Miljøprojekt Nr. 834 2003
Teknologiudviklingsprogrammet for
jord- og grundvandsforurening.

Oprensning af klorerede opløsningsmidler ved stimuleret reduktiv deklorering - bilagsrapport

Jægersborg Allé, Gentofte

Christian Mossing
Hedeselskabet Miljø og Energi A/S

Poul L. Bjerg
Danmarks Tekniske Universitet, Miljø & Ressourcer

Miljøstyrelsen
Miljøministeriet

Miljøstyrelsen vil, når lejligheden gives, offentliggøre rapporter og indlæg vedrørende forsknings- og udviklingsprojekter inden for miljøsektoren, finansieret af Miljøstyrelsens undersøgelsesbevilling.

Det skal bemærkes, at en sådan offentliggørelse ikke nødvendigvis betyder, at det pågældende indlæg giver udtryk for Miljøstyrelsens synspunkter.

Offentliggørelsen betyder imidlertid, at Miljøstyrelsen finder, at indholdet udgør et væsentligt indlæg i debatten omkring den danske miljøpolitik.

Indhold

Boreprofiler og sigtekurver

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Jordart Karakterisering	Aflejring	Alder
	DNN +10,6					
0				ASFALT, stabil grus		
				FYLD: MULD, sandet	O	Re
			10	MORÆNELER, st. sandet, gulbrunt	Gl	Gc
1						
			9			
2				SAND, gulbrunt	Sm	Gc
			8			
3						
			7			
4						
			6			
5		3 : 000725				
			5	SAND, vandførende, gulbrunt	Sm	Gc
6						
			4			
7						
			3			
8						
			2			
9						

Fortsættes

O 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 10,49
2 : Ø 63 mm PEH-filter, kote af filtertop = 10,51
3 : Ø 63 mm PEH-filter, kote af filtertop = 10,53

Boremetode : 10" snegl , med foring

Plan :

Sag : 364.99281 Jægersborg Allé

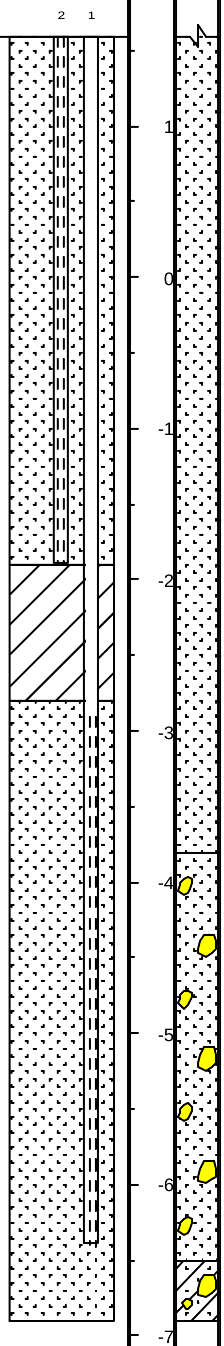
Strækning : Boret af : UDC Dato : 000629 DGU-nr.: **Boring : O1**

Udarb. af : UDC Kontrol : Godkendt : Dato : Bilag : 2 S. 1 / 2

HEDESELSKABET

Boreprofil

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
							Fortsat			
9–14.6							SAND, vandførende, gulbrunt	Sm	Gc	
14.6–17.1							SAND, groft, stenet, gråt	Sm	Gc	
17.1–17.5							MORÆNELER, stenet, gråt	Gl	Gc	



Dybde: 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 10,49
2 : Ø 63 mm PEH-filter, kote af filtertop = 10,51
3 : Ø 63 mm PEH-filter, kote af filtertop = 10,53

Boremetode : 10" snegl , med foring

Plan :

Sag : 364.99281 Jægersborg Allé

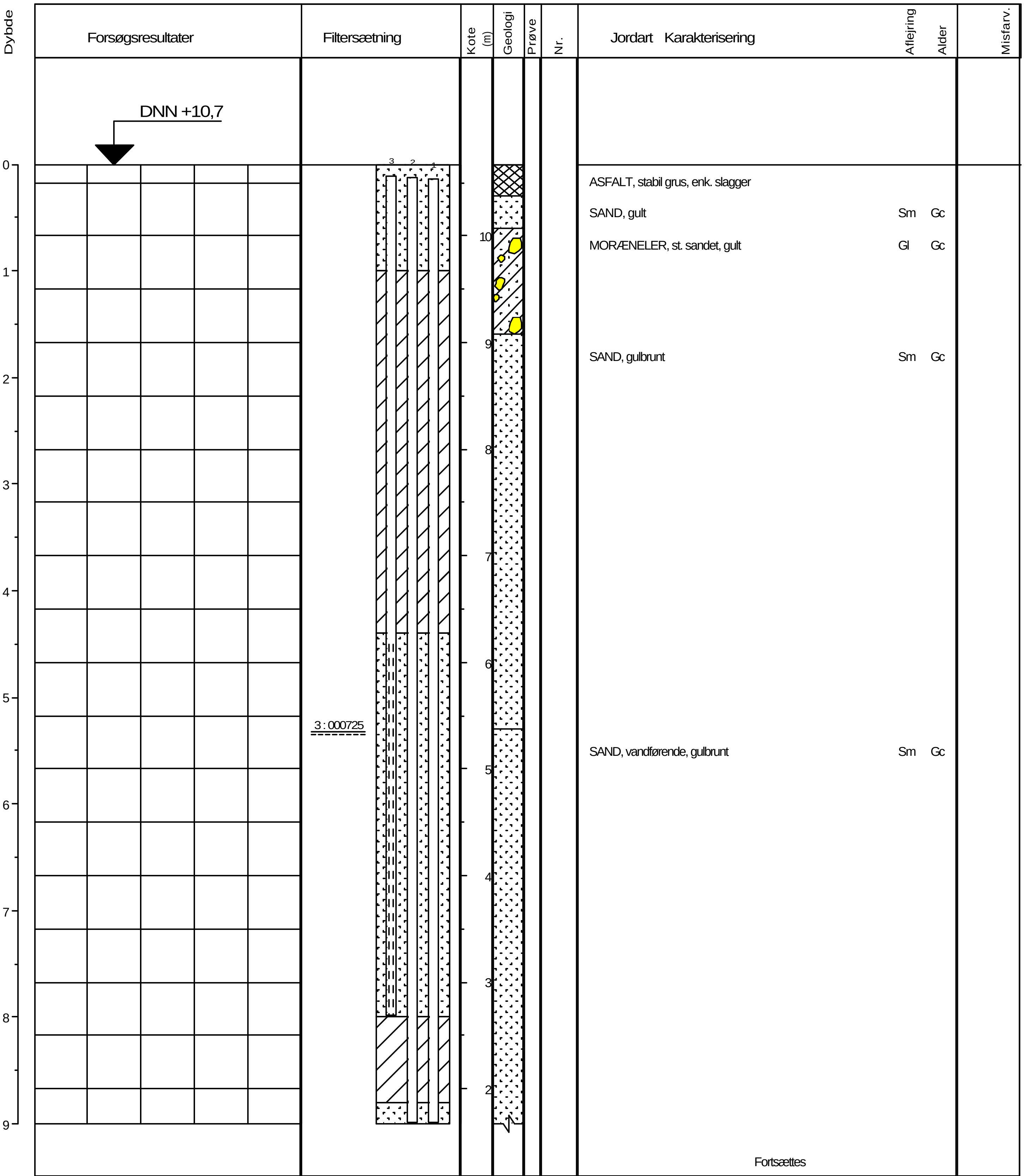
Strækning : | Boret af : UDC | Dato : 000629 | DGU-nr.: | Boring : O1

Udarb. af : UDC | Kontrol : | Godkendt : | Dato : | Bilag : 2 | S. 2 / 2

HEDESELSKABET

Boreprofil

BRegister - PSTMDK 2.0 - 11/03/2003 14:39:05



10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 10,58

2 : Ø 63 mm PEH-filter, kote af filtertop = 10,60

3 : Ø 63 mm PEH-filter, kote af filtertop = 10,61

Boremetode : 10" snegl , med foring

Plan :

Sag : 364.99281 Jægersborg Allé

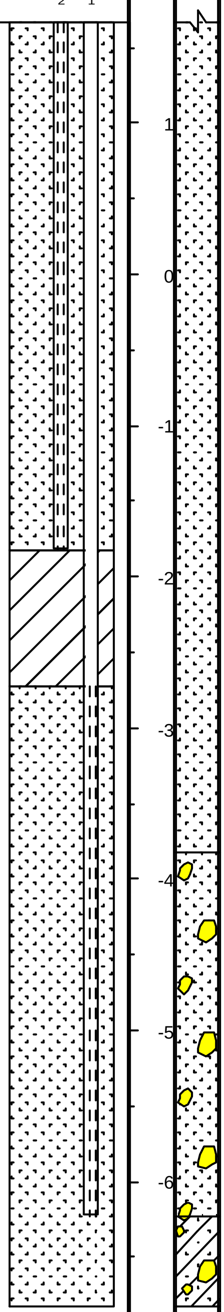
Strækning : Boret af : UDC Dato : 000703 DGU-nr.: Boring : O2

Udarb. af : UDC Kontrol : Godkendt : Dato : Bilag : 2 S. 1 / 2

HEDESELSKABET

Boreprofil

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
							Fortsat			
9		2 1								
			1							
10							SAND, vandførende, gulbrunt	Sm	Gc	
			0							
11										
			-1							
12										
			-2							
13										
			-3							
14										
			-4				SAND, stenet, gråt	Sm	Gc	
15										
			-5							
16										
			-6							
17							MORÆNELER, gråt	Gl	Gc	
			-7							
18										



O 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 10,58

2 : Ø 63 mm PEH-filter, kote af filtertop = 10,60

3 : Ø 63 mm PEH-filter, kote af filtertop = 10,61

Boremetode : 10" snegl , med foring

Plan :

Sag : 364.99281 Jægersborg Allé

Strækning : Boret af : UDC Dato : 000703 DGU-nr.: Boring : O2

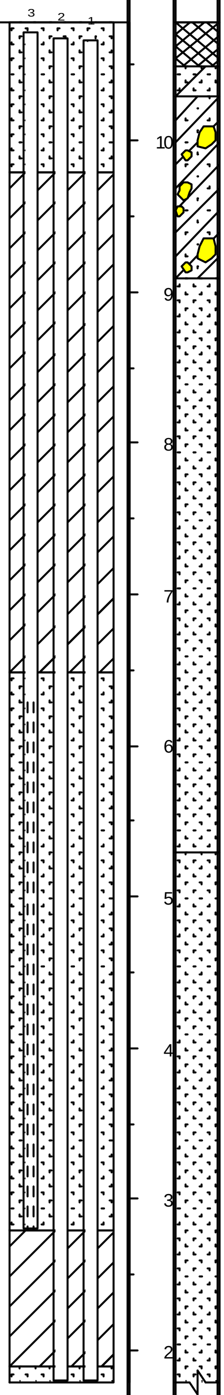
Udarb. af : UDC Kontrol : Godkendt : Dato : Bilag : 2 S. 2 / 2

HEDESELSKABET

Boreprofil

BRegister - PSTMDK 2.0 - 11/03/2003 15:32:41

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
	DNN +10,8									
0							ASFALT, stabil grus, murbrokker, slagger			
							SAND, leret	Sm	Gc	
			10				MORÆNELER, sandet, gulbrunt	Gl	Gc	
1										
2			9				SAND, gulbrunt	Sm	Gc	
3			8							
4			7							
5		3 : 000725	6							
6			5				SAND, vandførende, gulbrunt	Sm	Gc	
7			4							
8			3							
9			2							



Fortsættes

○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 10,71
2 : Ø 63 mm PEH-filter, kote af filtertop = 10,73
3 : Ø 63 mm PEH-filter, kote af filtertop = 10,76

Boremetode : 10" snegl , med foring

Plan :

Sag : 364.99281 Jægersborg Allé

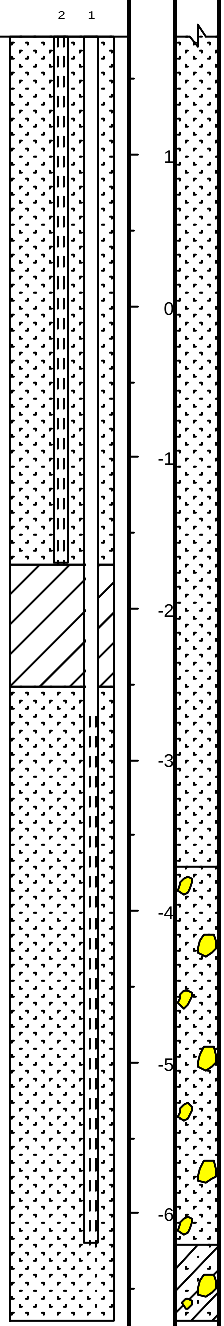
Strækning : Boret af : UDC Dato : 000706 DGU-nr.: **Boring : O3**

Udarb. af : UDC Kontrol : Godkendt : Dato : Bilag : 2 S. 1 / 2

HEDESELSKABET

Boreprofil

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
							Fortsat			
9		2 1								
			1							
10							SAND, vandførende, gulbrunt	Sm	Gc	
			0							
11										
			-1							
12										
			-2							
13										
			-3							
14										
			-4				SAND, groft, stenet, gråt	Sm	Gc	
15										
			-5							
16										
			-6							
17							MORÆNELER, gråt	Gl	Gc	
			-7							
18										



○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 10,71

2 : Ø 63 mm PEH-filter, kote af filtertop = 10,73

3 : Ø 63 mm PEH-filter, kote af filtertop = 10,76

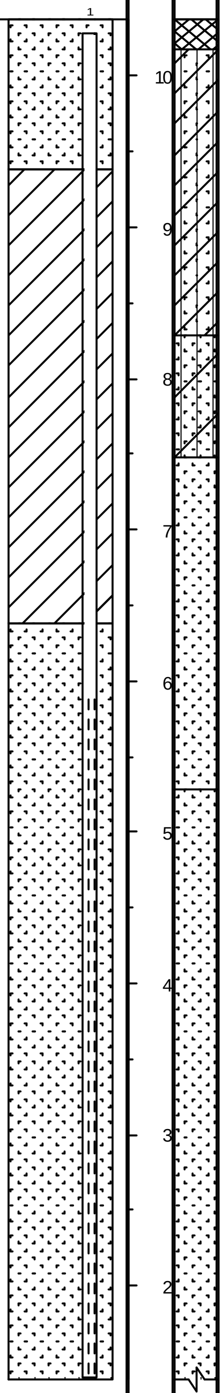
Boremetode : 10" snegl , med foring

Plan :

Sag : 364.99281 Jægersborg Allé				
Strækning :	Boret af : UDC	Dato : 000706	DGU-nr.:	Boring : O3
Udarb. af : UDC	Kontrol :	Godkendt :	Dato :	Bilag : 2 S. 2 / 2

HEDESELSKABET **Boreprofil**

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
	DNN +10,4									
0							ASFALT, stabil grus			
			10				FYLD: LER, sandet	O	Re	
1										
			9							
2							FYLD: SAND, leret	O	Re	
			8							
3							SAND, gulbrunt	Sm	Gc	
			7							
4										
			6							
5		1 : 000725								
			5				SAND, vandførende, gulbrunt	Sm	Gc	
6										
			4							
7										
			3							
8										
			2							
9										



Fortsættes

O 10 20 30 40 W (%)

1 : Ø 125 mm PEH-filter, kote af filtertop = 10,33

Boremetode : 10" snegl , med foring

Plan :

Sag : 364.99281 Jægersborg Allé

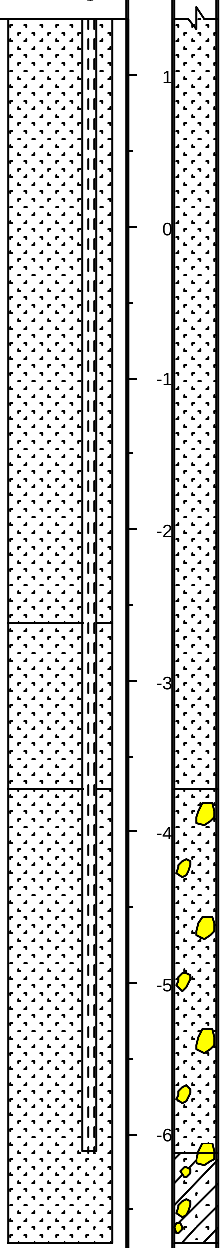
Strækning : Boret af : UDC Dato : 000713 DGU-nr.: Boring : P1

Udarb. af : UDC Kontrol : Godkendt : Dato : Bilag : 2 S. 1 / 2

HEDESELSKABET **Boreprofil**

BRegister - PSTMDK 2.0 - 11/03/2003 14:40:44

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
		1					Fortsat			
9			1							
10			0				SAND, vandførende, gulbrunt	Sm	Gc	
11			-1							
12			-2							
13			-3							
14			-4				SAND, groft, stenet, gråt	Sm	Gc	
15			-5							
16			-6				MORÆNELER	Gl	Gc	
17			-7							
18										



○ 10 20 30 40 W (%)

1 : Ø 125 mm PEH-filter, kote af filtertop = 10,33

Boremetode : 10" snegl , med foring

Plan :

Sag : 364.99281 Jægersborg Allé

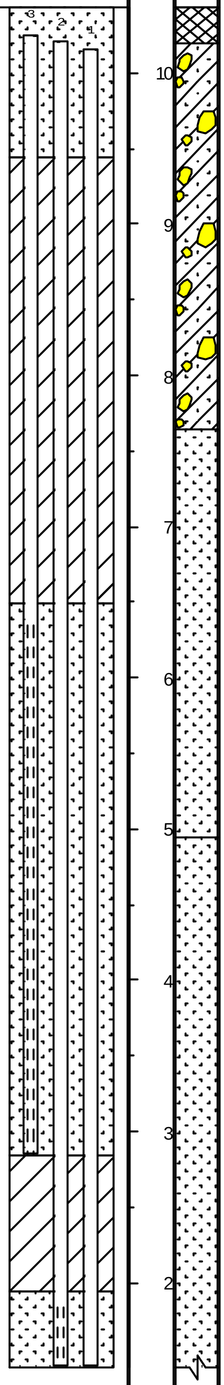
Strækning : Boret af : UDC Dato : 000713 DGU-nr.: Boring : P1

Udarb. af : UDC Kontrol : Godkendt : Dato : Bilag : 2 S. 2 / 2

HEDESELSKABET Boreprofil

BRegister - PSTMDK 2.0 - 11/03/2003 14:40:44

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
0	DNN +10,4						ASFALT, stabil grus			
			10				MORÆNELER, st. sandet, stenet, gulbrunt	Gl	Gc	
1			9							
2			8							
3							SAND, fint, gulbrunt	Sm	Gc	
			7							
4			6							
5			5							
6							SAND, fint, gulbrunt, fugtigt	Sm	Gc	
			4							
7			3							
8			2							
9										



Fortsættes

○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop= 10,153

2 : Ø 63 mm PEH-filter, kote af filtertop= 10,206

3 : Ø 63 mm PEH-filter, kote af filtertop= 10,253

Boremetode : 10¨ snegl, med foring

Plan :

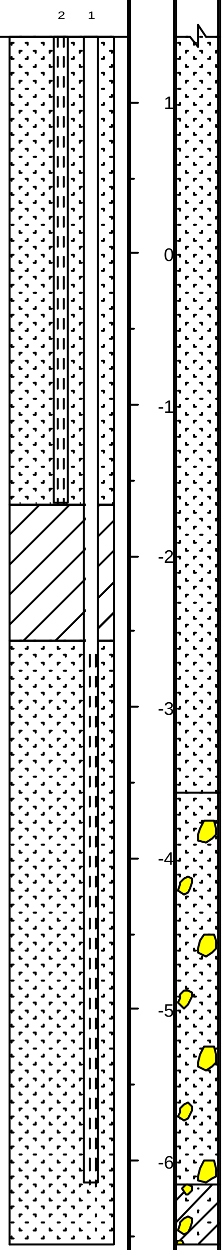
Sag : 364.00184 Jægersborg Allé

Strækning : Boret af : GEO Dato : 010323 DGU-nr.: Boring : M1

Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 1 / 2

HEDESELSKABET **Boreprofil**

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
							Fortsat			
9										
			1							
10							SAND, fint, gulbrunt, fugtigt	Sm	Gc	
			0							
11										
			-1							
12										
			-2							
13										
			-3							
14							SAND, groft, stenet, gulbrunt, fugtigt	Sm	Gc	
			-4							
15										
			-5							
16										
			-6				MORÆNELER, gråt	Gl	Gc	
17										
			-7							
18										



○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop= 10,153

2 : Ø 63 mm PEH-filter, kote af filtertop= 10,206

3 : Ø 63 mm PEH-filter, kote af filtertop= 10,253

Boremetode : 10¨ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

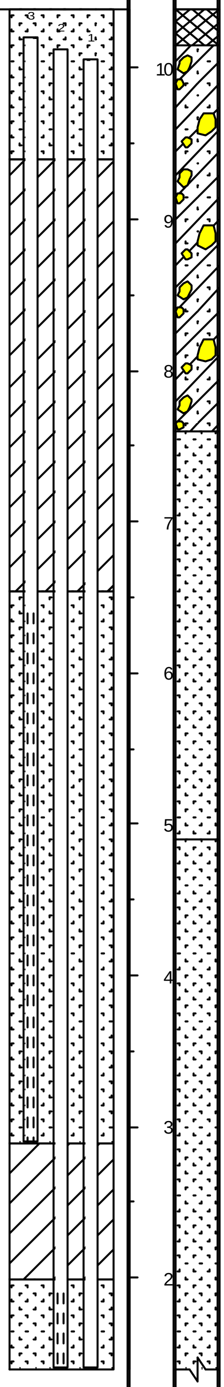
Strækning : Boret af : GEO Dato : 010323 DGU-nr.: Boring : M1

Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 2 / 2

BRegister - PSTMDK 2.0 - 11/03/2003 14:32:28

HEDESELSKABET Boreprofil

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
	DNN +10,4									
0			10				ASFALT, stabil grus			
							MORÆNELER, st. sandet, stenet, gulbrunt	Gl	Gc	
1			9							
2			8							
3			7							
4			6				SAND, fint, gulbrunt	Sm	Gc	
5			5							
							SAND, fint, gulbrunt, fugtigt	Sm	Gc	
6			4							
7			3							
8			2							
9							Fortsættes			



O 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 10,057
2 : Ø 63 mm PEH-filter, kote af filtertop = 10,124
3 : Ø 63 mm PEH-filter, kote af filtertop = 10,206

Boremetode : 10˝ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

Strækning : Boret af : GEO Dato : 010321 DGU-nr.: **Boring : M2**

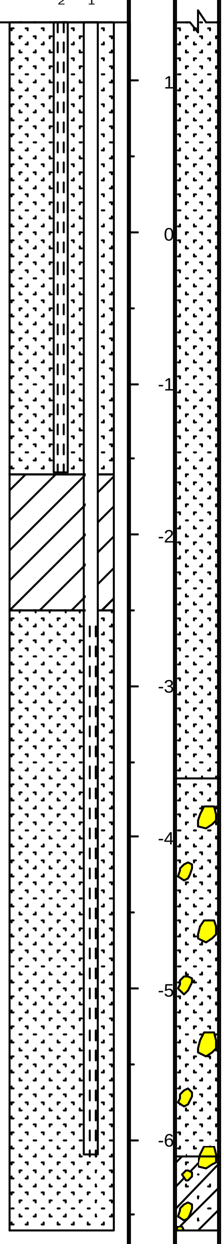
Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 1 / 2

HEDESELSKABET

Boreprofil

BRegister - PSTMDK 2.0 - 11/03/2003 14:34:49

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
							Fortsat			
9										
			1							
10							SAND, fint, gulbrunt, fugtigt	Sm	Gc	
			0							
11										
			-1							
12										
			-2							
13										
			-3							
14										
			-4				SAND, groft, stenet, gulbrunt	Sm	Gc	
15										
			-5							
16										
			-6				MORÆNELER, gråt	Gl	Gc	
17										
			-7							
18										



O 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 10,057
2 : Ø 63 mm PEH-filter, kote af filtertop = 10,124
3 : Ø 63 mm PEH-filter, kote af filtertop = 10,206

Boremetode : 10¨ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

Strækning : Boret af : GEO Dato : 010321 DGU-nr.: Boring : M2

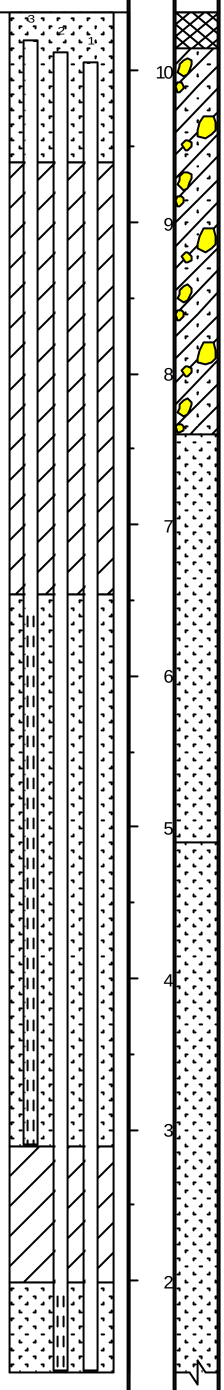
Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 2 / 2

HEDESELSKABET **Boreprofil**

BRegister - PSTMDK 2.0 - 11/03/2003 14:34:49

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.

DNN +10,4



Jordart Karakterisering	Aflejring	Alder
ASFALT, stabil grus		
MORÆNELER, st. sandet, stenet, gulbrunt	Gl	Gc
SAND, fint, gulbrunt	Sm	Gc
SAND, fint, gulbrunt, fugtigt	Sm	Gc

Fortsættes

○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 10,057
2 : Ø 63 mm PEH-filter, kote af filtertop = 10,124
3 : Ø 63 mm PEH-filter, kote af filtertop = 10,206

Boremetode : 10˝ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

Strækning : | Boret af : GEO | Dato : 010321 | DGU-nr.: | **Boring : M2**

Udarb. af : GEO | Kontrol : | Godkendt : | Dato : | Bilag : 2 | S. 1 / 2

HEDESELSKABET

Boreprofil

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
							Fortsat			
9		2 1								
			1							
10							SAND, fint, gulbrunt, fugtigt	Sm	Gc	
			0							
11										
			-1							
12										
			-2							
13										
			-3							
14										
			-4				SAND, groft, stenet, gulbrunt	Sm	Gc	
15										
			-5							
16										
			-6				MORÆNELER, gråt	Gl	Gc	
17										
			-7							
18										

O 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 10,057

2 : Ø 63 mm PEH-filter, kote af filtertop = 10,124

3 : Ø 63 mm PEH-filter, kote af filtertop = 10,206

Boremetode : 10´´ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

Strækning : Boret af : GEO Dato : 010321 DGU-nr.: **Boring : M2**

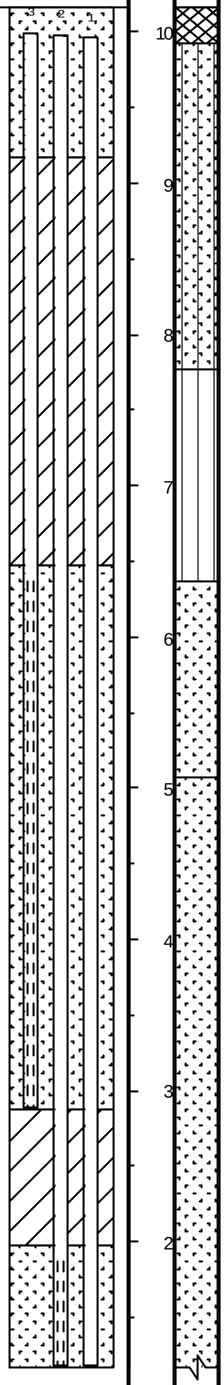
Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 2 / 2

HEDESELSKABET

Boreprofil

BRegister - PSTMDK 2.0 - 11/03/2003 14:35:13

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
0	DNN +10,2		10				ASFALT, slagger			
							FYLD: SAND, gulbrunt	O	Re	
1			9							
2			8				FYLD, stabil grus, enk. sten, gulbrunt	O	Re	
3			7							
4			6				SAND, fint, gulbrunt	Sm	Gc	
5			5				SAND, fint, gulbrunt, fugtigt	Sm	Gc	
6			4							
7			3							
8			2							
9			1				Fortsættes			



○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 9,962
2 : Ø 63 mm PEH-filter, kote af filtertop = 9,985
3 : Ø 63 mm PEH-filter, kote af filtertop = 9,997

Boremetode : 10¨ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

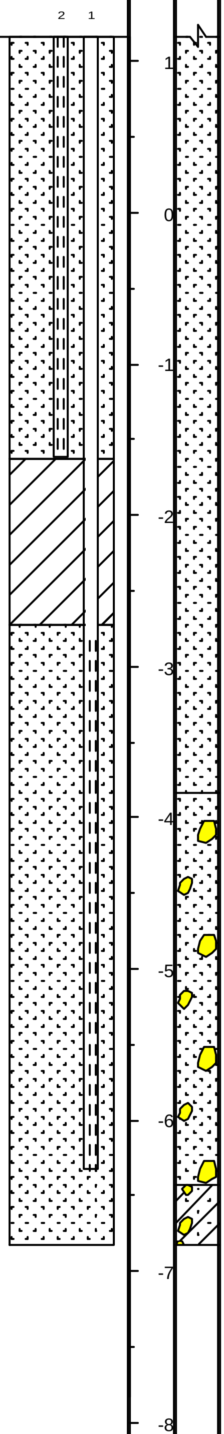
Strækning : Boret af : GEO Dato : 010330 DGU-nr.: **Boring : M4**

Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 1 / 2

HEDESELSKABET

Boreprofil

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
							Fortsat			
10							SAND, fint, gulbrunt, fugtigt	Sm	Gc	
14-15							SAND, groft, stenet, gulbrunt, fugtigt	Sm	Gc	
16-17							MORÆNELER, gråt	Gl	Gc	



Dybde: 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 9,962

2 : Ø 63 mm PEH-filter, kote af filtertop = 9,985

3 : Ø 63 mm PEH-filter, kote af filtertop = 9,997

Boremetode : 10¨ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

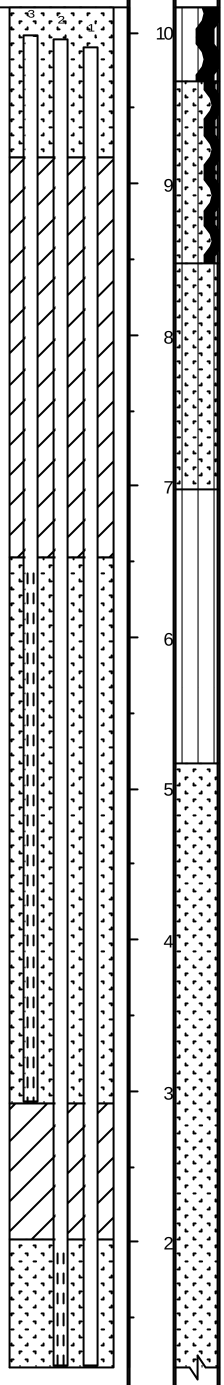
Strækning : Boret af : GEO Dato : 010330 DGU-nr.: **Boring : M4**

Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 2 / 2

HEDESELSKABET

Boreprofil

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
	DNN +10,2									
0			10				FYLD: MULD	O	Re	
							FYLD: SAND, muldet, brunt	O	Re	
1			9							
2			8				FYLD: SAND, gulbrunt	O	Re	
3			7				FYLD, stabil grus, enk. sten, gulbrunt	O	Re	
4			6							
5			5				SAND, fint, gulbrunt	Sm	Gc	
6			4							
7			3							
8			2							
9			1				Fortsættes			



○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 9,899
2 : Ø 63 mm PEH-filter, kote af filtertop = 9,951
3 : Ø 63 mm PEH-filter, kote af filtertop = 9,982

Boremetode : 10¨ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

Strækning : Boret af : GEO Dato : 010403 DGU-nr.: **Boring : M5**

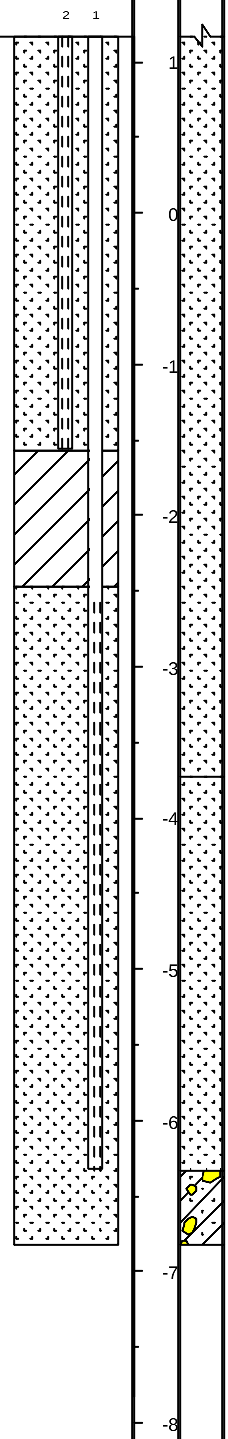
Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 1 / 2

HEDESELSKABET

Boreprofil

BRegister - PSTMDK 2.0 - 11/03/2003 14:35:53

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
							Fortsat			
9–~14			1 … -3				SAND, fint, gulbrunt	Sm	Gc	
~14–16,5			-4 … -6				SAND, groft, gulbrunt, fugtigt	Sm	Gc	
16,5–17							MORÆNELER, gråt	Gl	Gc	



Dybde: 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 9,899

2 : Ø 63 mm PEH-filter, kote af filtertop = 9,951

3 : Ø 63 mm PEH-filter, kote af filtertop = 9,982

Boremetode : 10¨ snegl, med foring

Plan :

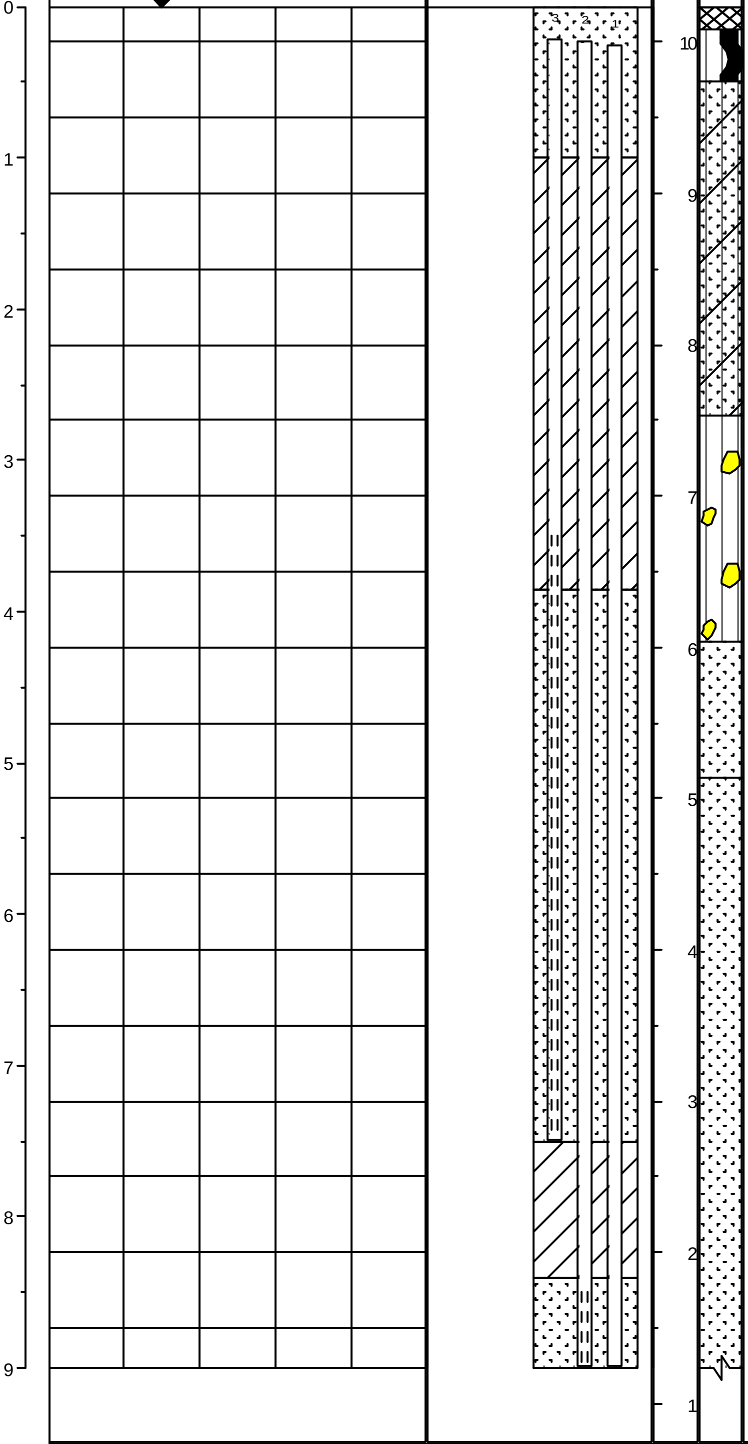
Sag : 364.00184 Jægersborg Allé

Strækning :		Boret af : GEO		Dato : 010403	DGU-nr.:	Boring : M5	
Udarb. af : GEO		Kontrol :		Godkendt :	Dato :	Bilag : 2	S. 2 / 2

HEDESELSKABET

Boreprofil

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
	DNN +10,2									
							ASFALT: BETON			
							FYLD: MULD	O	Re	
							FYLD: SAND, leret, enk. sten, gulbrunt	O	Re	
							FYLD, stabil grus, stenet, gulbrunt	O	Re	
							SAND, fint, gulbrunt, fugtigt	Sm	Gc	



Fortsættes

O 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 9,984
2 : Ø 63 mm PEH-filter, kote af filtertop = 10,007
3 : Ø 63 mm PEH-filter, kote af filtertop = 10,025

Boremetode : 10¨ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

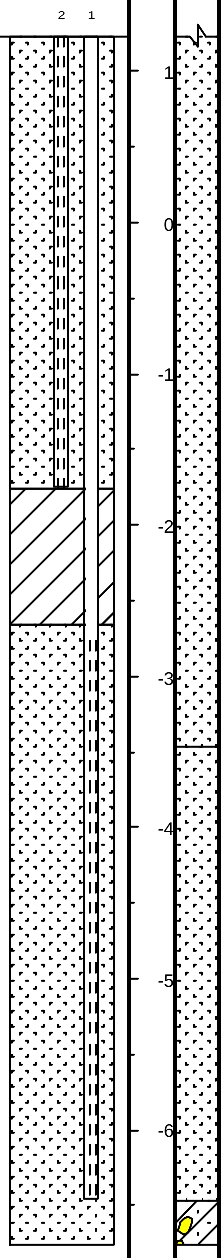
Strækning : | Boret af : GEO | Dato : 010404 | DGU-nr.: | Boring : M6

Udarb. af : GEO | Kontrol : | Godkendt : | Dato : | Bilag : 2 | S. 1 / 2

HEDESELSKABET

Boreprofil

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
							Fortsat			
9			1							
10			0				SAND, fint, gulbrunt, fugtigt	Sm	Gc	
11			-1							
12			-2							
13			-3							
14			-4				SAND, groft, gulbrunt, fugtigt	Sm	Gc	
15			-5							
16			-6							
17			-7				MORÆNELER, gråt	Gl	Gc	
18			-8							



O 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filtertop = 9,984
2 : Ø 63 mm PEH-filter, kote af filtertop = 10,007
3 : Ø 63 mm PEH-filter, kote af filtertop = 10,025

Boremetode : 10¨ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

Strækning : Boret af : GEO Dato : 010404 DGU-nr.: Boring : M6

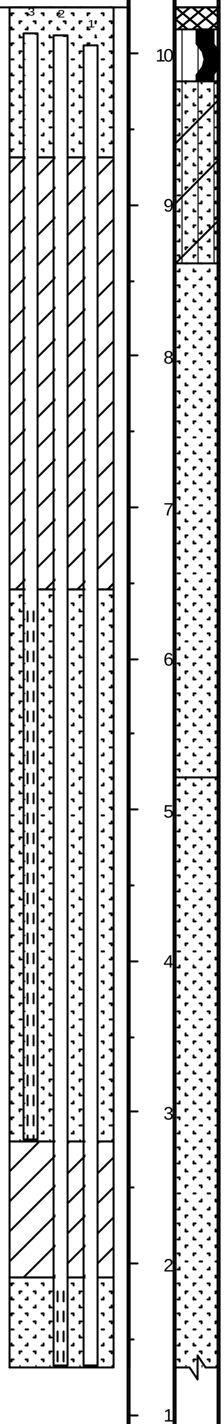
Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 2 / 2

HEDESELSKABET

Boreprofil

BRegister - PSTMDK 2.0 - 11/03/2003 14:36:18

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
	DNN +10,3									
0							ASFALT: BETON			
			10				FYLD: MULD	O	Re	
1							FYLD: SAND, leret, enk. sten, gulbrunt	O	Re	
			9							
2							SAND, fint, enk. sten, gulbrunt	Sm	Gc	
			8							
3										
			7							
4										
			6							
5			5				SAND, fint, gulbrunt, fugtigt	Sm	Gc	
6										
			4							
7										
			3							
8										
			2							
9										
			1				Fortsættes			



○ 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filter = 10,055

2 : Ø 63 mm PEH-filter, kote af filter = 10,121

3 : Ø 63 mm PEH-filter, kote af filter = 10,137

Boremetode : 10˝ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

Strækning : Boret af : GEO Dato : 010404 DGU-nr.: **Boring : M7**

Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 1 / 2

HEDESELSKABET

Boreprofil

BRegister - PSTMDK 2.0 - 11/03/2003 14:36:38

Dybde	Forsøgsresultater	Filtersætning	Kote (m)	Geologi	Prøve	Nr.	Jordart Karakterisering	Aflejring	Alder	Misfarv.
		2 1					Fortsat			
9										
			1							
10							SAND, fint, gulbrunt, fugtigt	Sm	Gc	
			0							
11										
			-1							
12										
			-2							
13										
			-3							
14							SAND - " -	Sm	Gc	
			-4							
15										
			-5							
16										
			-6							
17							MORÆNELER, gråt	Gl	Gc	
			-7							
18										
			-8							

