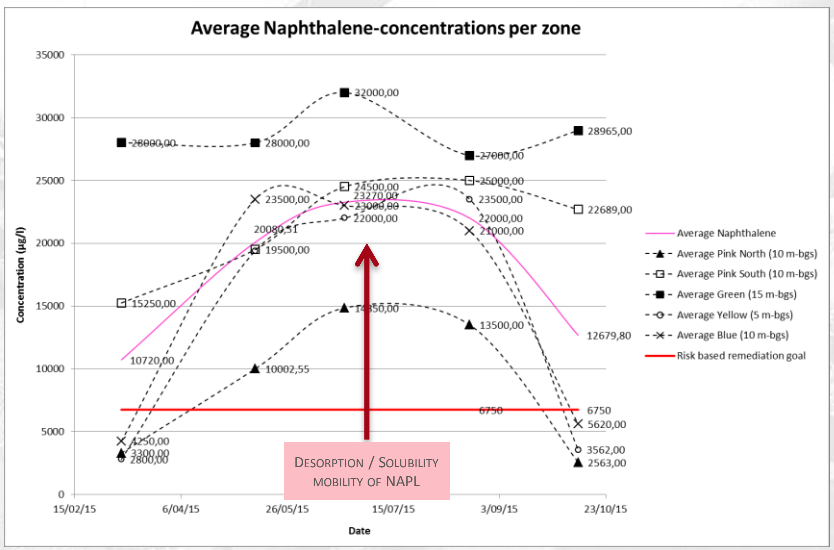
		>SW	>RW	>BSN	>TSW	P6008	P6006
BTEX							
benzeen	µg/l	0,5	2	10	1085	<10	35
tolueen	µg/l	0,5	20	700	50200	<10	56
ethylbenzeen	µg/l	0,5	20	300	4040000	<10	18
xyleen	µg/l	0,5	20	500	164000	-	-
HAP						1000	
naftaleen	µg/l	0,02	20	60	6 750	1100	29000
benzo(a)pyreen	µg/l	0,02	0,4	0,7	31	<1	-
fenantreen	µg/l	0,02	20	120	4 760	280	7600
fluoranteen	µg/l	0,02	2	4	2 760	41	2100
benzo(a)antraceen	µg/l	0,02	2	7	71,5	<3,0	200
chryseen	µg/l	0,02	0,9	1,5	500000000	<3,0	250
benzo(b)fluoranteen	µg/l	0,02	0,7	1,2	74,5	<2,0	61
benzo(k)fluoranteen	µg/l	0,02	0,4	0,76	74,5	<1,0	25
benzo(ghi)peryleen	µg/l	0,02	0,1	0,26	100000000	<1,0	<10
indeno(123-cd)pyreen	µg/l	0,02	0,06	0,1	74,5	<1,0	11
antraceen	µg/l	0,02	20	75	17000000	14	450
fluoreen	µg/l	0,02	20	120	10100000	220	26000
dibenz(a,h)antraceen	µg/l	0,02	0,3	0,5	15,6	<1,0	<10
acenafteen	µg/l	0,02	20	180	1 190	320	3600
acenfatyleen	µg/l	0,02	20	70	690	<5,0	370
pyreen	µg/l	0,02	20	90	6 980	18	1200
TPH	µg/l	100	300	500	20000	2850	15600