O 10 20 30 40 W (%)

1 : Ø 63 mm PEH-filter, kote af filter = 10,055

2 : Ø 63 mm PEH-filter, kote af filter = 10,121

3 : Ø 63 mm PEH-filter, kote af filter = 10,137

Boremetode : 10¨ snegl, med foring

Plan :

Sag : 364.00184 Jægersborg Allé

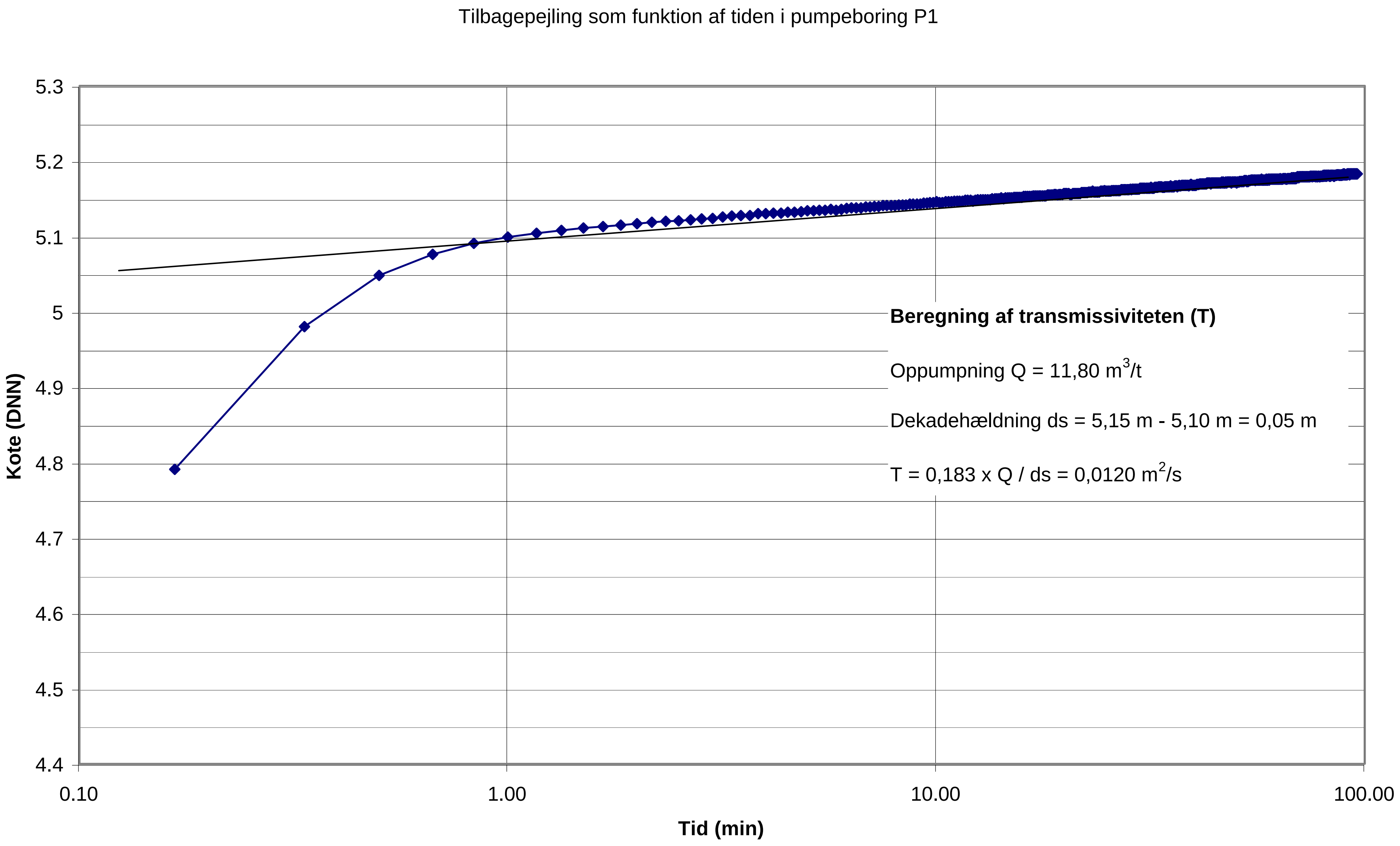
Strækning : Boret af : GEO Dato : 010404 DGU-nr.: Boring : M7

Udarb. af : GEO Kontrol : Godkendt : Dato : Bilag : 2 S. 2 / 2

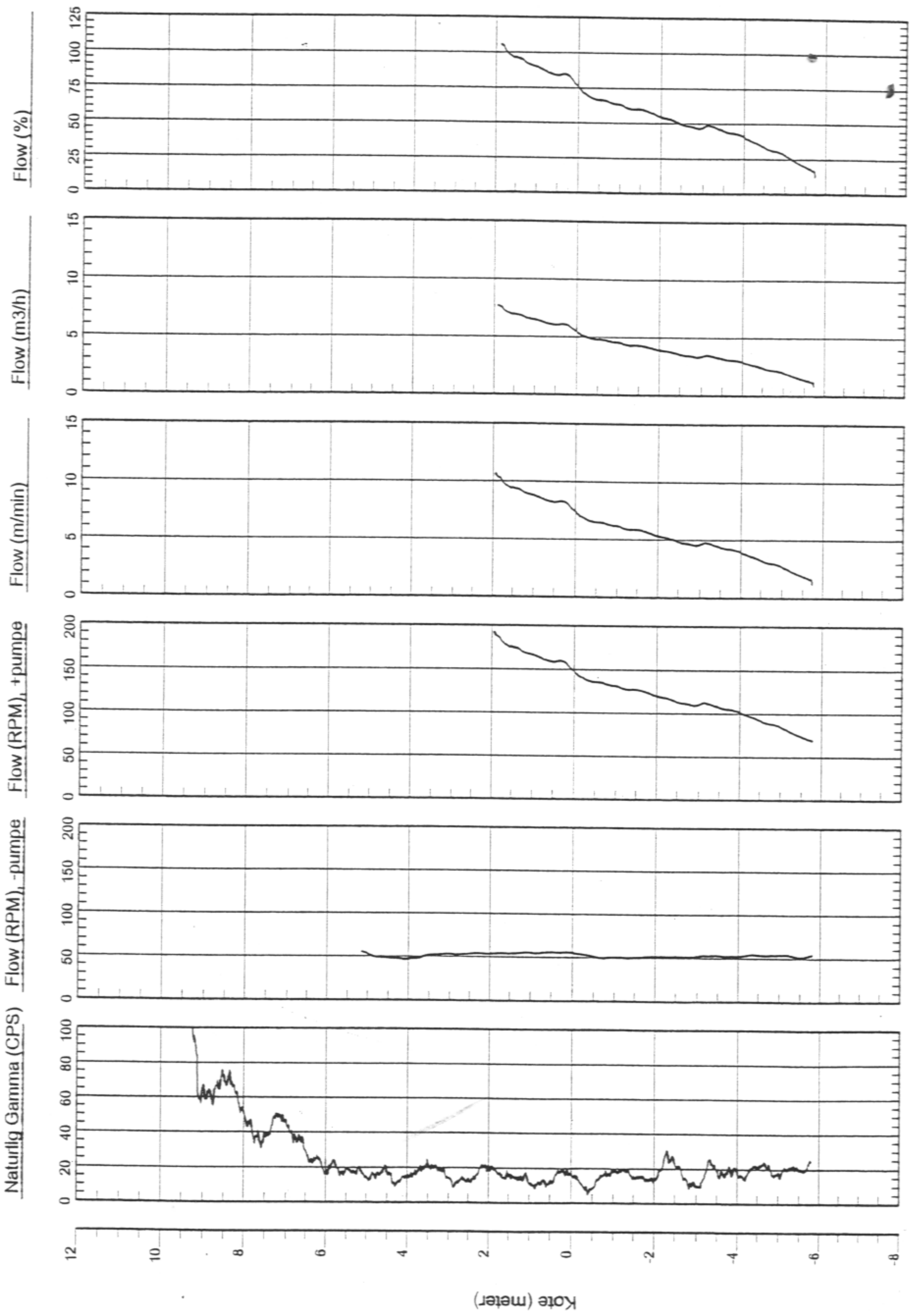
HEDESELSKABET

Boreprofil

Resultat af trinvis pumpetest samt flowlog (forundersøgelse)



Tilbagepejling som funktion af tiden i pumpeboring P1
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
4.4
Kote (DNN)
0.10
1.00
10.00
100.00
Tid (min)
Beregning af transmissiviteten (T)
Oppumpning Q = 11,80 m3/t
Dekadehældning ds = 5,15 m - 5,10 m = 0,05 m
T = 0,183 x Q / ds = 0,0120 m2/s



GEO

SAG: 161 18612 Jægersborg Allé

Udført	: INS	Dato: 2000-09-29	Emne: Flowlog, boring P1 (kote, DNN)
Kontrolleret	: ANK	Dato: 2000-09-29	Side 1 / 1
Godkendt	: JBC	Dato: 2000-09-29	Rapport 1 — Bilag 2 — Rev. 0

Pejleresultater og grundvandspotentialekort

Jægersborg Allé (nivellement og pejlinger)

Boring	Kote DNN	Dato: Pejling	25-07-2000 VS, DNN	middelværdi 3 filtre	Dato: Pejling	06-10-2000 VS, DNN	middelværdi 3 filtre
O1Ø	10.487	5.130	5.357		5.275	5.212	
O1M	10.463	5.115	5.348	5.351	5.255	5.208	5.209
O1N	10.438	5.090	5.348		5.230	5.208	
O1 terræn	10.595						
O2Ø	10.562	5.210	5.352		5.360	5.202	
O2M	10.548	5.200	5.348	5.350	5.345	5.203	5.205
O2N	10.530	5.180	5.350		5.320	5.210	
O2 terræn	10.672						
O3Ø	10.713	5.370	5.343		5.510	5.203	
O3M	10.681	5.340	5.341	5.341	5.480	5.201	5.203
O3N	10.660	5.320	5.340		5.455	5.205	
O3 terræn	10.790						
P1	10.287	4.950	5.337	5.337	5.095	5.192	5.192
P1 terræn	10.383						
M1Ø	10.253						
M1M	10.206						
M1N	10.153						
M1 terræn	10.439						
M2Ø	10.206						
M2M	10.124						
M2N	10.057						
M2 terræn	10.394						
M3Ø	10.312						
M3M	10.257						
M3N	10.213						
M3 terræn	10.505						
M4Ø	9.997						
M4M	9.985						
M4N	9.962						
M4 terræn	10.170						
M5Ø	9.982						
M5M	9.951						
M5N	9.899						
M5 terræn	10.173						
M6Ø	10.025						
M6M	10.007						
M6N	9.984						
M6 terræn	10.237						
M7Ø	10.137						
M7M	10.121						
M7N	10.055						
M7 terræn	10.312						
G5	10.72				5.83	4.89	4.89
G5 terræn	10.72						
G10	10.970	5.620	5.350	5.35	5.785	5.185	5.185
G10 terræn	10.970						
G11	10.32				5.23	5.09	5.09
G11 terræn	10.32						
U1	11.65				6.135	5.515	5.515
U1 terræn	11.72						
U3	12.05				6.69	5.36	5.36
U3 terræn	12.14						
B1	11.35				5.95	5.4	5.4
B1 terræn	11.41						

Boring	Kote DNN	Dato: Pejling	24-04-2001 VS, DNN	middelværdi 3 filtre	Dato: Pejling	10-10-2001 VS, DNN	middelværdi 3 filtre
O1Ø	10.487	5.3	5.187		5.25	5.237	
O1M	10.463	5.275	5.188	5.189	5.24	5.223	5.229
O1N	10.438	5.245	5.193		5.21	5.228	
O1 terræn	10.595						
O2Ø	10.562	5.375	5.187		5.34	5.222	
O2M	10.548	5.36	5.188	5.188	5.32	5.228	5.227
O2N	10.530	5.34	5.190		5.3	5.230	
O2 terræn	10.672						
O3Ø	10.713	5.53	5.183		5.49	5.223	
O3M	10.681	5.5	5.181	5.183	5.46	5.221	5.221
O3N	10.660	5.475	5.185		5.44	5.220	
O3 terræn	10.790						
P1	10.287	5.11	5.177	5.177	5.07	5.217	5.217
P1 terræn	10.383						
M1Ø	10.253	5.07	5.183		5.04	5.213	
M1M	10.206	5.02	5.186	5.184	4.98	5.226	5.221
M1N	10.153	4.97	5.183		4.93	5.223	
M1 terræn	10.439						
M2Ø	10.206	5.03	5.176		4.99	5.216	
M2M	10.124	4.94	5.184	5.181	4.91	5.214	5.216
M2N	10.057	4.875	5.182		4.84	5.217	
M2 terræn	10.394						
M3Ø	10.312	5.14	5.172		5.1	5.212	
M3M	10.257	5.08	5.177	5.177	5.04	5.217	5.217
M3N	10.213	5.03	5.183		4.99	5.223	
M3 terræn	10.505						
M4Ø	9.997	4.85	5.147		4.8	5.197	
M4M	9.985	4.83	5.155	5.153	4.785	5.200	5.200
M4N	9.962	4.805	5.157		4.76	5.202	
M4 terræn	10.170						
M5Ø	9.982	4.84	5.142		4.8	5.182	
M5M	9.951	4.81	5.141	5.144	4.77	5.181	5.184
M5N	9.899	4.75	5.149		4.71	5.189	
M5 terræn	10.173						
M6Ø	10.025	4.88	5.145		4.84	5.185	
M6M	10.007	4.86	5.147	5.149	4.82	5.187	5.185
M6N	9.984	4.83	5.154		4.8	5.184	
M6 terræn	10.237						
M7Ø	10.137	4.99	5.147		4.96	5.177	
M7M	10.121	4.97	5.151	5.151	4.94	5.181	5.184
M7N	10.055	4.9	5.155		4.86	5.195	
M7 terræn	10.312						
G5	10.72						
G5 terræn	10.72						
G10	10.970						
G10 terræn	10.970						
G11	10.32						
G11 terræn	10.32						
U1	11.65						
U1 terræn	11.72						
U3	12.05						
U3 terræn	12.14						
B1	11.35						
B1 terræn	11.41						

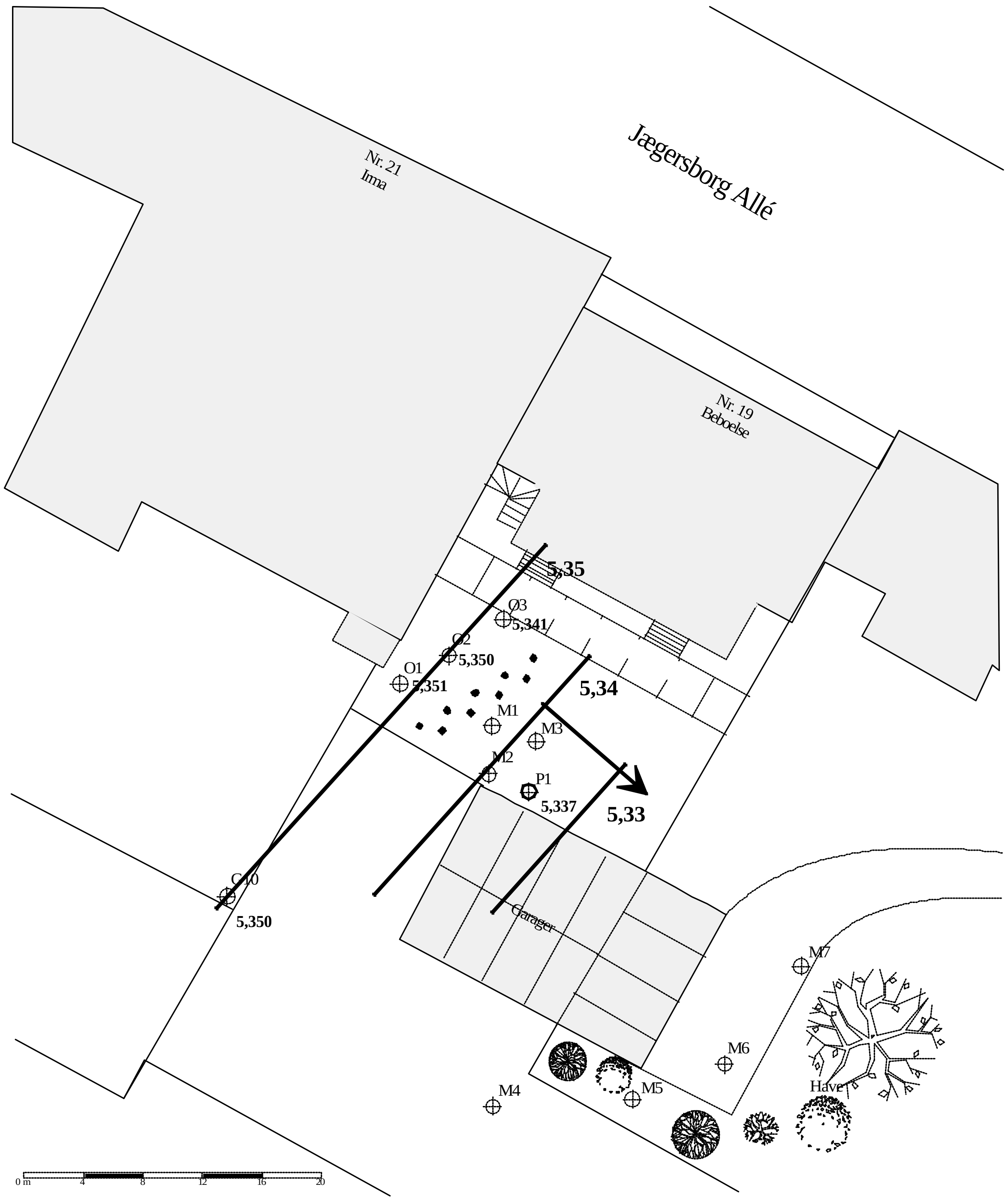
Eksisterende boring

5,34 Vandspejlskote, 6. oktober 2000

1 : 1000

0 25m

Grundvandspotentialekort



N

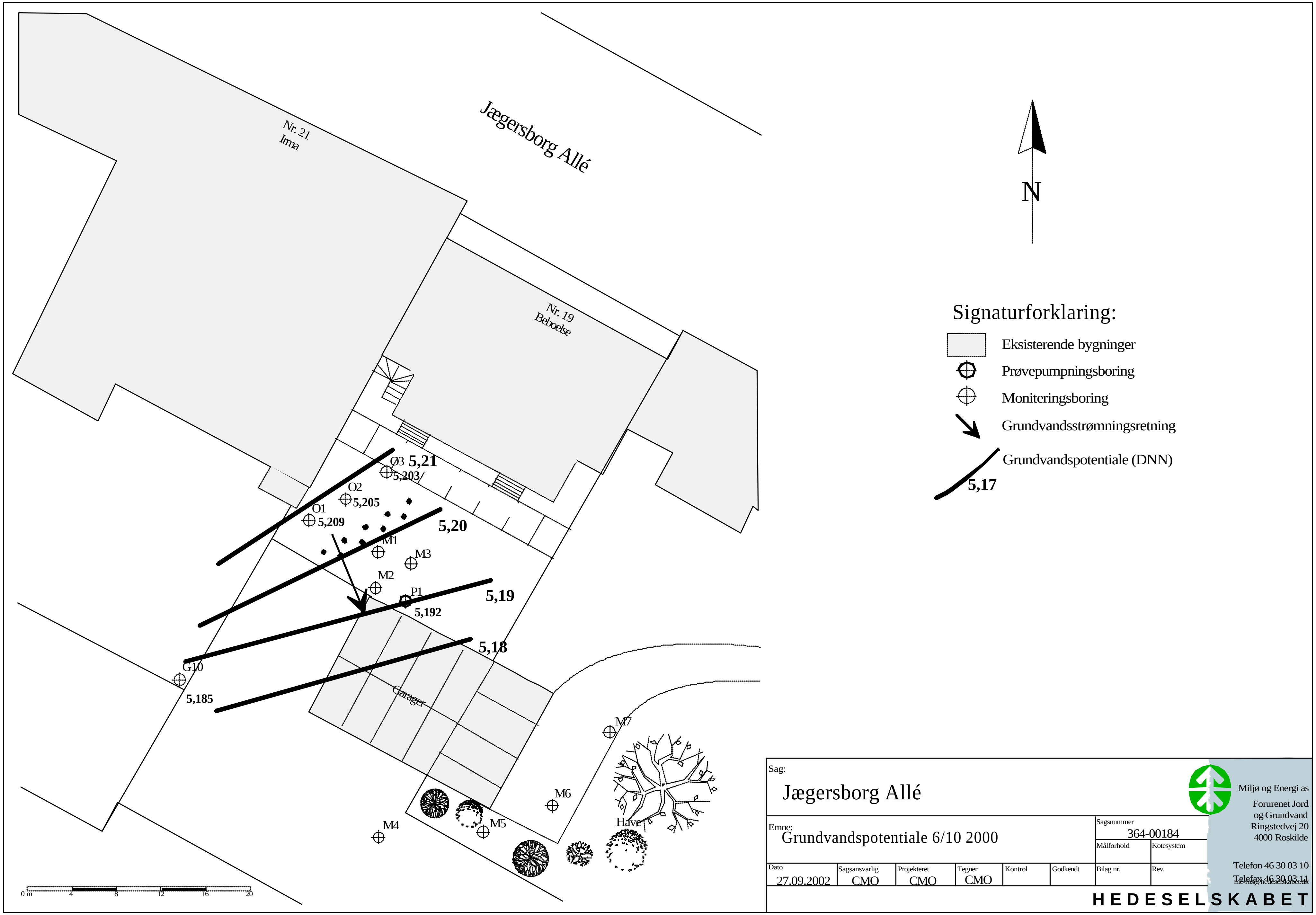
Signaturforklaring:

- Eksisterende bygninger
- Prøvepumpningsboring
- Moniteringsboring
- Grundvandsstrømningsretning
- Grundvandspotentiale (DNN) 5,17

Sag: Jægersborg Allé							
Emne: Grundvandspotentiale 25/7 2000						Sagsnummer 364-00184	
						Målforhold	Kotesystem
Dato 27.09.2002	Sagsansvarlig CMO	Projekteret CMO	Tegner CMO	Kontrol	Godkendt	Bilag nr.	Rev.

Miljø og Energi as
Forurenet Jord
og Grundvand
Ringstedvej 20
4000 Roskilde
Telefon 46 30 03 10
Telefax 46 30 03 11

HEDESELSKABET



Jægersborg Allé
Nr. 21
Irma
Nr. 19
Beboelse
Garager
Have
Ø3
5,203
O2
5,205
O1
5,209
M1
M2
M3
P1
5,192
G10
5,185
M4
M5
M6
M7
5,21
5,20
5,19
5,18
N
Signaturforklaring:
Eksisterende bygninger
Prøvepumpningsboring
Moniteringsboring
Grundvandsstrømningsretning
Grundvandspotentiale (DNN)
5,17
0 m
4
8
12
16
20
Sag:
Jægersborg Allé
Emne:
Grundvandspotentiale 6/10 2000
Sagsnummer
364-00184
Målforhold
Kotesystem
Dato
27.09.2002
Sagsansvarlig
CMO
Projekteret
CMO
Tegner
CMO
Kontrol
Godkendt
Bilag nr.
Rev.
Miljø og Energi as
Forurenet Jord
og Grundvand
Ringstedvej 20
4000 Roskilde
Telefon 46 30 03 10
Telefax 46 30 03 11
HEDESELSKABET

Sag:

Jægersborg Allé

Emne: Grundvandspotentiale 24/4 2001

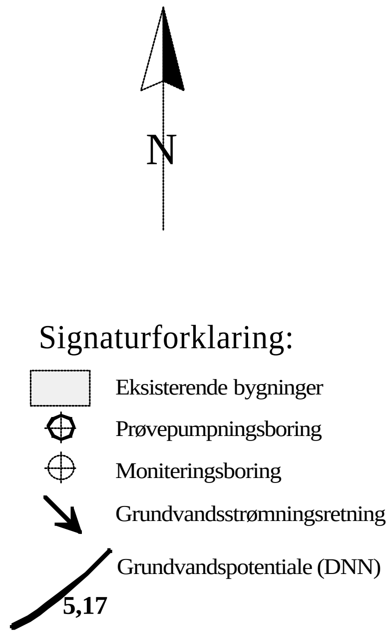
Sagsnummer		
364-00184		
Målforhold	Kotesystem	

Dato	Sagsansvarlig	Projekteret	Tegner	Kontrol	Godkendt	Bilag nr.	Rev.
27.09.2002	CMO	CMO	CMO				

Miljø og Energi as
Forurenet Jord
og Grundvand
Ringstedvej 20
4000 Roskilde

Telefon 46 30 03 10
Telefax 46 30 03 11
me-ros@hedeselskabet.dk

HEDESELSKABET



Sag: Jægersborg Allé							
Emne: Grundvandspotentiale 10/10 2001						Sagsnummer 364-00184	
						Målforhold	Kotesystem
Dato 27.09.2002	Sagsansvarlig CMO	Projekteret CMO	Tegner CMO	Kontrol	Godkendt	Bilag nr.	Rev.

Miljø og Energi as
Forurenet Jord
og Grundvand
Ringstedvej 20
4000 Roskilde

Telefon 46 30 03 10
Telefax 46 30 03 11

HEDESELSKABET

Produktblad på HRC^{TM} og HRC Primer

MATERIAL SAFETY DATA SHEET

Last Revised: July 1, 2000

****
Section 1 - Material Identification
****

Supplier:	Applied Power Concepts, Inc. 411 East Julianna St. Anaheim, CA 92801
Telephone:	(714) 502-1150
Facsimile:	(714) 502-2450
Chemical Name:	Propanoic acid, 2-[2-[2-(2-hydroxy-1-oxopropoxy)-1-oxopropoxy] -1-oxopropoxy]-1,2,3-propanetriyl ester
Chemical Family:	Organic Chemical
Trade Name:	Glycerol tripolylactate

Product Name: Hydrogen Release Compound® (HRC®)

****
Section 2 - Hazardous Ingredients
****

CAS #: 201167-72-8

One should anticipate the potential for eye irritation and skin irritation with large scale exposure or in sensitive individuals.

****
Section 3 - Physical Data
****

Melting Point:	NA
Boiling Point:	ND
Flash Point:	ND
Density:	1.347
Solubility:	Acetone and DMSO
Appearance:	Pale white semi-solid
Odor:	Not detectable
Vapor Pressure:	None

****

Section 4 - Fire and Explosion Hazard Data

****

Extinguishing Media: Carbon Dioxide, Dry Chemical Powder or Appropriate Foam.

Water may be used to keep exposed containers cool.

For large quantities involved in a fire, one should wear full protective clothing and a NIOSH approved self contained breathing apparatus with full face piece operated in the pressure demand or positive pressure mode as for a situation where lack of oxygen and excess heat are present.

****

Section 5 - Toxicological Information

****

Acute Effects: May be harmful by inhalation, ingestion, or skin absorption.
May cause irritation. To the best of our knowledge, the chemical, physical, and toxicological properties of the glycerol tripolylactate have not been investigated. Listed below are the toxicological information for glycerol and lactic acid.

RTECS#: MA8050000
Glycerol

Irritation data:	SKN-RBT 500 MG/24H MLD	85JCAE-,207,1986
	EYE-RBT 126 MG MLD	BIOFX* 9-4/1970
	EYE-RBT 500 MG/24H MLD	85JCAE-,207,1986
Toxicity data:	ORL-MUS LD50:4090 MG/KG	FRZKAP (6),56,1977
	SCU-RBT LD50:100 MG/KG	NIIRDN 6,215,1982
	ORL-RAT LD50:12600 MG/KG	FEPRA7 4,142,1945
	IHL-RAT LC50: >570 MG/M3/1H	BIOFX* 9-4/1970
	IPR-RAT LD50: 4420 MG/KG	RCOCB8 56,125,1987
	IVN-RAT LD50:5566 MG/KG	ARZNAD 26,1581,1976
	IPR-MUS LD50: 8700 MG/KG	ARZNAD 26,1579,1978
	SCU-MUS LD50:91 MG/KG	NIIRDN 6,215,1982
	IVN-MUS LD50: 4250 MG/KG	JAPMA8 39,583,1950
	ORL-RBT LD50: 27 GM/KG	DMDJAP 31,276,1959
	SKN-RBT LD50:>10GM/KG	BIOFX* 9-4/1970
	IVN-RBT LD50: 53 GM/KG	NIIRDN 6,215,1982
	ORL-GPG LD50: 7750 MG/KG	JIHTAB 23,259,1941

Target Organ data: Behavioral (headache), gastrointestinal (nausea or vomiting), Paternal effects (spermatogenesis, testes, epididymis, sperm duct), effects of fertility (male fertility index, post-implantation mortality).

RTECS#: OD2800000
Lactic acid

Irritation data:	SKN-RBT 5MG/24H SEV	85JCAE -,656,86
	EYE-RBT 750 UG SEV	AJOPAA 29,1363,46
Toxicity data:	ORL-RAT LD50:3543 MG/KG	FMCHA2-,C252,91
	SKN-RBT LD50:>2 GM/KG	FMCHA2-,C252,91
	ORL-MUS LD50: 4875 MG/KG	FAONAU 40,144,67
	ORL-GPG LD50: 1810 MG/KG	JIHTAB 23,259,41
	ORL-QAL LD50: >2250 MG/KG	FMCHA2-,C252,91

Only selected registry of toxic effects of chemical substances (RTECS) data is presented here. See actual entry in RTECS for complete information on lactic acid and glycerol.

****
Section 6 - Health Hazard Data
****

Handling: Avoid continued contact with skin.
Avoid contact with eyes.

In any case of any exposure which elicits a response, a physician should be consulted immediately.

First Aid Procedures:

Inhalation: Remove to fresh air. If not breathing give artificial respiration. In case of labored breathing give oxygen. Call a physician.

Ingestion: No effects expected. Do not give anything to an unconscious person. Call a physician immediately.

Skin Contact: Flush with plenty of water. Contaminated clothing may be washed or dry cleaned normally.

Eye contact: Wash eyes with plenty of water for at least 15 minutes lifting both upper and lower lids. Call a physician.

****
Section 7 - Reactivity Data
****

Conditions to Avoid: Strong oxidizing agents, bases and acids
Hazardous Polymerization: None known
Further Information: Hydrolyses in water to form Lactic Acid and Glycerol.

****
Section 8 - Spill, Leak or Accident Procedures
****

After Spillage or Leakage: Neutralization is not required. This combustible material may be burned in a chemical incinerator equipped with an afterburner and scrubber.

Disposal: Laws and regulations for disposal vary widely by locality. Observe all applicable regulations and laws. This material, may be disposed of in solid waste. Material is readily degradable and hydrolyses in several hours.

No requirement for a reportable quantity (CERCLA) of a spill is known.

****
Section 9 - Special Protection or Handling
****

Should be stored in plastic lined steel, plastic, glass, aluminum, stainless steel, or reinforced fiberglass containers.

Protective Gloves:	Vinyl or Rubber
Eyes:	Splash Goggles or Full Face Shield Area should have approved means of washing eyes.
Ventilation:	General exhaust.
Storage:	Store in cool, dry, ventilated area. Protect from imcompatible materials.

****
Section 10 - Other Information
****
This material will degrade in the environment by hydrolysis to lactic acid and glycerol. Materials containing reactive chemicals should be used only by personnel with appropriate chemical training.

The information contained in this document is the best available to the supplier as of the time of writing. Some possible hazards have been determined by analogy to similar classes of material. No separate tests have been performed on the toxicity of this material. The items in this document are subject to change and clarification as more information becomes available.

Applied Power Concepts, Inc.
411 E. Julianna Street
Anaheim, CA 92801

TEL (714) 502-1150
FAX (714) 502-2450

November 21, 2000

Certificate of Analysis
HRC Primer

Glycerol Polylactate	50.0%
Lactic Acid	40.0%
Glycerin	10.0%
Viscosity	1,020 Cp
Density	1.02 g/ml
Solubility	Water Soluble

Note: Lactic acid and glycerin are used as viscosity control agents.

Regenesis´ forslag til substratmængder

9 Bard Avenue
Red Hook, NY 12571
Phone: 914.758.9243
Fax: 914.758.9253
Corporate: 949.366.8000
Homepage: http//www.regenesis.com
e-mail: dave@regenesis.com

9 October 2000

Christian Mossing H157d
Hedeselskabet
Denmark
Via G. Moller; baltecdk@post2.tele.dk

Subject: Field Pilot Test for Use of Hydrogen Release Compound (HRC) at the Copenhagen County site (Jægesborg Allé 24 and Trunnevangen 2).

Dear Mr. Mossing:

We have evaluated the latest information that you provided for the Copenhagen County HRC pilot site. The following sections describe the use of HRC for CH treatment and design information for the proposed HRC field pilot implementation. Additional sections at the end of this proposal discuss performance and delivery issues and recommended monitoring for an HRC program.

Effect of Competing Electron Acceptors on HRC Requirements

- The concentrations of competing electron acceptors (CEAs) such as dissolved oxygen, nitrate, ferric iron, and sulfate, have an effect on the amount of HRC required for the enhancement of in situ bioremediation. In particular, sulfate levels have a significant impact on HRC dosing requirements.
- Based on the available data we have assumed the following CEA concentrations: oxygen <1ppm, nitrate <50 ppm, manganese reduction potential <0.5 ppm, ferric iron reduction potential(soil and water)<4 ppm, and sulfate reduction demand <50 ppm. Higher CEA electron donor demand may require increased amounts of HRC to achieve remedial goals. However, the use of HRC Primer will be used to quickly improve these aquifer conditions.

Field Testing Program

Due to the high concentration of some competing electron acceptors we are recommending the use of HRC Primer in an additional upgradient injection line from the primary HRC treatment injection line. The distance from the installed array of monitoring wells (O1, O2, & O3) and the HRC Primer line should be 3 meters; we have seen upgradeint diffusion of the HRC affects into the wells at closer distances. After the HRC Primer injection line there should be 2 meters to the HRC injection line. The injection points between the two injection rows should form a swatooth pattern.

For the pilot test we have assumed the higher velocity of the lower zone of 118m/year. The same HRC/HRC Primer injection rates will be used through the entire treatment thickness. This seems the best approach due to the competing electron acceptor presence. Design parameters for the HRC field test are described below:

E:\share\hrc\proposals\Baltec..\ Baltec-Copenhagen Cty H157dOct00

NOTE: Regenesis foreslår anvendelse af 1.034 kg HRC Primer og 830 kg HRC. Af nedenstående fremgår det imidlertid, at der er byttet om på mængderne, således at der skal injiceres HRC i 5 punkter, svarende til de 1.034 kg og at der skal injiceres primer i 4 punkter svarende til 830 kg.

Jaegersborge Alle Field Test Design Feature	Specification
Contaminated saturated thickness	11.5 m (38ft), 5.5m-17m depth
Number of HRC Primer delivery points Number of HRC delivery pts.	4 points, 2 m spacing, 1 row 5 points, 2 m spacing, 1 rows
HRC Primer application rate HRC application rate	18 kg/ vertical meter or 12 lbs/ft 18 kg/m or 12 lbs/ft
HRC Primer material requirement (30lbs/bucket) **HRC** material requirement (30 lbs/bucket)	5 pts x 38 ft x 12 lbs = **2,280 pounds(1034 kg)** 4 pts x 38 ft x 12 lbs=1824 or **1830 pounds (830 kg)**

HRC Delivery to Contaminated Zone

Typically, HRC and HRC Primer are applied using direct push hydraulic equipment. Drive rods are pushed to the bottom of the contaminated saturated zone and then HRC is injected as the rods are withdrawn. The minimum recommended rod size is a 0.625-inch (16mm) inner diameter. For sites where direct push is not feasible, auger-based equipment can be used to deliver HRC. Also, the use of permanent, small diameter re-injection wells may be a more cost-effective approach for sites requiring repeated applications of HRC. Technical support personnel at Regenesis are available to discuss the suitability of alternate HRC delivery methods.

Costs for HRC injection should be obtained from local subcontractors. If necessary, Regenesis can assist in locating qualified HRC injection subcontractors. Budgetary cost estimates for direct push-based injection range from $1,000 to $2,000US per day. Typically, one to two HRC injection points can be completed per hour and up to 20 points can be completed per day, depending on soil type, depths of injection, and subcontractor experience.

HRC should be injected using an appropriate pump capable of processing a material with a viscosity of 20,000 centipoise at flow rates of 11 to 38 liters (3 to 10 gallons) per minute at pressures ranging from 14 bar to 102 bar (200 psig to 1,500 psig). Failure to use appropriate equipment could increase field time and result in improper application of the HRC. Regenesis can provide a suitable pump for a cost of $150US per day plus shipping.

Recommended Groundwater Monitoring Program for Pilot/Full Scale Treatment

Monitoring of selected wells should be conducted to validate the HRC-based enhancement of reductive dechlorination processes. Also, an initial or “baseline” round of sampling should be performed to identify pre-HRC installation groundwater conditions. After delivery of the HRC to the subsurface, samples can be collected on a monthly or bi-monthly frequency. After the initial biodegradation and geochemical trends have been identified, the monitoring frequency can be decreased to a quarterly, semiannual, or annual program.

E:\share\hrc\proposals\Baltec..\ Baltec-Copenhagen Cty H157dOct00

The monitoring program should employ low flow groundwater sampling techniques and include the measurement of the following field/chemical parameters:

- all relevant contaminants
- field parameters: dissolved oxygen, ORP, pH, temperature, and ferrous iron (optional field measurement)
- natural attenuation/inorganic parameters: total and dissolved iron, total and dissolved manganese, nitrate, sulfate, sulfide, and chloride (design phase)
- HRC-based electron donor: total organic carbon and metabolic acids (lactic, pyruvic, acetic, propionic, and butyric)
- End-product dissolved gases: carbon dioxide, methane, ethane and ethene

A specially qualified laboratory should do the analytical testing for the metabolic acids, otherwise most laboratories can provide testing for the remaining parameters. A typical cost for the above testing program is approximately $300US per sample.

We appreciate the opportunity to provide this information for your project. Please feel free to call if you have any questions or need more information. I can be reached at 914.758.9243 EST. You can also contact Pen Herring at 949.366.8000 PST. Our email addresses are pen@regenesis.com and dave@regenesis.com.

Sincerely,
David S. Peterson
Applications Engineering Manager

cc: Pen Herring, Regenesis

E:\share\hrc\proposals\Baltec..\ Baltec-Copenhagen Cty H157dOct00

Beregning af substratmængder

Beregning af substratmængde

Reaktionsligninger

Mælkesyre (hydrogen laktat) har bruttoformlen $CH_3CHOHCOOH$ ($C_3H_6O_3$). I denne forbindelse har carbon oxidationstrinnet 0. Mælkesyre har molvægten 90.

Mælkesyre kan reagere med følgende oxidanter O_2, NO_3^-, Fe^{+++}, SO_4^{--}, og ved forgæring med vand (metanogenese).

Reaktionsligningerne for reaktionerne er:

Med fri ilt:

$C_3H_6O_3 + 3\ O_2 \Rightarrow 3\ CO_2 + 6\ H_2O$, her bruges 90 g laktat til 96 g ilt eller 0,93 g laktat/g ilt

Med nitrat:

$5\ C_3H_6O_3 + 12\ NO_3^- + 12\ H^+ \Rightarrow 15\ CO_2 + 6\ N_2 + 21\ H_2O$, her bruges 450 g laktat til 744 g nitrat eller 0,61 g laktat/g nitrat

Med jern:

$C_3H_6O_3 + 12\ Fe^{+++} + 3\ H_2O \Rightarrow 3\ CO_2 + 12\ Fe^{++} + 12\ H^+$, her bruges 90 g laktat til 670 g Fe, eller 0,13 g laktat/g jern

Med sulfat:

$4\ C_3H_6O_3 + 6\ SO_4^{--} \Rightarrow 12\ CO_2 + 6\ S^{--} + 12\ H_2O$, her bruges 360 g laktat til 576 g sulfat, eller 0,63 g laktat/g sulfat

Ved forgæring:

$2\ C_3H_6O_3 \Rightarrow 3\ CO_2 + 3\ CH_4$, her bruges 180 g laktat til 48 g metan, eller 3,75 g laktat/g metan.

Flux beregninger

I det følgende vurderes om de anbefalede mængder HRC og primer er tilstrækkelige til at ”fjerne” det årlige flux af konkurrerende elektronacceptorer, således at betingelserne for reduktiv deklorering er tilstede.

Følgende forudsætninger gælder for beregningerne:

Grundvandsstrømningshastigheden er 190 m/år, porøsiteten er 0,25, baggrundsniveauet for ilt er 1 mg/l, nitrat 75 mg/l, jern (III) 0,5g/kg (udfældet jern) og sulfat 200 mg/l. Baggrundsniveauet for ilt, nitrat og sulfat er baseret på de kemiske analyser der er udført i forbindelse med forundersøgelsen /2/, mens indholdet af sedimentbundet jern(III) er baseret på analyserne af sedimentets oxidationskapacitet.

Regensis har vurderet, at HRC og primer har en levetid på ca. 1 år. Mængden af HRC og primer skal derfor sammenlignes med det årlige flux af konkurrerende elektronacceptorer gennem tværsnittet for injektionen af HRC og Primeren.

Opløste forbindelser

Baggrundsniveauerne i grundvandet er vurderet til at være følgende:

Opl. Ilt:	= 1 mg/l
Nitrat:	= 75 mg/l
Sulfat	= 200 mg/l

Der er desuden anvendt en grundvandsstrømningshastighed på 190 m/år og en porøsitet på 0,25. Bredden af behandlingszonen er 10 meter og dybden af behandlingszonen (akviferen) er 11 meter. Det totale årlige vandflux gennem tværsnittet er således 190 m x 10 m x 11 m x 0,25 = 5.225 m^3.

Fluxen af konkurrerende elektronacceptorer er derfor følgende:

Opl. Ilt (5.225 m^3 x 1 g/m^3)	= 5.225 g (5,2 kg)
Nitrat (5.225 m^3 x 75 g/m^3)	= 391.875 g (391 kg)
Sulfat (5.225 m^3 x 200 g/m^3)	= 1.045.000 g (1.045 kg)

Ved at gange fluxen med reaktionsforholdet med laktat fås et estimat af den samlede mængde laktat, der skal tilsættes for at fjerne disse elektronacceptorer:

Opl. Ilt (5,2 kg x 0,93)	= 4,8 kg laktat
Nitrat (391 kg x 0,61)	= 239 kg laktat
Sulfat (1.045 kg x 0,63)	= 658 kg laktat

Faste forbindelser

Baggrundsniveauet for sedimentbundet jern(III) er vurderet til at være 0,5 g/kg.