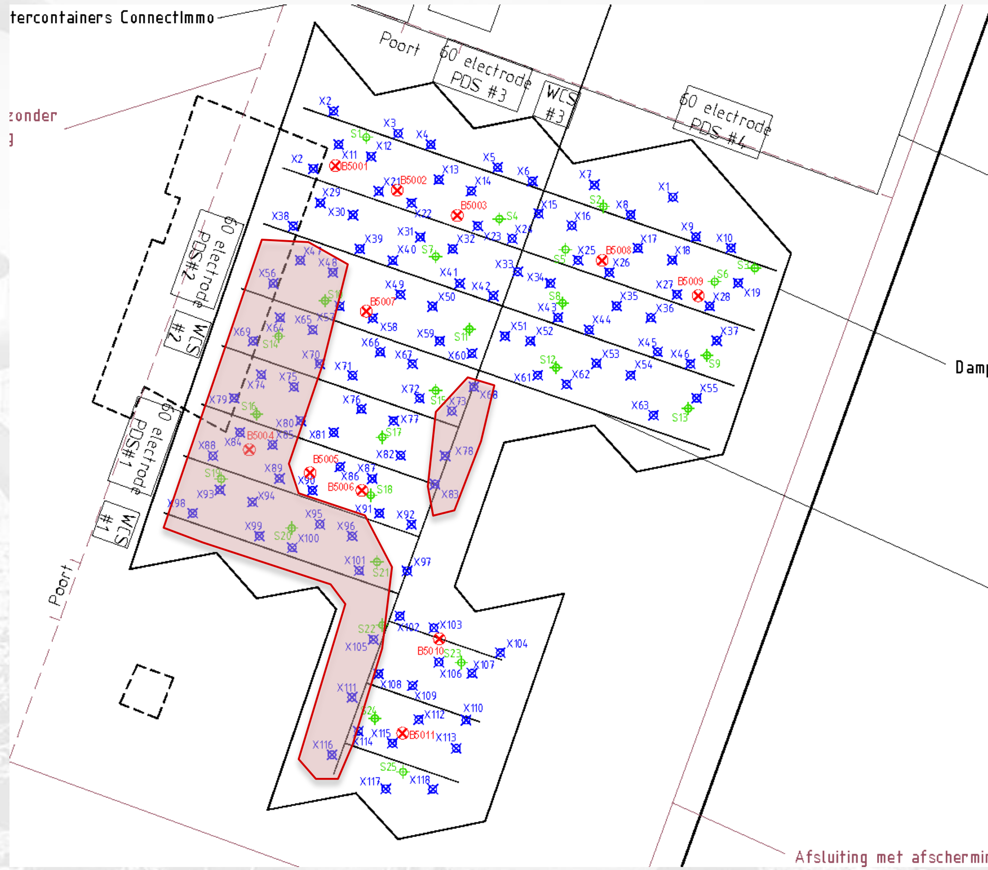


X-WELLS CONTAMINATION INDICATION

X-WELLS LOCATED AT THE EDGE EAST & SOUTH HAVE ALWAYS SHOWN HIGH CONCENTRATIONS & NAPL WHILE THE OTHERS IN THE CENTER HADN'T HAD ANYMORE :

- THIS OBSERVATION DOESN'T LOOK LIKE AS A COINCIDENCE
- CONCENTRATIONS MEASURED IN THOSE WELLS HAVE LEVELLED AT HIGH VALUES
- NAPHTHALENE HAD NEVER DECREASED HERE