Det berørte sedimentvolumen kan regnes ud på følgende vis: 190 m x 10 m x 11 m = 20.900 m^3.

Med en porøsitet på 0,25 udgør den faste del af sedimentet 15.675 m^3. Vægten af sedimentet er: 15.675 m^3 x 1,8 t/m^3 = 28.215 t.

Ved anvendelse af et indhold af jern(III) på 0,5 g pr. kg sediment fås således et samlet indhold af jern(III) på: 28.215.000 kg x 0,5 g/kg = 14.107 kg.

På samme vis som ved de opløste forbindelser kan laktatbehovet regnes ud fra de støkiometriske reaktionsforhold:

Jern(III) (14.107 kg x 0,13)	= 1.834 kg laktat

Modelsimulering af stofspredning

Forudsætninger for modelsimuleringer

I den oprindelige forundersøgelse er der udført en simuleret udbredelse af en tracer i de oprindeligt planlagte HRC-injektionspunkter. På baggrund af modellen blev det vurderet, at der ville være fuldt gennembrud af stoffet i det midterste lag i grundvandsmagasinet (hvor porevandshastigheden er langsomst) efter 45 dage. Det ville altså tage ca. 45 dage før hele det oprindelige testområde ville være "dækket" af HRC.

De kritiske parametre for at sikre en homogen opblanding af HRC og primer i akviferen er dispersiviteterne. Der er derfor gennemført en følsomhedsanalyse ved indsættelse af forskellige værdier for dispersiviteterne i den opstillede model.

I det følgende gennemgås kort de tre dispersiviteter og deres influens på udbredelsen af HRC og primer.

Horisontal longitudinal (αL): er dispersiviteten, der beskriver opblandingen i grundvandsstrømningsretningen. Stofspredningen i denne retning som funktion af dispersionen overskygges langt af usikkerhederne i grundvandsstrømningshastigheden, hvorfor bestemmelse af denne dispersivitet er af mindre betydning.

Horisontal transversal (αT): er dispersiviteten, der beskriver opblandingen horisontalt på tværs af grundvandsstrømningsretningen. Denne dispersivitet er meget afgørende for om der sker en homogen opblanding af HRC og primer nedstrøms de 9 injektionspunkter eller om der kommer 9 smalle faner.

Vertikal transversal (αV): er dispersiviteten, der beskriver opblandingen henover dybden af akviferen. Denne dispersivitet er mindre væsentlig for spredningen, da HRC og Primeren injiceres over hele akviferdybden, hvorfor man må forvente fuld opblanding over hele den mættede zone.

I begge modelsimuleringerne er der anvendt en effektiv porøsitet på 0,25, en gradient på 0,0015, en K_H på 1,1 * 10-3 m/s og en K_V på 1,1 * 10-4 m/s. Den molekylære diffusion $D_{molekylær}$ er sat til 0 og cellestørrelsen er sat til 0,2 m.

Den horisontale longitudinale dispersivitet αL ligger ca. mellem 0,5 og 5 m, med en forsøgsskala omkring 30 meter (Bjerg et al., 1996)

Plot over udbredelsen 25 dage efter injektion af HRC er vedlagt som hhv. plot nr. 1 og 2. Bemærk at boringsplaceringen er fra et ældre setup. Boring M2, M4 og M5 bibeholdes som boring M1, M2 og M3 i det nye setup.

I plot nr. 1 er følgende dispersiviteter anvendt:

αL : 0,005 m

αT : 0,0005 m

αV : 0,00005 m

I dette tilfælde er αT –værdien 1/20 af den anbefalede værdi på 0,01 (Miljøstyrelsen, 1998). Som følge af dette ses tydeligt den dårlige opblanding af HRC´en og de 9 enkelte faner. Denne αT –værdi vurderes dog at være urealistisk lav.

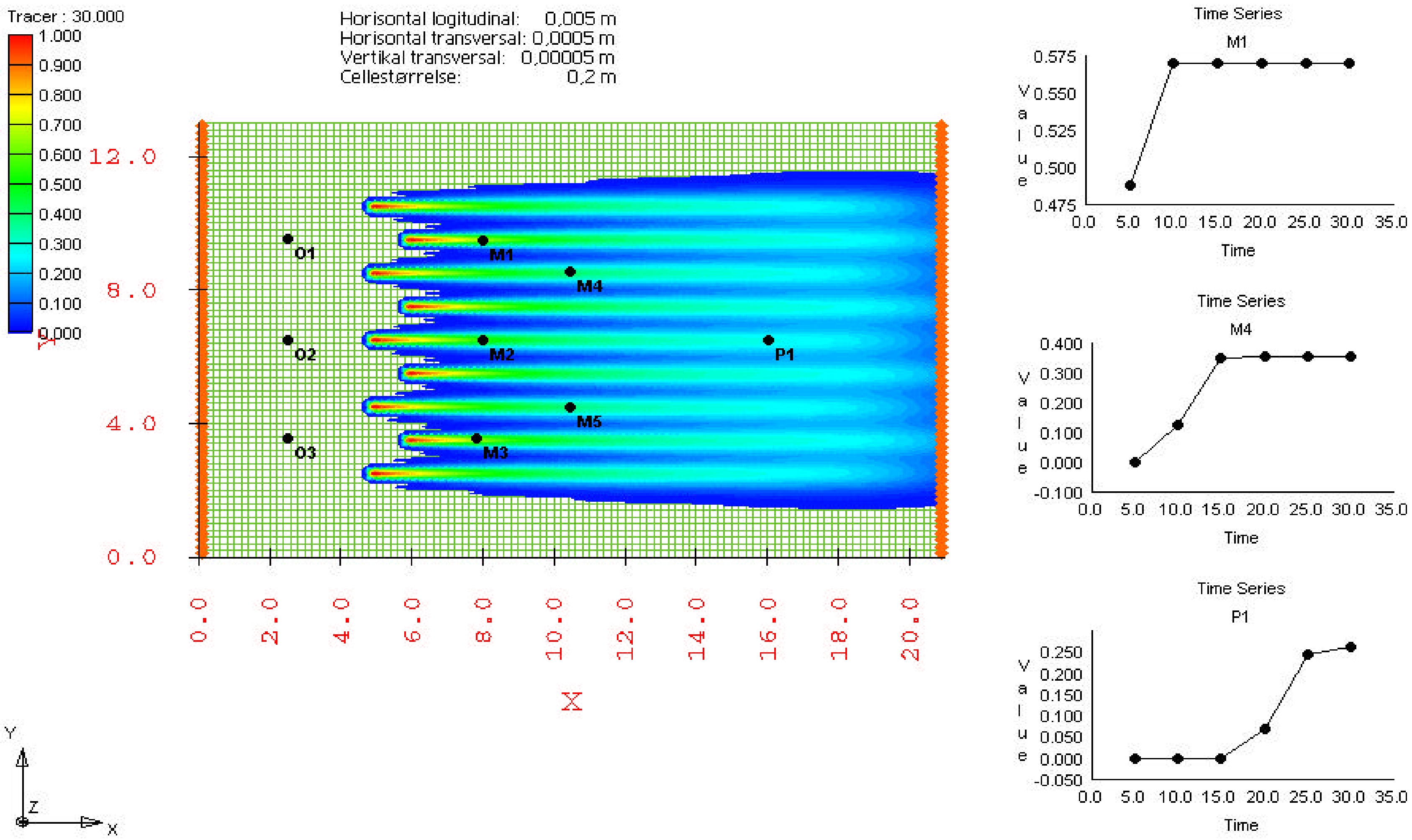
I plot nr. 2 er følgende dispersiviteter anvendt:

αL : 0,02 m

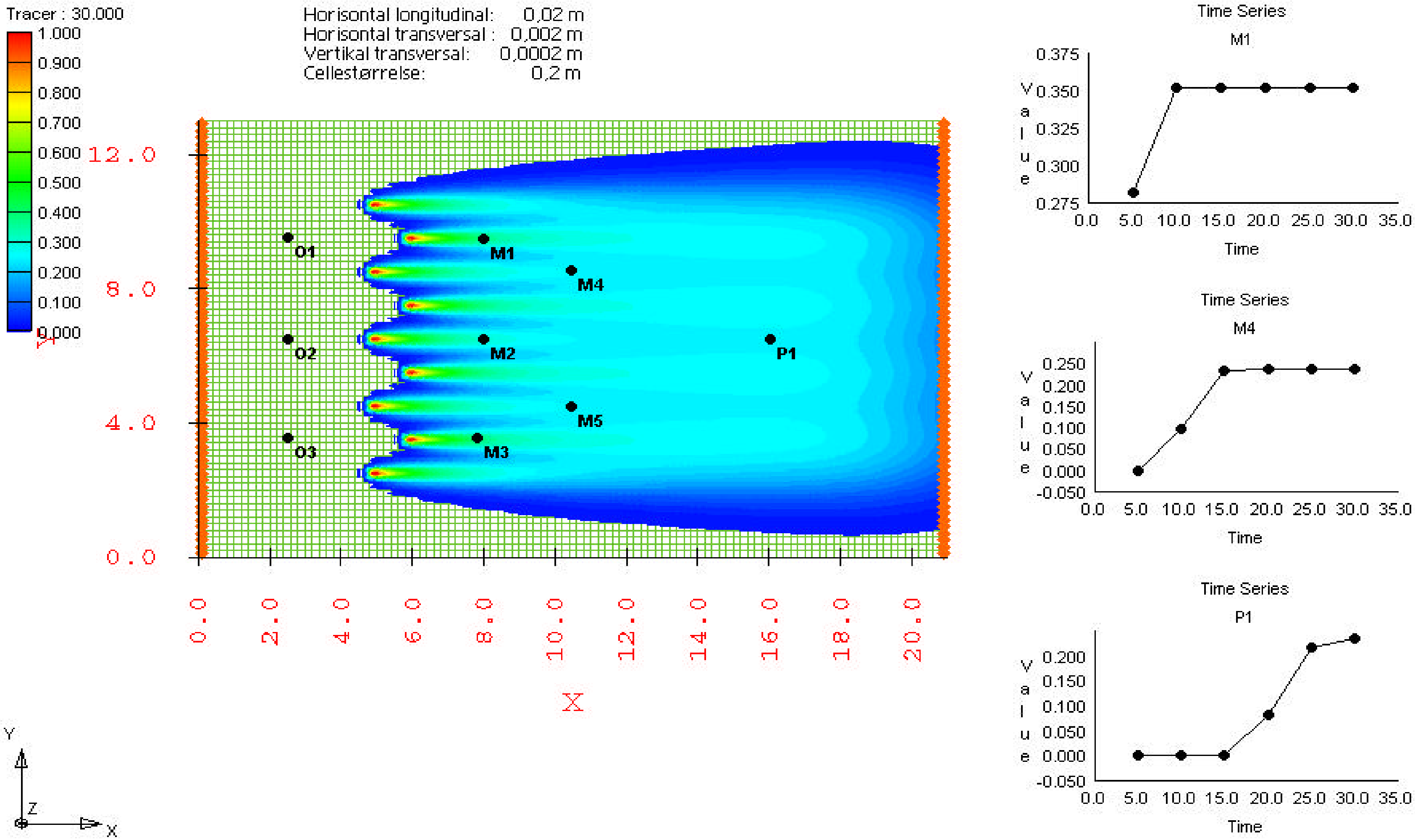
αT : 0,002 m

αV : 0,0002 m

I dette tilfælde er αT –værdien 1/5 af den anbefalede værdi på 0,01 (Miljøstyrelsen, 1998). Denne αT –værdi vurderes at være realistisk (og et konservativt estimat). Som det ses af plottet, sker der en forholdsvis hurtig og homogen opblanding af HRC og Primer horisontalt, på tværs af grundvandsstrømningsretningen.



Tracer : 30.000
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Horisontal logitudinal: 0,005 m
Horisontal transversal: 0,0005 m
Vertikal transversal: 0,00005 m
Cellestørrelse: 0,2 m
12.0
8.0
4.0
0.0
Y
O1
O2
O3
M1
M2
M3
M4
M5
P1
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
X
Y
Z
X
Time Series
M1
Value
0.575
0.550
0.525
0.500
0.475
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0
Time
Time Series
M4
Value
0.400
0.300
0.200
0.100
0.000
-0.100
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0
Time
Time Series
P1
Value
0.250
0.200
0.150
0.100
0.050
0.000
-0.050
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0
Time


Tracer : 30.000
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Horisontal longitudinal: 0,02 m
Horisontal transversal : 0,002 m
Vertikal transversal: 0,0002 m
Cellestørrelse: 0,2 m
12.0
8.0
4.0
0.0
O1
O2
O3
M1
M2
M3
M4
M5
P1
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
X
Y
Z
X
Time Series
M1
Value
0.375
0.350
0.325
0.300
0.275
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0
Time
Time Series
M4
Value
0.250
0.200
0.150
0.100
0.050
0.000
-0.050
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0
Time
Time Series
P1
Value
0.200
0.150
0.100
0.050
0.000
-0.050
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0
Time

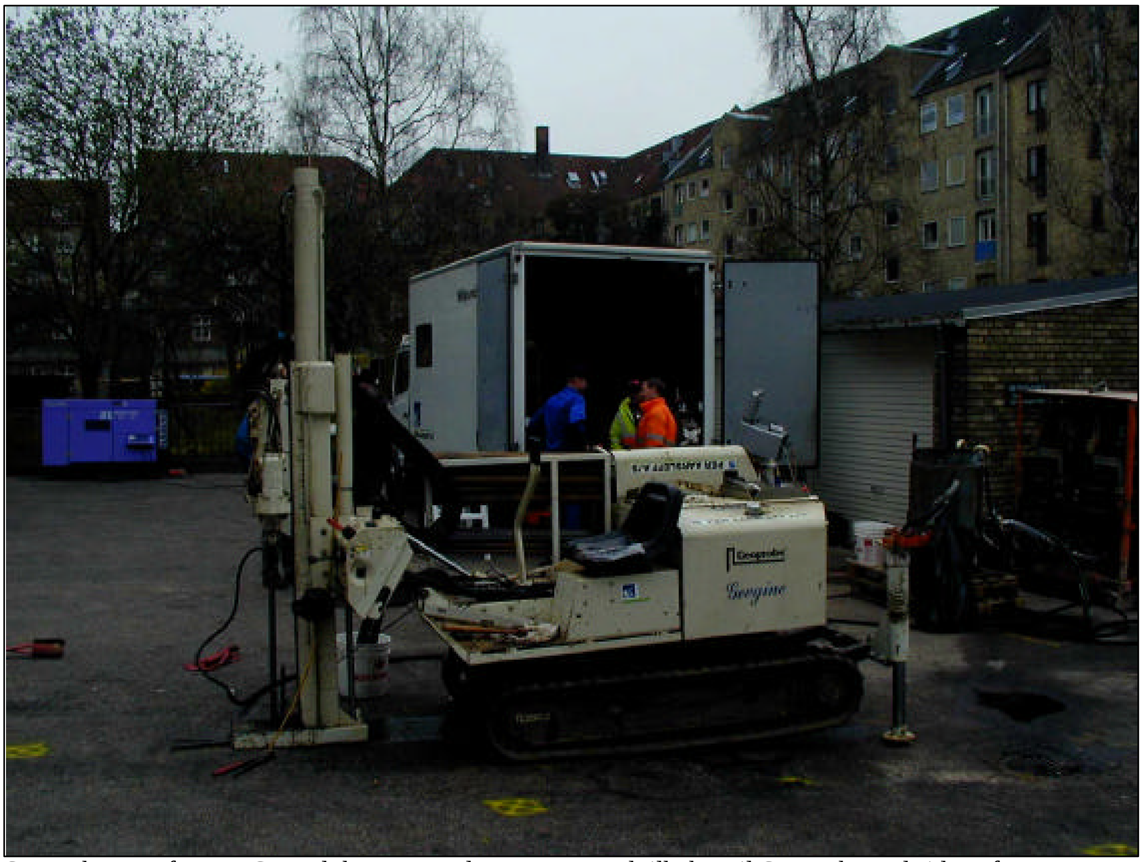
Bilag H

Fotos fra injektionen

Billeder af injektionen

Omhældning af HRC/primer til beholder. Til højre ses stempelpumpen med de 2 kredsløb. Til venstre ses kontrolenhed.


Beholder med primer.



Geoproben ses forrest. Centralt bagerst ses lastvognen med tilbehør til Geoprobe ved siden af generatoren

I forbindelse med injektionen holdes borestænger i spande for at undgå spild .

Beskrivelse af injektionsmetode samt erfaringer fra injektionen

1. Indledning

I forbindelse med forurening af chlorerede opløsningsmidler på Jægersborg Allé 24, Gentofte har Københavns Amt og Miljøstyrelsen igangsat et pilotprojekt for afværge.

Pilotprojektet for afværge er at tilsætte HRC til grundvandet ved hjælp af Geoprobe.

Ejlskov Consult har udført injektionen af HRC ved hjælp af Geoprobe, i samarbejde med entreprenørfirmaet Per Aarsleff A/S.

2. Baggrund og injektionsprincip

Koncentrationerne af CEAs (Competing electron acceptors) som for eksempel opløst ilt, Nitrat, Jern(III) og Sulfat har en effekt på den mængde af HRC som er nødvendig for at forøge in situ bioremediationen. Sulfatmængden vil i særdeleshed have en betydelig ind-flydelse på doseringen af HRC.

Baseret på de tilgængelige data er følgende estimater gjort på CEA-koncentrationerne: ilt<1 ppm, Nitrat<50 ppm, Mangan reduktion<0,5 ppm, Jern(III) reduktion<4 ppm og Sulfat reduktion<50 ppm.

På baggrund af de høje CEA-koncentrationer er der tilsat en HRC Primer i en opadrettet gradient injektionslinje fra HRC injektionslinjen.

Distancen fra moniteringsboringerne, benævnt O1, O2 og O3, og injektionslinjen med HRC Primer er 3 meter, da man tidligere har erfaret, at der er sket en opadrettet diffusion af HRC i moniteringsboringerne, hvis distancen er mindre.

Der bør/skal være 2 meter fra injektionslinjen med HRC Primer til selve HRC injektions-linjen. Injektionspunkterne mellem de to injektionsrækker skal danne et zigzag mønster.

3. Bore- og injektionsarbejder

Bore- og injektionsarbejderne er udført i perioden mandag 2001-04-30 til fredag den 2001-05-04.

Injektionspunkterne var afsat af Hedeselskabet inden opstart af borearbejdet.

Borearbejderne er udført af Ejlskov Consult i samarbejde med Per Aarsleff A/S. Rammeboringerne er alle udført med 1,25 ” Geoprobe borestænger. Hvorigennem injektionen er foretaget.

Der blev udført en række med 4 boringer med injektion af Primer. Boringerne er benævnt 1, 2, 3 og 4 og vist på Tegning 1.

Der blev herefter udført en række med 5 boringer med injektion af HRC. Boringerne er benævnt 5, 6, 7, 8A og 9 og vist på Tegning 1.

Ved injektionen af Primer og HRC blev der benyttet en specialpumpe med en trykydelse på op til 100 bar. Som udgangspunkt er der foretaget injektion af Primer/HRC i intervaller á 30-50 cm. Som dokumentation for de forskellige intervaller henvises til injektionsskemaerne i bilag 1.

Under udførsel af borearbejde ved boring 6 knækkede der en borestang. Der blev efterfølgende udført en ny boring ved siden af.

Der er i de 4 Primer-boringer pumpet 692 l Primer ned i grundvandet.

Der er er i de 5 HRC-boringer pumpet 912 l HRC ned i grundvandet.

Der blev også udført en boring 8b. Fra boring 8b blev der udtaget 6 intakte kerneprøver til geologisk beskrivelse. De 6 intakte kerneprøver blev udtaget i følgende dybder: [5,25-5,75], [6,25-6,75], [8,25-8,75], [10,25-10,75], [12,75-13,25] og [15,25-15,75]. Dybderne er angivet i meter under terræn.

4. Konklusion

I dette pilotprojekt er der i 9 punkter nedrammet 1,25 ” Geoprobe borestænger ned i jorden, til ca. mellem 14-18 m u.t. Igennem disse borestænger er der nedpumpet. Der er blevet pumpet 692 l Primer og 912 l HRC ned i grundvandet.

Erfaringer med injektion af HRC/HRC Primer

Injektionen blev udført i perioden mandag den 30. april 2001 til fredag den 4. maj 2001. Det samlede tidsforbrug til injektionen var således 5 dage mod forventede 3 dage. Den ene dag blev dog brugt på at udtage intakte sedimentkerner.

Udstyret til injektionen var specielt hjemtaget til opgaven og styring af pumpen foregik ved en kontrolenhed, hvor dybden, injektionsvolumen, modtryk og tid blev registreret. For hver 30-50 cm blev der gjort ophold under tilbagetrækningen af rørene, og der blev pumpet et gennemsnitligt volumen på 5 liter ned pr. ophold.

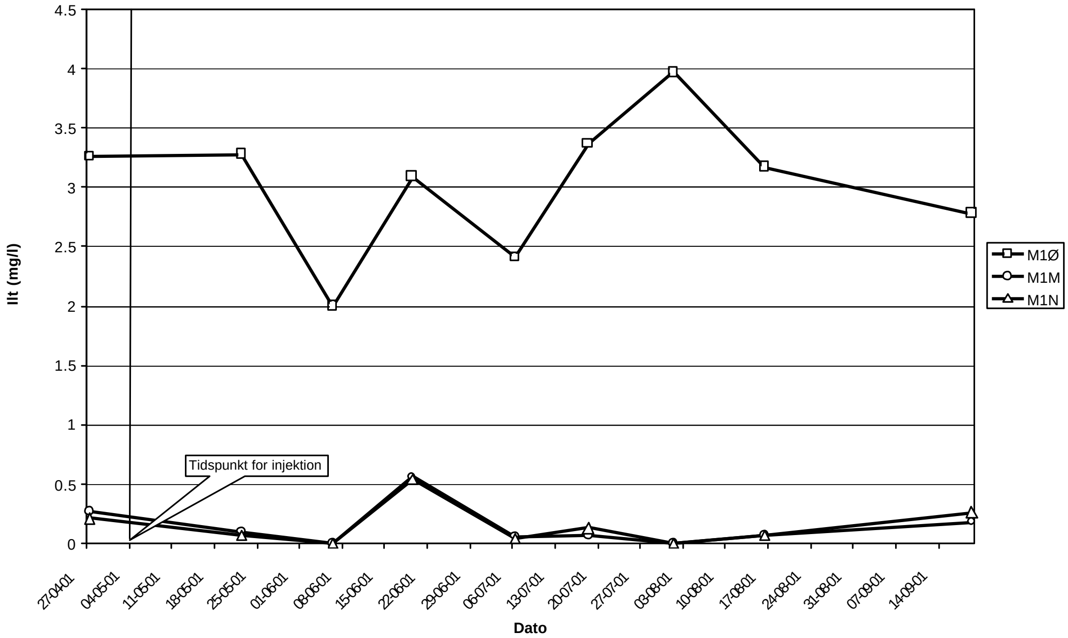
De injicerede volumener varierer dog meget og skyldes vanskeligheder ved at trykke substratet ud i formationen. Dette tilskrives primært variation i permeabiliteten i sedimentet. Opvarmningen af HRC ved friktionen i pumpen hjalp noget, men substratet blev sandsynligvis nedkølet igen i den lange passage gennem slanger og rør.

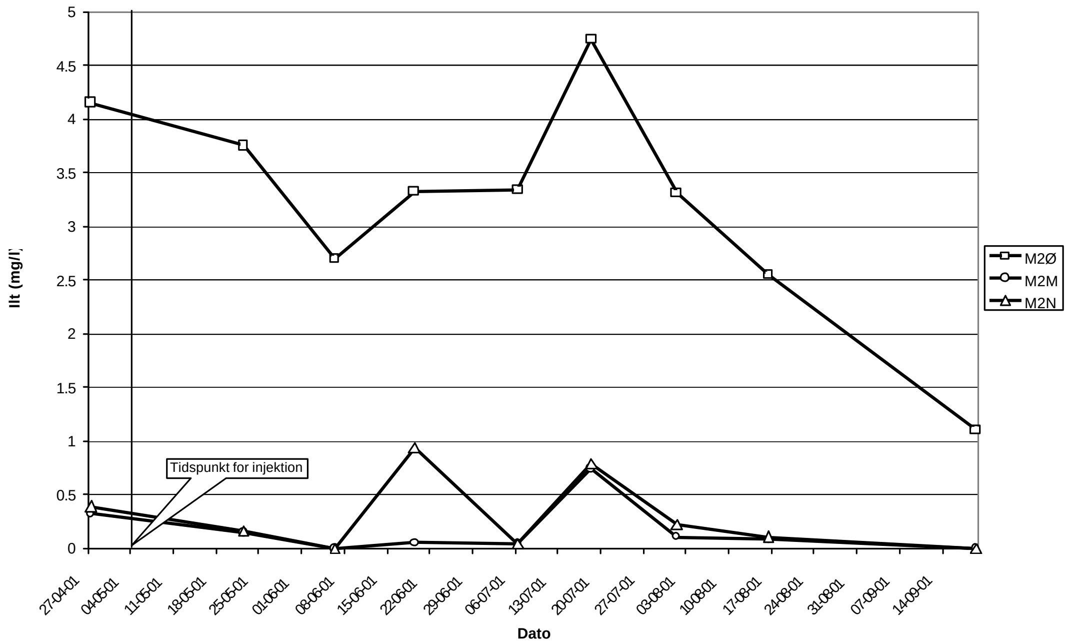
Tilstedeværelsen af HRC i et filter ca. 2-3 meter fra injektionen indikerer, at der er sket en frakturering i sedimentet. En sådan frakturering kan kun ske under kraftigt tryk, hvorfor det resulterende tryk, hvormed HRC er injiceret i sedimentet må have været ganske betydeligt. Det vurderes dog, at injektionen kunne have været nemmere ved brug af en større diameter slanger og rør. Dels ville afkølingen af HRC være mindre, ligesom tryktabet vil reduceres. Enkelte injektioner blev ikke ført helt til bund af grundvandsmagasinet, pga. problemer med sten etc..

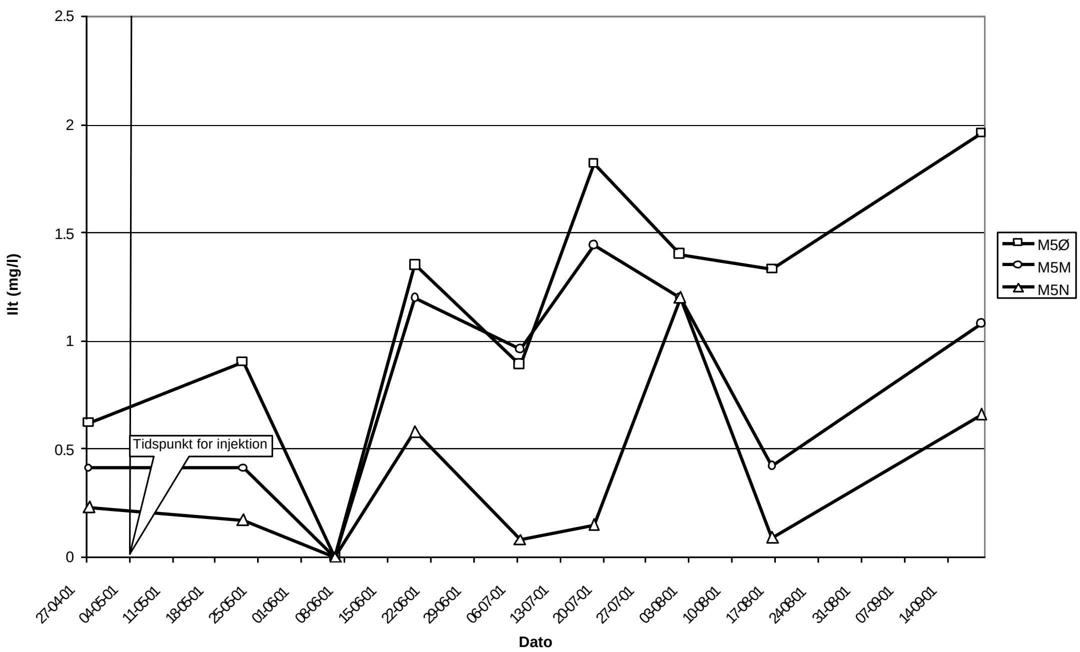
Af afsnittet 4.4 (resultater) fremgår det, at substratet er meget ujævnt fordelt i grundvandsmagasinet. Der er således primært konstateret substrat i de nedre filtre, og der er tillige observeret HRC i en af de opstrøms boringer, hvor "baggrundsniveauerne" skulle overvåges.

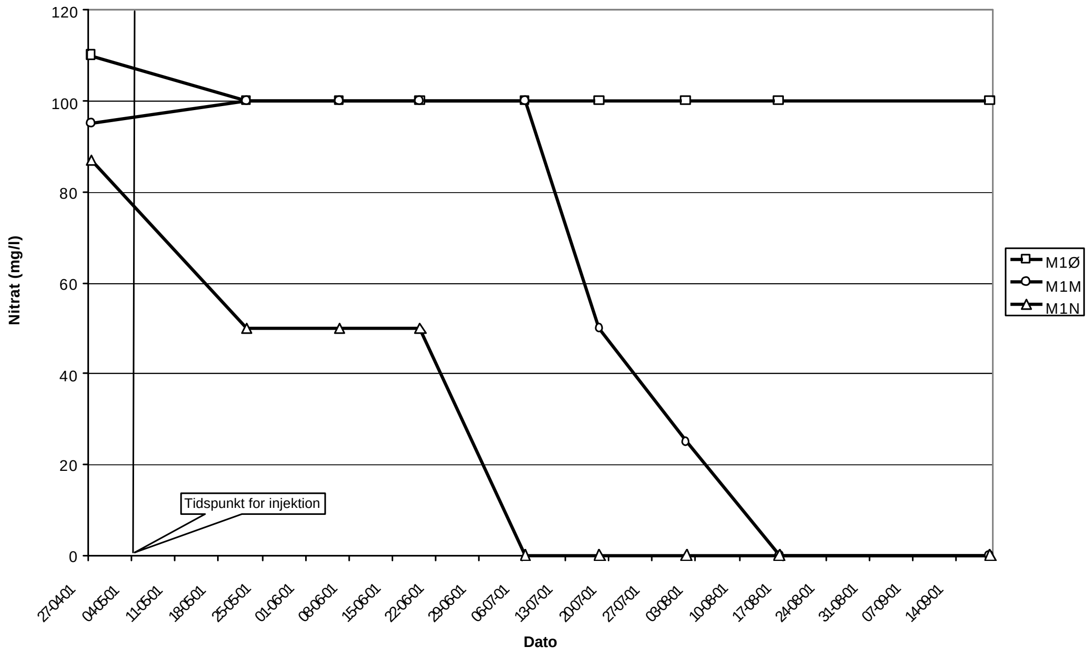
Den ujævne fordeling af substrat skyldes ikke injektion af forskelligt volumen i dybdeintervallet, som det fremgår af loggen over injicerede mængder (bilag I). Derimod vurderes selve metoden med "open tip" at være årsag til den ujævne fordeling. Ved at injicere fra bunden af grundvandsmagasinet til toppen efterlades et åbent hul i sedimentet hvori substratet kan flyde. Strømningen af substrat vil altid følge passager med lavere modstand. Sedimentet i bunden af grundvandsmagasinet er mere grovkornet og dermed må antages at have større permeabilitet. Det injicerede substrat vil derfor følge det efterladte åbne hul i sedimentet og skydes ud langs det grove sediment bunden, i stedet for at trænge ind i det mere lavpermeable sediment i den mellemste og øvre del af grundvandsmagasinet.

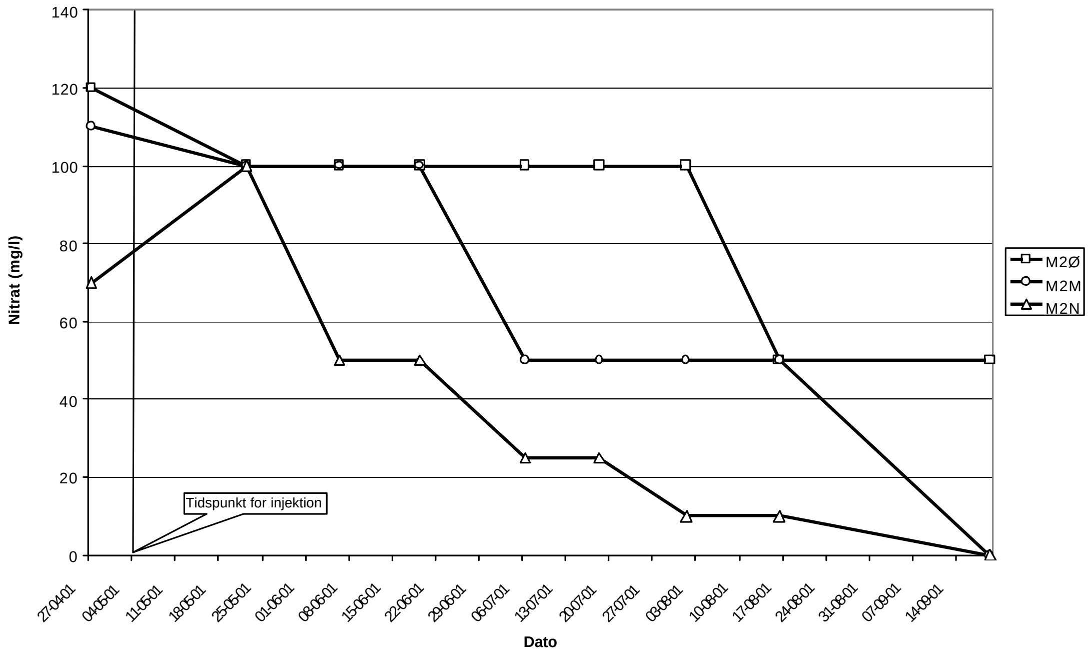
Indledende målinger af ilt og nitrat

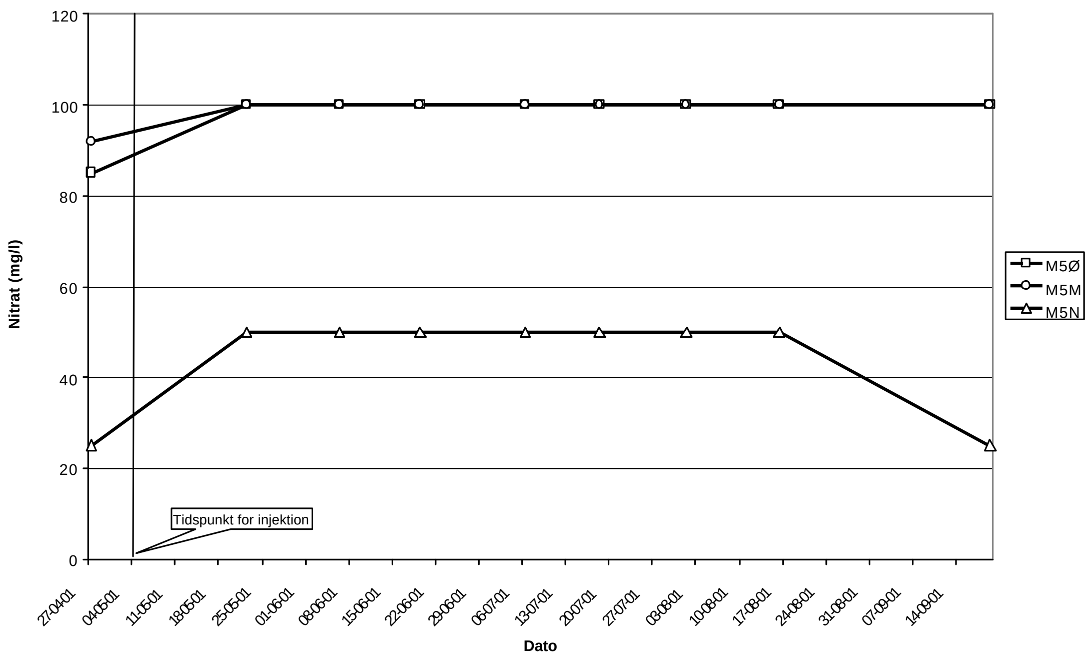

Ilt (mg/l)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Tidspunkt for injektion
M1Ø
M1M
M1N
27-04-01
04-05-01
11-05-01
18-05-01
25-05-01
01-06-01
08-06-01
15-06-01
22-06-01
29-06-01
06-07-01
13-07-01
20-07-01
27-07-01
03-08-01
10-08-01
17-08-01
24-08-01
31-08-01
07-09-01
14-09-01
Dato

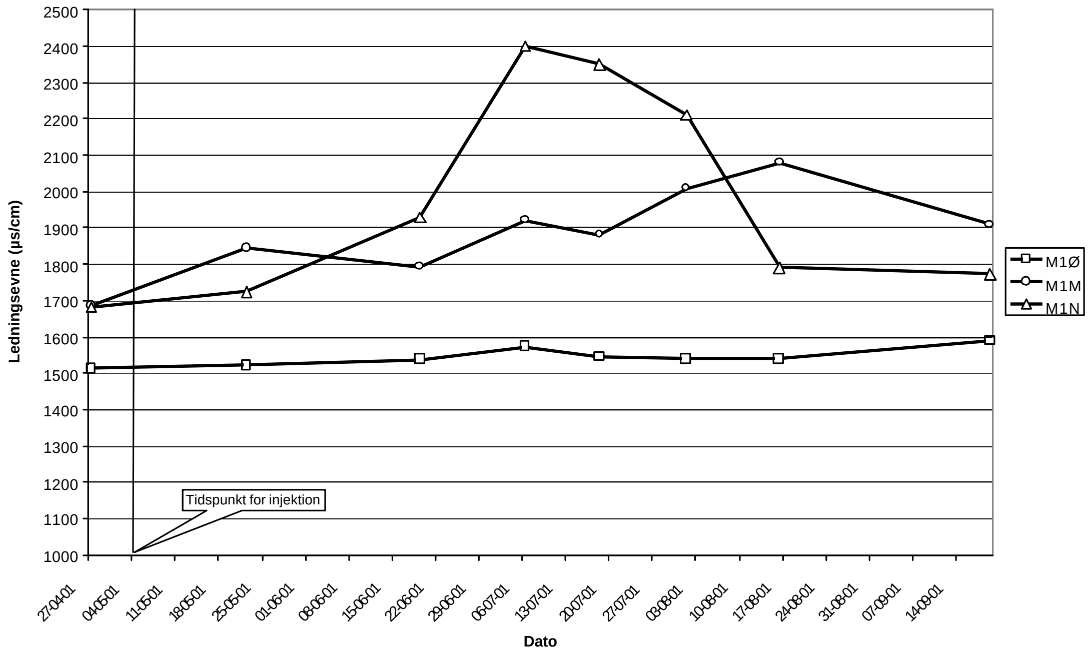

Ilt (mg/l)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Tidspunkt for injektion
M2Ø
M2M
M2N
27-04-01
04-05-01
11-05-01
18-05-01
25-05-01
01-06-01
08-06-01
15-06-01
22-06-01
29-06-01
06-07-01
13-07-01
20-07-01
27-07-01
03-08-01
10-08-01
17-08-01
24-08-01
31-08-01
07-09-01
14-09-01
Dato

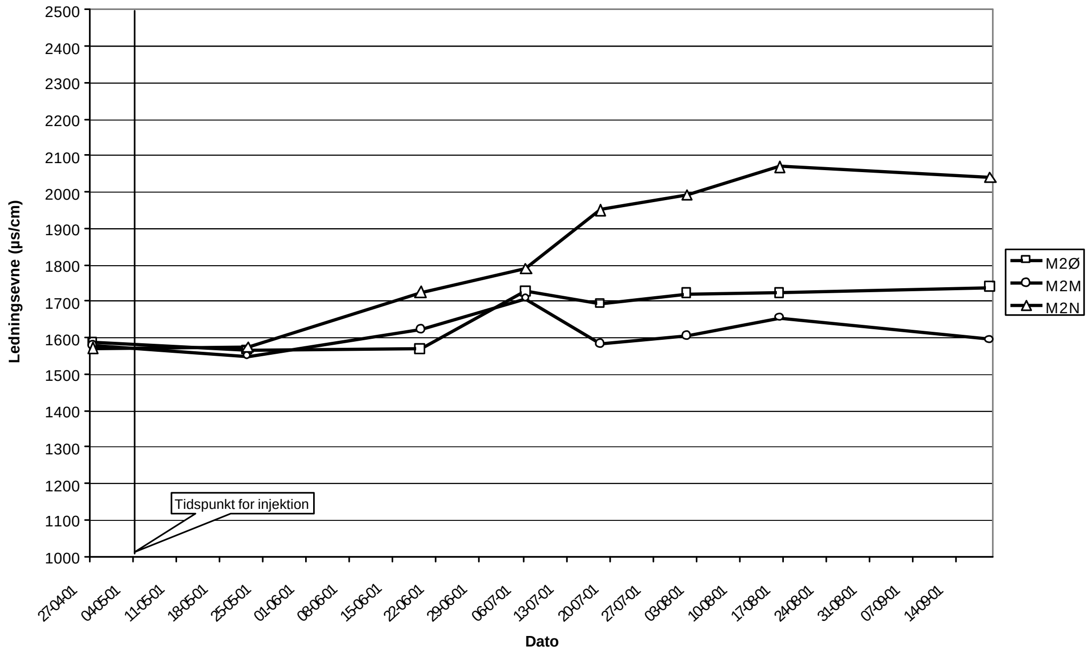

Ilt (mg/l)
0
0.5
1
1.5
2
2.5
Tidspunkt for injektion
M5Ø
M5M
M5N
27-04-01
04-05-01
11-05-01
18-05-01
25-05-01
01-06-01
08-06-01
15-06-01
22-06-01
29-06-01
06-07-01
13-07-01
20-07-01
27-07-01
03-08-01
10-08-01
17-08-01
24-08-01
31-08-01
07-09-01
14-09-01
Dato