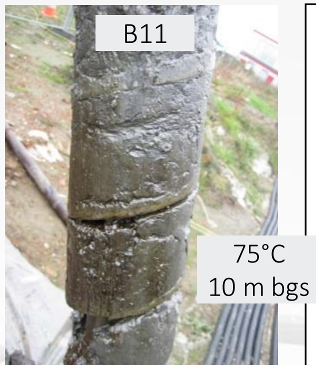


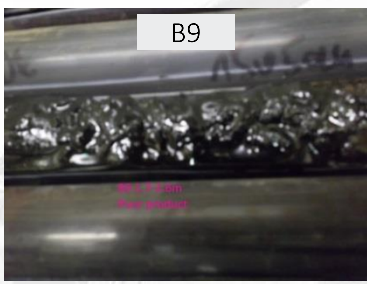
EXTRA INVESTIGATIONS HAD BEEN DONE OUT OF THE TREATMENT ZONE

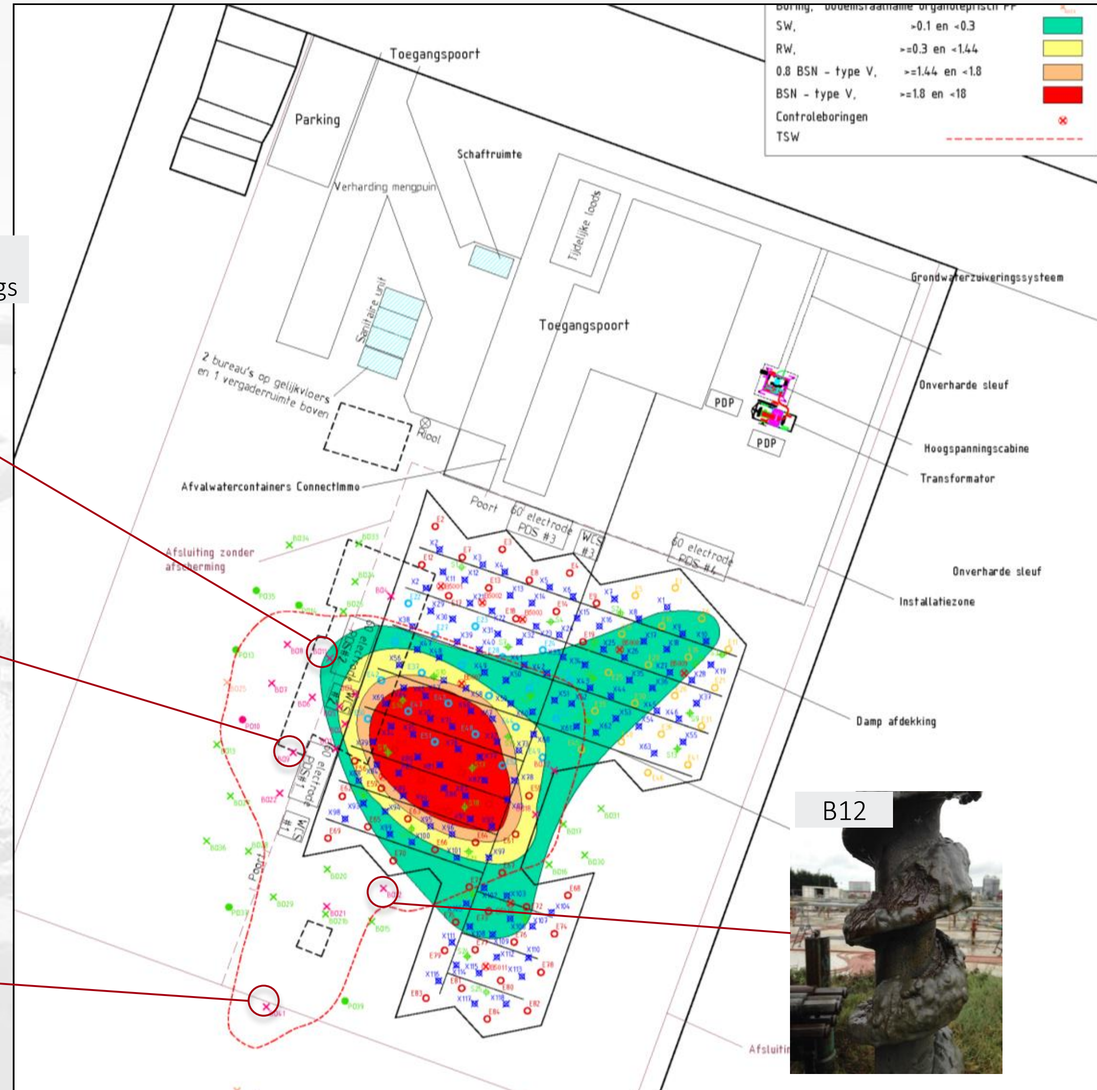
EXTRA INVESTIGATIONS

INITIAL TREATMENT ZONE VERSUS NAPL DELINEATION

- About 35 borings
- Geoprobe Vs Auger
- Heat outside : still 70°C distance of 15m
- Extended treatment zone to about 1000 m²