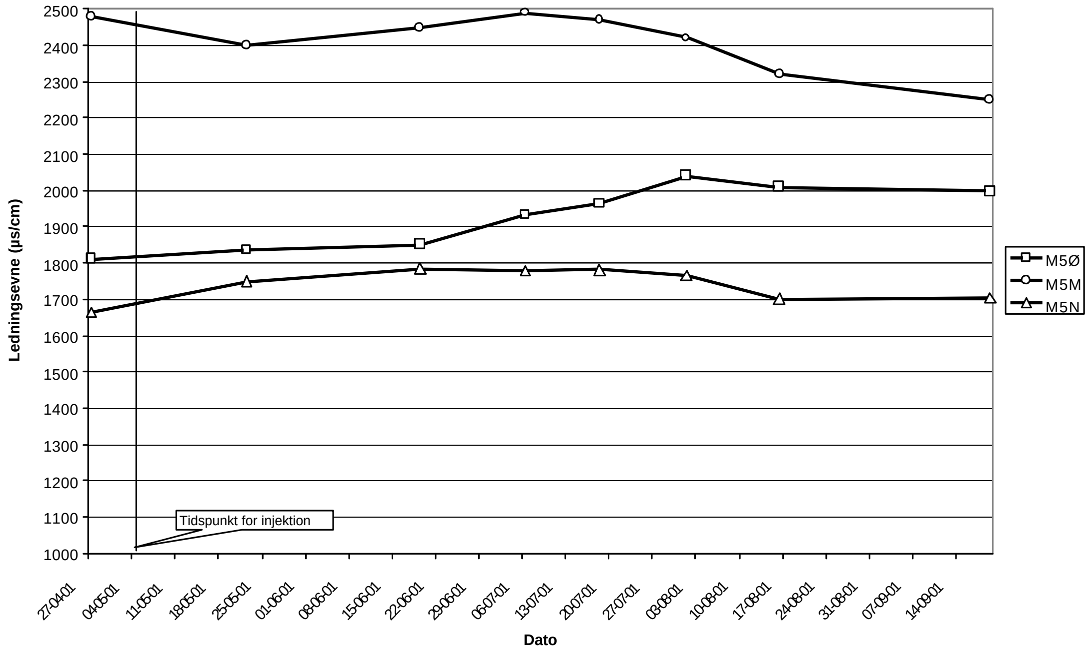

Nitrat (mg/l)
120
100
80
60
40
20
0
Tidspunkt for injektion
27-04-01
04-05-01
11-05-01
18-05-01
25-05-01
01-06-01
08-06-01
15-06-01
22-06-01
29-06-01
06-07-01
13-07-01
20-07-01
27-07-01
03-08-01
10-08-01
17-08-01
24-08-01
31-08-01
07-09-01
14-09-01
Dato
M1Ø
M1M
M1N


Nitrat (mg/l)
140
120
100
80
60
40
20
0
Tidspunkt for injektion
27-04-01
04-05-01
11-05-01
18-05-01
25-05-01
01-06-01
08-06-01
15-06-01
22-06-01
29-06-01
06-07-01
13-07-01
20-07-01
27-07-01
03-08-01
10-08-01
17-08-01
24-08-01
31-08-01
07-09-01
14-09-01
Dato
M2Ø
M2M
M2N


Nitrat (mg/l)
120
100
80
60
40
20
0
Tidspunkt for injektion
27-04-01
04-05-01
11-05-01
18-05-01
25-05-01
01-06-01
08-06-01
15-06-01
22-06-01
29-06-01
06-07-01
13-07-01
20-07-01
27-07-01
03-08-01
10-08-01
17-08-01
24-08-01
31-08-01
07-09-01
14-09-01
Dato
M5Ø
M5M
M5N


Ledningsevne (µs/cm)
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
Tidspunkt for injektion
27-04-01
04-05-01
11-05-01
18-05-01
25-05-01
01-06-01
08-06-01
15-06-01
22-06-01
29-06-01
06-07-01
13-07-01
20-07-01
27-07-01
03-08-01
10-08-01
17-08-01
24-08-01
31-08-01
07-09-01
14-09-01
Dato
M1Ø
M1M
M1N


Ledningsevne (µs/cm)
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
Tidspunkt for injektion
27-04-01
04-05-01
11-05-01
18-05-01
25-05-01
01-06-01
08-06-01
15-06-01
22-06-01
29-06-01
06-07-01
13-07-01
20-07-01
27-07-01
03-08-01
10-08-01
17-08-01
24-08-01
31-08-01
07-09-01
14-09-01
Dato
M2Ø
M2M
M2N


Ledningsevne (µs/cm)
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
Tidspunkt for injektion
27-04-01
04-05-01
11-05-01
18-05-01
25-05-01
01-06-01
08-06-01
15-06-01
22-06-01
29-06-01
06-07-01
13-07-01
20-07-01
27-07-01
03-08-01
10-08-01
17-08-01
24-08-01
31-08-01
07-09-01
14-09-01
Dato
M5Ø
M5M
M5N

Analyseresultater

_April 2001

			Filter												
Parameter	**Parameter (english)**	**Enhed**	P1	O1Ø	O1M	O1N	O2Ø	O2M	O2N	O3Ø	O3M	O3N	M1Ø	M1M	M1N
Myresyre		mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Eddikesyre	acetic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
n-propionsyre	propionic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Mælkesyre	lactic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Pyruvat syre	pyruvic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Total jern	Iron (total)	mg/l	0.15	0.17	0.097	0.49	0.32	0.014	0.042	<0.010	<0.010	0.15	2	1.3	0.74
Jern(II) filtreret	dissolved iron	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.11	<0.010	<0.010	<0.010
Total mangan	Manganese (total)	mg/l	0.56	0.026	0.19	0.81	0.051	0.26	0.48	0.17	0.37	0.69	0.52	0.38	0.53
Mangan(II) filtreret	dissolved manganese	mg/l	0.24	0.023	0.2	0.74	0.047	0.26	0.47	0.16	0.36	0.67	0.42	0.3	0.49
Nitrit	nitrite	mg/l	0.036	0.012	0.099	0.19	0.011	0.021	0.13	0.03	0.078	0.078	0.045	0.027	0.042
Nitrat	nitrate	mg/l	71	110	74	37	120	120	23	100	69	6.2	110	95	87
Chlorid	chloride	mg/l	160	200	140	170	220	270	170	150	140	200	180	200	200
Sulfat	sulphate	mg/l	140	88	140	160	87	110	150	97	120	150	91	130	140
NVOC	NVOC	mg/l	1.8	1.8	2	2.2	1.5	1.8	1.8	2.2	2.7	2.2	2.9	1.9	2.1
Sulfid-S	Sulfide-S	mg/l	0.011	0.012	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.027
Methan	Methane	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ethan	Ethane	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ethen	Ethene	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ilt	dissolved oxygen	mg/l	0.4	4.19	0.23	0.17	3.77	0.07	0.15	2.85	0.4	0.11	3.26	0.27	0.21
Chloroform	Chloroforme	µg/l	0.15	0.21	0.48	<0.050	0.25	0.24	<0.050	0.19	0.058	<0.050	0.27	0.16	<0.050
Trichlorethan	Trichlorethane	µg/l	1.5	0.78	2.5	0.5	0.61	1.7	1	1.6	2.9	1.3	1.1	2.2	1.5
Tetrachlormethan	Tetrachlormethane	µg/l	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Trichlorethylen	Trichlorethylene	µg/l	4.6	7.6	2.8	2.1	6	5.8	3.1	5.8	3.4	3	11	3.8	4.3
Tetrachlorethylen	Tetrachlorethylene	µg/l	260	320	230	25	340	660	110	460	330	140	310	310	160
1,1-dichlorethylen	1,1-dichlorethylene	µg/l	0.11	<0.10	0.33	<0.10	<0.10	0.13	<0.10	0.1	<0.1	<0.1	<0.10	<0.10	<0.10
trans-1,2-dichlorethylen	trans-1,2-dichlorethylene	µg/l	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.1	<0.10	<0.10	<0.10
cis-1,2-dichlorethylen	cis-1,2-dichlorethylene	µg/l	0.51	0.46	0.12	0.47	0.82	0.87	0.75	0.5	0.5	0.6	0.17	0.19	0.47
1,1-dichlorethan	1,1-dichlorethane	µg/l	0.78	<0.20	0.22	0.86	<0.20	0.36	1	0.2	0.4	<0.2	<0.20	0.21	0.91
Vinylchlorid	Vinylchloride	µg/l	<0.020	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.2	<0.2	<0.2	<0.20	<0.20	<0.20
Ledningsevne	Conductivity	µs/cm	1501	1562	1441	1556	1622	1872	1508	1467	1450	1525	1513	1686	1681
pH	pH		6.95	7.03	6.94	6.89	6.98	6.94	6.98	6.92	6.97	6.95	7.04	6.9	6.96
Temperatur	Temperature	Grader C	12.6	12.5	13.1	13	12.9	13.5	13.2	13.4	i.m.	13.5	12.4	13.1	13.2

_April 2001

Parameter	**Parameter (english)**	**Enhed**	M2Ø	M2M	M2N	M3Ø	M3M	M3N	M4Ø	M4M	M4N	M5Ø	M5M	M5N
Myresyre		mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Eddikesyre	acetic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
n-propionsyre	propionic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Mælkesyre	lactic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Pyruvat syre	pyruvic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Total jern	Iron (total)	mg/l	2.7	2	0.96	0.22	0.36	1.1	4.4	1.3	1.4	2.6	0.46	1.2
Jern(II) filtreret	dissolved iron	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	0.013	<0.010	<0.010	<0.010	0.047	0.011	0.29
Total mangan	Manganese (total)	mg/l	0.3	0.38	0.65	0.45	0.36	0.63	0.36	0.48	0.68	0.44	0.22	0.76
Mangan(II) filtreret	dissolved manganese	mg/l	0.23	0.32	0.61	0.41	0.32	0.62	0.26	0.42	0.6	0.34	0.21	0.76
Nitrit	nitrite	mg/l	0.023	0.027	0.082	0.04	0.029	0.046	0.078	0.073	0.12	0.047	0.022	0.098
Nitrat	nitrate	mg/l	120	110	70	110	100	21	130	140	27	85	92	25
Chlorid	chloride	mg/l	200	160	170	220	210	180	180	180	170	250	460	220
Sulfat	sulphate	mg/l	93	130	140	85	120	150	100	100	190	110	81	160
NVOC	NVOC	mg/l	1.7	2.1	3.6	1.7	2.1	2.3	2.4	2.5	4	4.1	3.1	2.1
Sulfid-S	Sulfide-S	mg/l	<0.010	0.011	0.014	0.011	0.019	<0.010	<0.010	<0.010	<0.010	<0.010	0.019	0.042
Methan	Methane	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ethan	Ethane	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ethen	Ethene	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ilt	dissolved oxygen	mg/l	4.15	0.32	0.39	3.49	0.16	0.21	0.25	0.12	0.11	0.62	0.41	0.23
Chloroform	Chloroforme	µg/l	0.29	0.44	<0.050	0.4	0.25	<0.050	0.75	0.4	<0.050	<0.050	0.46	<0.050
Trichlorethan	Trichlorethane	µg/l	0.64	2.9	0.54	0.5	3.2	1.8	14	4.4	0.12	17	11	0.18
Tetrachlormethan	Tetrachlormethane	µg/l	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.033	<0.020	<0.020	0.063	0.042	<0.020
Trichlorethylen	Trichlorethylene	µg/l	14	6.5	2.6	5.8	11	4.1	51	17	0.19	23	14	0.39
Tetrachlorethylen	Tetrachlorethylene	µg/l	310	300	26	350	600	38	450	230	1.5	180	140	1.1
1,1-dichlorethylen	1,1-dichlorethylene	µg/l	<0.10	<0.10	0.36	<0.10	0.19	<0.10	0.98	0.54	<0.10	1.3	1.2	<0.10
trans-1,2-dichlorethylen	trans-1,2-dichlorethylene	µg/l	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.15	<0.1	<0.10	0.18	<0.10
cis-1,2-dichlorethylen	cis-1,2-dichlorethylene	µg/l	0.82	0.55	0.38	0.16	0.74	0.65	1.3	1.9	0.2	1.2	3.9	0.3
1,1-dichlorethan	1,1-dichlorethane	µg/l	<0.20	1.3	0.28	<0.20	0.41	0.61	0.39	1.3	0.48	0.45	0.42	0.91
Vinylchlorid	Vinylchloride	µg/l	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ledningsevne	Conductivity	µs/cm	1588	1578	1572	1629	1741	1545	1632	1545	1662	1811	2480	1665
pH	pH		7.02	6.95	6.91	7.03	6.93	6.96	7.05	7.17	7.01	7.04	6.95	6.97
Temperatur	Temperature	Grader C	12.1	12.8	12.9	12.2	13	13	10.3	11.8	11.4	10.4	0.41	11.8

_April 2001

Parameter	Parameter (english)	Enhed	M6Ø	M6M	M6N	M7Ø	M7M	M7N
Myresyre		mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Eddikesyre	acetic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
n-propionsyre	propionic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Mælkesyre	lactic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Pyruvat syre	pyruvic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Total jern	Iron (total)	mg/l	3.4	2.2	1.5	4	1.7	0.81
Jern(II) filtreret	dissolved iron	mg/l	0.019	0.021	0.19	0.015	0.041	0.55
Total mangan	Manganese (total)	mg/l	0.91	0.61	0.82	1.1	0.46	0.86
Mangan(II) filtreret	dissolved manganese	mg/l	0.75	0.47	0.76	0.89	0.39	0.83
Nitrit	nitrite	mg/l	0.089	0.086	0.14	0.22	0.032	0.1
Nitrat	nitrate	mg/l	94	160	5.8	76	89	42
Chlorid	chloride	mg/l	390	240	150	620	200	160
Sulfat	sulphate	mg/l	81	140	200	86	100	170
NVOC	NVOC	mg/l	3.7	3	3.5	3.6	2.5	2.8
Sulfid-S	Sulfide-S	mg/l	0.036	<0.010	<0.010	<0.010	<0.010	0.02
Methan	Methane	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ethan	Ethane	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ethen	Ethene	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ilt	dissolved oxygen	mg/l	3.65	0.25	0.26	1.57	0.18	0
Chloroform	Chloroforme	µg/l	0.29	0.34	0.08	0.23	0.36	0.073
Trichlorethan	Trichlorethane	µg/l	1.5	4.6	0.52	0.68	3.2	0.86
Tetrachlormethan	Tetrachlormethane	µg/l	0.037	<0.020	<0.020	0.029	<0.20	<0.020
Trichlorethylen	Trichlorethylene	µg/l	41	11	0.35	5.8	9.1	0.25
Tetrachlorethylen	Tetrachlorethylene	µg/l	350	330	1.2	220	490	2.4
1,1-dichlorethylen	1,1-dichlorethylene	µg/l	<0.10	0.61	<0.10	<0.10	0.21	<0.10
trans-1,2-dichlorethylen	trans-1,2-dichlorethylene	µg/l	<0.10	0.34	0.24	<0.10	0.12	0.36
cis-1,2-dichlorethylen	cis-1,2-dichlorethylene	µg/l	2.1	12	3.6	0.42	1.7	1.9
1,1-dichlorethan	1,1-dichlorethane	µg/l	<0.20	0.71	1.5	<0.20	0.6	1.1
Vinylchlorid	Vinylchloride	µg/l	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ledningsevne	Conductivity	µs/cm	2130	1971	1506	1959	1729	1552
pH	pH		7.1	7.01	6.97	7.17	6.99	7.08
Temperatur	Temperature	Grader C	10.3	11.6	11.8	10.6	11.9	12.1

_Oktober 2001

			Filter												
Parameter (Danish)	**Parameter (english)**	**Enhed**	P1	O1Ø	O1M	O1N	O2Ø	O2M	O2N	O3Ø	O3M	O3N	M1Ø	M1M	M1N
Myresyre		mg/l	<1	<1	<1	<1	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0
Eddikesyre	acetic acid	mg/l	<1	<1	<1	<1	<1,0	<1,0	36	<1,0	<1,0	<1,0	<1,0	9.2	550
n-propionsyre	propionic acid	mg/l	<1	<1	<1	<1	<1,0	<1,0	18	<1,0	<1,0	<1,0	<1,0	21	30
Mælkesyre	lactic acid	mg/l	0.65	<0,50	0.9	<0,50	0.67	<0,50	5100	0.93	<0,50	0.9	<0,50	8.6	<0,50
Pyruvat syre	pyruvic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Total jern	Iron (total)	mg/l	0.22	0.13	0.09	0.38	0.074	0.013	4	0.087	0.039	0.28	0.37	15	6.2
Jern(II) filtreret	dissolved iron	mg/l	0.34	<0,010	0.076	0.2	0.84	0.14	4.1	<0,010	0.012	0.16	0.52	15	7.6
Total mangan	Manganese (total)	mg/l	0.32	0.015	0.23	0.85	0.036	0.28	0.83	0.18	0.36	0.82	0.25	1.7	0.78
Mangan(II) filtreret	dissolved manganese	mg/l	0.35	0.014	0.24	0.82	0.038	0.27	0.83	0.17	0.36	0.79	0.23	1.8	0.9
Nitrit	nitrite	mg/l	0.068	0.01	0.11	0.19	<0,010	0.02	<0,010	0.021	0.056	0.04	0.2	1.2	1.4
Nitrat	nitrate	mg/l	72	110	44	44	110	110	66	110	88	1.5	90	5.3	16
Chlorid	chloride	mg/l	190	240	140	180	260	290	200	160	220	250	220	240	230
Sulfat	sulphate	mg/l	140	86	160	160	80	110	130	110	120	150	84	110	160
NVOC	NVOC	mg/l	2.8	2.4	2.7	2.3	2.3	2.1	2800	2.2	5	4.5	2.1	20	6.7
Sulfid-S	Sulfide-S	mg/l	<0,010	<0,010	<0,010	0.022	<0,010	<0,010	3.92	<0,010	<0,010	0.041	<0,010	0.324	<0,010
Methan	Methane	mg/l	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010
Ethan	Ethane	mg/l	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010
Ethen	Ethene	mg/l	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010
Ilt	dissolved oxygen	mg/l	0.86	5	0.1	0.36	3.36	2.23	0.51	2.36	0.43	0.44	3.41	0.16	0.14
Chloroform	Chloroforme	µg/l	<0,050	0.12	0.32	<0,050	0.091	0.086	0.11	0.091	0.12	<0,050	<0,050	<0,050	<0,050
Trichlorethan	Trichlorethane	µg/l	1.3	0.92	3.6	0.38	0.44	1.6	0.91	2.2	<0,10	0.96	1.2	0.64	0.35
Tetrachlormethan	Tetrachlormethane	µg/l	<0,020	<0,020	<0,020	<0,020	<0,020	<0,020	<0,020	<0,020	0.46	<0,020	<0,020	<0,020	<0,020
Trichlorethylen	Trichlorethylene	µg/l	5.3	6	4.5	1.8	7.1	6.3	3	4.4	0.34	2.4	9.7	5.2	3.4
Tetrachlorethylen	Tetrachlorethylene	µg/l	240	440	280	18	330	550	240	430	<0,10	65	400	400	110
1,1-dichlorethylen	1,1-dichlorethylene	µg/l	0.13	<0,1	0.28	<0,10	<0,10	0.11	<0,10	<0,10	<0,050	<0,10	<0,10	0.17	<0,10
trans-1,2-dichlorethylen	trans-1,2-dichlorethylene	µg/l	<0,10	<0,1	<0,1	<0,10	<0,10	<0,10	<0,10	<0,10	3.8	<0,10	<0,10	<0,10	<0,10
cis-1,2-dichlorethylen	cis-1,2-dichlorethylene	µg/l	0.44	0.71	0.27	0.56	0.61	0.72	0.55	0.27	<0,020	0.31	0.51	0.33	1.6
1,1-dichlorethan	1,1-dichlorethane	µg/l	0.56	<0,1	0.26	0.45	<0,10	0.37	0.77	0.19	4.5	0.12	<0,10	0.67	1.2
Vinylchlorid	Vinylchloride	µg/l	<0,10	<0,1	<0,1	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10
Ledningsevne	Conductivity	µs/cm	1617	1606	1389	1555	1666	1896	1832	1479	1695	1628	1536	1704	1698
pH	pH		6.82	7.05	6.98	6.92	7.04	6.99	4.2	6.95	7	6.95	6.96	6.78	6.92
Temperatur	Temperature	Grader C	13.3	15.1	13.7	13.4	15	13.8	13.6	15.2	14	13.8	14.7	13.7	13.6