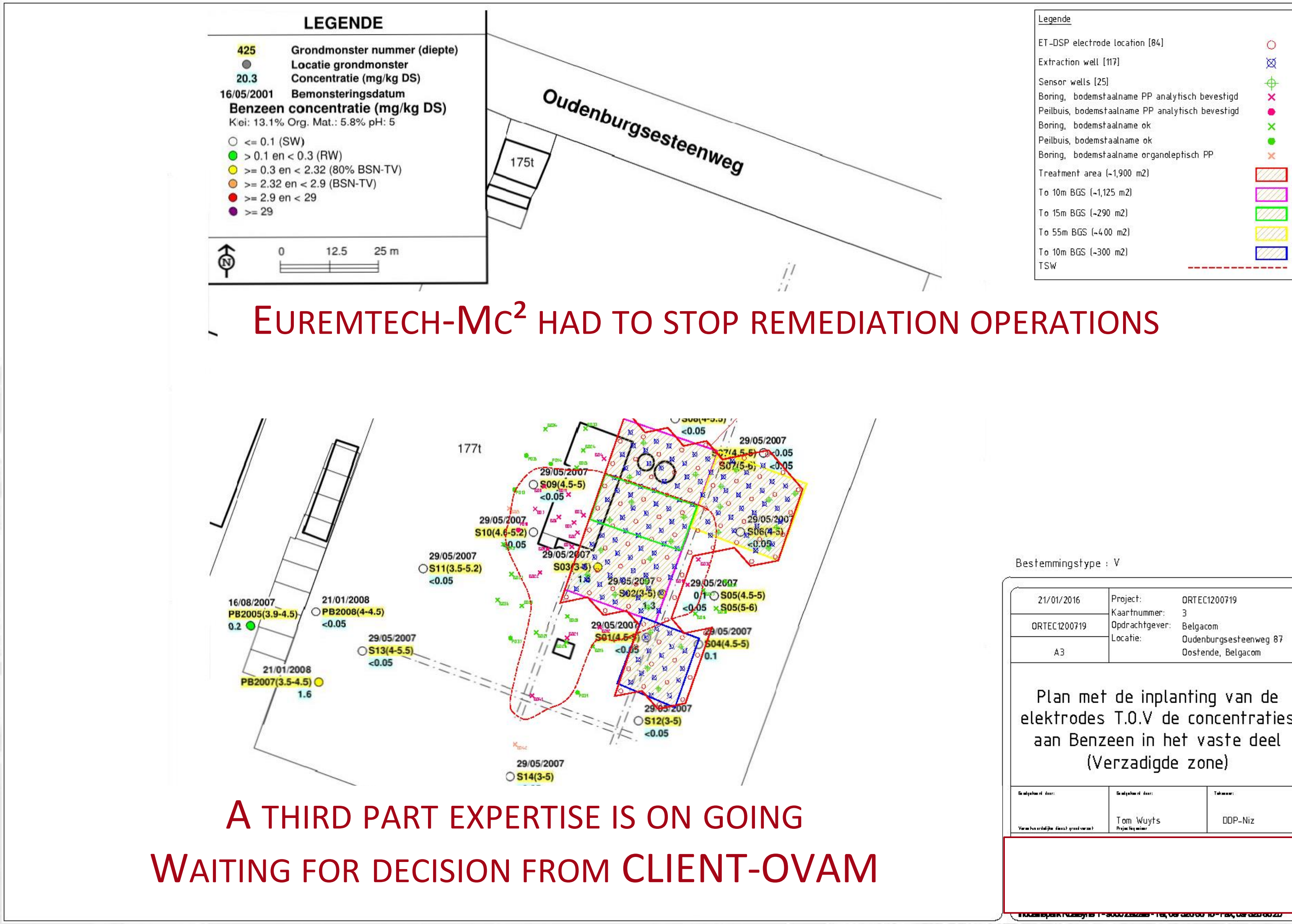






EXTRA INVESTIGATIONS

INITIAL OUTSIDE INVESTIGATIONS



EUREMTECH-MC² HAD TO STOP REMEDIATION OPERATIONS

A THIRD PART EXPERTISE IS ON GOING

WAITING FOR DECISION FROM CLIENT-OVAM

CONCLUSION

1ST ET-DSP™ IN EUROPE – FORMER CREOSOTE SITE

HIGH PERFORMANCE & RAPID REMEDIATION:

- 28 tons of contamination has been removed for the subsurface : 90% from liquid phase
- Cleanup values have been met for almost 60 % of the whole treatment zone
- 272 days of treatment operations
- Energy consumption : 194 kWh/m3 (20 €/m^3) – 12 % of the total cost

REMEDIATION OPERATIONS IN STAND-BY…

- No decrease of Naphthalene concentrations along the edge of the treatment zone supposes that source contamination is likely present outside
- 35 extra borings were drilled in emergency
- Many have indicated NAPL contamination
- **More than 1000 m² should have been taken into account initially**

FIXED PRICE & CONTRACT WITH GUARANTEES IS DEMANDING SO WE ARE TOO:

- Site characterization especially contamination delineation is a paramount step for designing properly
- Squeezing the budget for contamination delineation = big risk for the client to pay significantly more afterwards
- Euremtech-Mc² cannot hold the current contract because treatment zone delineation is one of the primary condition of guarantees – fixed price
- Client is obviously not satisfied and frustrated due to the wrong contamination delineation

THANK YOU FOR YOUR ATTENTION

« In Situ remediation is very complex..

Our people are passionate about developing the right

solution for our clients »

euremtech

In Situ Specialists