_Oktober 2001

Parameter (Danish)	Parameter (english)	Enhed	M2Ø	M2M	M2N	M3Ø	M3M	M3N	M4Ø	M4M	M4N	M5Ø	M5M	M5N
Myresyre		mg/l	<1,0	<1,0	<1,0	<1,0	<1,0	1	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0
Eddikesyre	acetic acid	mg/l	<1,0	<1,0	30	<1,0	<1,0	330	<1,0	<1,0	<1,0	<1,0	<1,0	8.2
n-propionsyre	propionic acid	mg/l	<1,0	<1,0	39	<1,0	<1,0	530	<1,0	<1,0	<1,0	<1,0	<1,0	11
Mælkesyre	lactic acid	mg/l	<0,50	<0,50	7.6	<0,50	<0,50	330	0.5	<0,50	<0,50	<0,50	<0,50	11
Pyruvat syre	pyruvic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Total jern	Iron (total)	mg/l	0.076	5.5	23	0.47	0.36	91	0.082	0.085	0.39	0.24	0.29	1.9
Jern(II) filtreret	dissolved iron	mg/l	0.011	5.5	29	0.019	0.44	83	0.13	0.21	<0,010	0.12	0.17	2
Total mangan	Manganese (total)	mg/l	0.4	0.99	1.4	0.6	0.81	4.3	0.021	0.31	0.77	0.037	0.17	0.73
Mangan(II) filtreret	dissolved manganese	mg/l	0.48	0.91	1.7	0.47	0.83	4.4	0.019	0.3	0.75	0.03	0.16	0.74
Nitrit	nitrite	mg/l	0.27	0.54	0.46	0.045	0.12	0.42	0.047	0.25	0.44	<0,010	0.13	0.22
Nitrat	nitrate	mg/l	94	6.2	12	110	86	<1,0	130	140	88	85	110	44
Chlorid	chloride	mg/l	280	160	230	280	250	230	240	220	240	350	390	250
Sulfat	sulphate	mg/l	91	140	100	89	110	1	110	100	120	90	88	150
NVOC	NVOC	mg/l	2.6	4.5	37	2	3.7	460	1.9	2	2.1	2.9	2.6	13
Sulfid-S	Sulfide-S	mg/l	<0,010	0.178	0.164	0.014	0.011	0.266	0.015	0.013	0.036	0.018	0.02	0.018
Methan	Methane	mg/l	<0,010	<0,010	0.012	<0,010	<0,010	0.049	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010
Ethan	Ethane	mg/l	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010
Ethen	Ethene	mg/l	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010
Ilt	dissolved oxygen	mg/l	1.97	0.22	0.19	2.52	0.18	0.09	0.37	0.85	2.91	3.57	1.34	0.9
Chloroform	Chloroforme	µg/l	<0,050	<0,050	<0,050	0.11	0.13	0.13	0.45	0.44	<0,050	0.24	0.36	0.075
Trichlorethan	Trichlorethane	µg/l	0.71	1.2	0.34	0.23	2.3	0.41	12	9.4	0.17	14	12	0.94
Tetrachlormethan	Tetrachlormethane	µg/l	<0,020	<0,020	<0,020	<0,020	<0,020	0.04	0.045	0.026	<0,020	0.055	0.063	<0,020
Trichlorethylen	Trichlorethylene	µg/l	17	10	5.1	5.4	8	7.6	53	18	0.068	29	29	0.47
Tetrachlorethylen	Tetrachlorethylene	µg/l	490	320	37	150	740	190	360	300	0.15	180	140	1.6
1,1-dichlorethylen	1,1-dichlorethylene	µg/l	<0,10	0.32	<0,10	<0,10	<0,10	<0,10	0.86	0.87	<0,10	0.74	0.53	0.2
trans-1,2-dichlorethylen	trans-1,2-dichlorethylene	µg/l	<0,10	<0,10	0.1	<0,10	0.15	0.15	<0,10	0.14	<0,010	<0,10	0.1	<0,10
cis-1,2-dichlorethylen	cis-1,2-dichlorethylene	µg/l	0.35	0.26	0.52	0.49	0.9	0.9	0.4	1.6	0.12	2.4	3	1.5
1,1-dichlorethan	1,1-dichlorethane	µg/l	<0,10	1.3	1.3	<0,10	1.6	1.6	0.53	0.86	0.83	0.13	<0,10	0.71
Vinylchlorid	Vinylchloride	µg/l	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10
Ledningsevne	Conductivity	µs/cm	1770	1438	1879	1740	1725	2470	1760	1704	1753	1963	2190	1741
pH	pH		6.95	6.83	6.66	6.98	6.81	6.37	6.9	6.96	6.94	6.96	6.93	6.91
Temperatur	Temperature	Grader C	14.1	13.3	13.4	14.5	13.5	13.5	12.5	12.1	12.1	12.1	11.8	12.1

_Oktober 2001

Parameter (Danish)	**Parameter (english)**	**Enhed**	M6Ø	M6M	M6N	M7Ø	M7M	M7N
Myresyre		mg/l	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0
Eddikesyre	acetic acid	mg/l	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0
n-propionsyre	propionic acid	mg/l	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0
Mælkesyre	lactic acid	mg/l	0.86	<0,50	<0,50	<0,50	<0,50	<0,50
Pyruvat syre	pyruvic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Total jern	Iron (total)	mg/l	0.4	0.8	0.41	3.7	0.12	0.078
Jern(II) filtreret	dissolved iron	mg/l	0.48	0.22	0.63	0.021	0.059	0.047
Total mangan	Manganese (total)	mg/l	0.059	0.41	0.75	0.15	0.34	0.59
Mangan(II) filtreret	dissolved manganese	mg/l	0.042	0.4	0.75	0.057	0.33	0.58
Nitrit	nitrite	mg/l	<0,010	0.18	0.16	0.029	0.052	0.28
Nitrat	nitrate	mg/l	100	150	21	83	91	57
Chlorid	chloride	mg/l	470	180	170	310	200	190
Sulfat	sulphate	mg/l	96	140	170	97	120	140
NVOC	NVOC	mg/l	2.1	1.8	2.7	3.3	2	2
Sulfid-S	Sulfide-S	mg/l	0.022	0.014	<0,010	0.03	<0,010	<0,010
Methan	Methane	mg/l	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010
Ethan	Ethane	mg/l	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010
Ethen	Ethene	mg/l	<0,010	<0,010	<0,010	<0,010	<0,010	<0,010
Ilt	dissolved oxygen	mg/l	6.87	3.77	4.48	3.92	0.67	0.64
Chloroform	Chloroforme	µg/l	0.2	0.23	<0,050	0.21	0.27	<0,050
Trichlorethan	Trichlorethane	µg/l	0.58	6.8	0.64	0.58	4.7	1.2
Tetrachlormethan	Tetrachlormethane	µg/l	0.047	<0,020	<0,020	<0,020	<0,020	<0,020
Trichlorethylen	Trichlorethylene	µg/l	13	13	0.21	10	18	<0,050
Tetrachlorethylen	Tetrachlorethylene	µg/l	220	220	0.062	470	1100	0.19
1,1-dichlorethylen	1,1-dichlorethylene	µg/l	<0,10	0.63	0.17	<0,10	0.17	<0,10
trans-1,2-dichlorethylen	trans-1,2-dichlorethylene	µg/l	<0,10	0.28	0.5	<0,10	0.13	0.39
cis-1,2-dichlorethylen	cis-1,2-dichlorethylene	µg/l	0.37	4.7	5.3	0.4	1.7	2.7
1,1-dichlorethan	1,1-dichlorethane	µg/l	<0,10	0.7	1.4	<0,10	0.7	1.3
Vinylchlorid	Vinylchloride	µg/l	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10
Ledningsevne	Conductivity	µs/cm	2190	1617	1499	1808	1630	1510
pH	pH		7	6.96	6.88	6.98	6.96	6.99
Temperatur	Temperature	Grader C	12.4	11.9	12	12.6	12.2	12.3

M1N			Dato for prøvetagning/sampling date				
Parameter (Danish)	**Parameter (english)**	**Enhed**	25-04-2001	10-10-2001	27-02-2002	03-04-2002	07-05-2002
Myresyre		mg/l	i.a.	<1,0	i.a.	<0,4	<0,4
Eddikesyre	acetic acid	mg/l	i.a.	550	<0,4	<0,4	<0,4
n-propionsyre	propionic acid	mg/l	i.a.	30	<0,4	<0,4	<0,4
Mælkesyre	lactic acid	mg/l	i.a.	<0,50	<0,5	<0,50	<0,50
Pyruvat syre	pyruvic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.
Sum fede syrer	Sum fatty acids	mg/l	i.a.	580	0	0	0
Total jern	Iron (total)	mg/l	0.74	6.2	1.2	1.9	0.37
Jern(II) filtreret	dissolved iron	mg/l	<0.010	7.6	1.1	1.9	0.3
Total mangan	Manganese (total)	mg/l	0.53	0.78	0.41	0.49	0.43
Mangan(II) filtreret	dissolved manganese	mg/l	0.49	0.9	0.4	0.49	0.45
Nitrit	nitrite	mg/l	0.042	1.4	0.21	0.41	0.84
Nitrat	nitrate	mg/l	87	16	26	41	44
Chlorid	chloride	mg/l	200	230	280	210	200
Sulfat	sulphate	mg/l	140	160	110	140	140
NVOC	NVOC	mg/l	2.1	6.7	2.1	2.2	2.4
Sulfid-S	Sulfide-S	mg/l	0.027	<0,010	0.035	0.063	<0,01
Methan	Methane	mg/l	<0.010	<0,010	0.021	0.033	16
Ethan	Ethane	mg/l	<0.010	<0,010	<0,01	<0,01	<0,01
Ethen	Ethene	mg/l	<0.010	<0,010	<0,01	<0,01	<0,01
Ilt	dissolved oxygen	mg/l	0.21	0.14	0.22	0.2	0.2
Alkalinitet, total	Alcalinity, total	mmol/l	i.a.	i.a.	5.33	7.44	7.24
Chloroform	Chloroforme	µg/l	<0.050	<0,050	<0,050	<0,05	<0,02
Trichlorethan	Trichlorethane	µg/l	1.5	0.35	0.25	0.35	0.95
Tetrachlormethan	Tetrachlormethane	µg/l	<0.020	<0,020	<0,020	<0,020	<0,02
Trichlorethylen	Trichlorethylene	µg/l	4.3	3.4	1.4	1.6	3
Tetrachlorethylen	Tetrachlorethylene	µg/l	160	110	49	51	85
1,1-dichlorethylen	1,1-dichlorethylene	µg/l	<0.10	<0,10	<0,1	<0,1	0.22
trans-1,2-dichlorethylen	trans-1,2-dichlorethylene	µg/l	<0.10	<0,10	<0,1	<0,1	0.12
cis-1,2-dichlorethylen	cis-1,2-dichlorethylene	µg/l	0.47	1.6	0.35	0.68	0.43
1,1-dichlorethan	1,1-dichlorethane	µg/l	0.91	1.2	0.45	1.1	0.96
Vinylchlorid	Vinylchloride	µg/l	<0.20	<0,10	<0,1	<0,1	0.06
Monochloroethan	Monochloroethane	mg/l	i.a.	i.a.	i.a.	<0,1	<0,1
Ledningsevne	Conductivity	µs/cm	1681	1698	1735	1536	2360
pH	pH		6.96	6.92	i.m.	i.m.	i.m.
Temperatur	Temperature	Grader C	13.2	13.6	13.1	13.6	13.6

i.m. = ikke målt

M3N			Dato for prøvetagning/sampling date				
Parameter (Danish)	**Parameter (english)**	**Enhed**	25-04-2001	10-10-2001	27-02-2002	03-04-2002	07-05-2002
Myresyre		mg/l	i.a.	1	12	<0,4	1.3
Eddikesyre	acetic acid	mg/l	i.a.	330	<0,4	<0,4	70
n-propionsyre	propionic acid	mg/l	i.a.	530	<0,4	<0,4	<0,4
Mælkesyre	lactic acid	mg/l	i.a.	330	78	58	22
Pyruvat syre	pyruvic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.
Sum fede syrer	Sum fatty acids	mg/l	i.a.	1191	90	58	93.3
Total jern	Iron (total)	mg/l	1.1	91	40	32	29
Jern(II) filtreret	dissolved iron	mg/l	0.013	83	40	32	28
Total mangan	Manganese (total)	mg/l	0.63	4.3	2.5	2.1	1.7
Mangan(II) filtreret	dissolved manganese	mg/l	0.62	4.4	2.5	2.1	1.7
Nitrit	nitrite	mg/l	0.046	0.42	0.041	0.24	0.13
Nitrat	nitrate	mg/l	21	<1,0	<0,1	<0,1	<0,1
Chlorid	chloride	mg/l	180	230	250	240	220
Sulfat	sulphate	mg/l	150	1	37	77	58
NVOC	NVOC	mg/l	2.3	460	97	66	35
Sulfid-S	Sulfide-S	mg/l	<0.010	0.266	0.348	0.455	0.448
Methan	Methane	mg/l	<0.010	0.049	9	10	4.1
Ethan	Ethane	mg/l	<0.010	<0,010	<0,01	<0,01	<0,01
Ethen	Ethene	mg/l	<0.010	<0,010	<0,01	<0,01	<0,01
Ilt	dissolved oxygen	mg/l	0.21	0.09	0.13	0.2	0.19
Alkalinitet, total	Alcalinity, total	mmol/l	i.a.	i.a.	10.9	9.87	10.1
Chloroform	Chloroforme	µg/l	<0.050	0.13	<0,05	<0,05	<0,02
Trichlorethan	Trichlorethane	µg/l	1.8	0.41	0.052	0.064	0.11
Tetrachlormethan	Tetrachlormethane	µg/l	<0.020	0.04	<0,02	<0,02	<0,02
Trichlorethylen	Trichlorethylene	µg/l	4.1	7.6	8.1	7.5	6.9
Tetrachlorethylen	Tetrachlorethylene	µg/l	38	190	120	110	75
1,1-dichlorethylen	1,1-dichlorethylene	µg/l	<0.10	<0,10	<0,1	<0,1	0.03
trans-1,2-dichlorethylen	trans-1,2-dichlorethylene	µg/l	<0.10	0.15	<0,1	<0,1	0.12
cis-1,2-dichlorethylen	cis-1,2-dichlorethylene	µg/l	0.65	0.9	0.45	0.48	0.43
1,1-dichlorethan	1,1-dichlorethane	µg/l	0.61	1.6	0.81	0.99	1.1
Vinylchlorid	Vinylchloride	µg/l	<0.20	<0,10	<0,1	<0,1	0.1
Monochloroethan	Monochloroethane	mg/l	i.a.	i.a.	i.a.	<0,1	<0,1
Ledningsevne	Conductivity	µs/cm	1545	2470	1939	1763	1747
pH	pH		6.96	6.37	i.m.	i.m.	i.m.
Temperatur	Temperature	Grader C	13	13.5	12.8	13.2	i.m.

i.m. = ikke målt

M5N			Dato for prøvetagning/sampling date				
Parameter (Danish)	**Parameter (english)**	**Enhed**	25-04-2001	10-10-2001	27-02-2002	03-04-2002	07-05-2002
Myresyre		mg/l	i.a.	<1,0	1.3	<0,4	1.4
Eddikesyre	acetic acid	mg/l	i.a.	8.2	22	<0,4	<0,4
n-propionsyre	propionic acid	mg/l	i.a.	11	42	<0,4	<0,4
Mælkesyre	lactic acid	mg/l	i.a.	11	19	12	<0,5
Pyruvat syre	pyruvic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.
Sum fede syrer	Sum fatty acids	mg/l	i.a.	30.2	84.3	12	1.4
Total jern	Iron (total)	mg/l	1.2	1.9	14	12	8
Jern(II) filtreret	dissolved iron	mg/l	0.29	2	13	11	7.9
Total mangan	Manganese (total)	mg/l	0.76	0.73	1.5	1.4	1.1
Mangan(II) filtreret	dissolved manganese	mg/l	0.76	0.74	1.5	1.4	1.1
Nitrit	nitrite	mg/l	0.098	0.22	0.18	0.21	0.19
Nitrat	nitrate	mg/l	25	44	53	37	25
Chlorid	chloride	mg/l	220	250	200	200	200
Sulfat	sulphate	mg/l	160	150	140	130	130
NVOC	NVOC	mg/l	2.1	13	28	20	5.8
Sulfid-S	Sulfide-S	mg/l	0.042	0.018	<0,01	0.016	0.014
Methan	Methane	mg/l	<0.010	<0,010	0.61	2.1	0.67
Ethan	Ethane	mg/l	<0.010	<0,010	<0,01	<0,01	<0,1
Ethen	Ethene	mg/l	<0.010	<0,010	<0,01	<0,01	<0,01
Ilt	dissolved oxygen	mg/l	0.23	0.9	0.15	0.3	0.11
Alkalinitet, total	Alcalinity, total	mmol/l	i.a.	i.a.	7.9	7.69	7.62
Chloroform	Chloroforme	µg/l	<0.050	0.075	<0,05	<0,05	<0,02
Trichlorethan	Trichlorethane	µg/l	0.18	0.94	0.52	0.63	0.71
Tetrachlormethan	Tetrachlormethane	µg/l	<0.020	<0,020	<0,02	<0,02	<0,02
Trichlorethylen	Trichlorethylene	µg/l	0.39	0.47	0.72	0.84	0.94
Tetrachlorethylen	Tetrachlorethylene	µg/l	1.1	1.6	2.4	1.9	1.5
1,1-dichlorethylen	1,1-dichlorethylene	µg/l	<0.10	0.2	0.14	0.12	<0,03
trans-1,2-dichlorethylen	trans-1,2-dichlorethylene	µg/l	<0.10	<0,10	<0.1	<0,1	0.22
cis-1,2-dichlorethylen	cis-1,2-dichlorethylene	µg/l	0.3	1.5	0.35	0.43	0.05
1,1-dichlorethan	1,1-dichlorethane	µg/l	0.91	0.71	0.67	0.74	0.27
Vinylchlorid	Vinylchloride	µg/l	<0.20	<0,10	<0.1	<0,1	0.71
Monochloroethan	Monochloroethane	mg/l	i.a.	i.a.	i.a.	<0,1	<0,1
Ledningsevne	Conductivity	µs/cm	1665	1741	1672	1515	1532
pH	pH		6.97	6.91	i.m.	i.m.	i.m.
Temperatur	Temperature	Grader C	11.8	12.1	11.9	11.8	12

i.m. = ikke målt

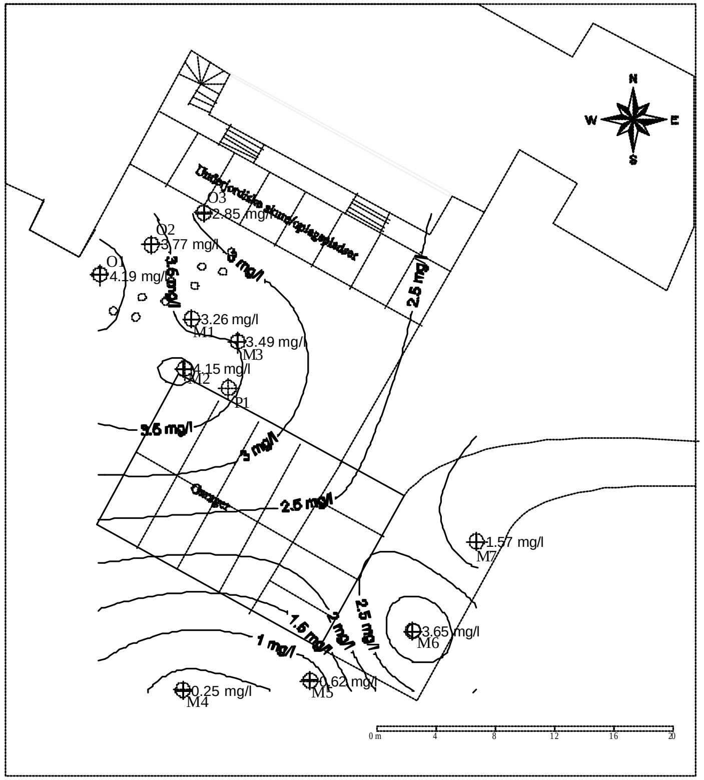
O1N			Dato for prøvetagning/sampling date				
Parameter (Danish)	**Parameter (english)**	**Enhed**	25-04-2001	10-10-2001	27-02-2002	03-04-2002	07-05-2002
Myresyre		mg/l	i.a.	<1	<0,4	<0,4	2.7
Eddikesyre	acetic acid	mg/l	i.a.	<1	<0,4	8.7	0.87
n-propionsyre	propionic acid	mg/l	i.a.	<1	<0,4	16	2.2
Mælkesyre	lactic acid	mg/l	i.a.	<0,50	0.63	1.8	<0,5
Pyruvat syre	pyruvic acid	mg/l	i.a.	i.a.	i.a.	i.a.	i.a.
Sum fede syrer	Sum fatty acids	mg/l	i.a.	0	0.63	26.5	5.77
Total jern	Iron (total)	mg/l	0.49	0.38	0.88	0.22	8.7
Jern(II) filtreret	dissolved iron	mg/l	<0.010	0.2	0.91	0.31	0.028
Total mangan	Manganese (total)	mg/l	0.81	0.85	0.91	0.86	1.1
Mangan(II) filtreret	dissolved manganese	mg/l	0.74	0.82	0.88	0.89	0.77
Nitrit	nitrite	mg/l	0.19	0.19	0.12	0.13	0.16
Nitrat	nitrate	mg/l	37	44	22	23	18
Chlorid	chloride	mg/l	170	180	190	190	190
Sulfat	sulphate	mg/l	160	160	150	150	150
NVOC	NVOC	mg/l	2.2	2.3	3	2.5	2.5
Sulfid-S	Sulfide-S	mg/l	<0.010	0.022	0.037	<0,01	0.081
Methan	Methane	mg/l	<0.010	<0,010	0.14	0.31	<0,01
Ethan	Ethane	mg/l	<0.010	<0,010	<0,01	<0,01	<0,01
Ethen	Ethene	mg/l	<0.010	<0,010	<0,01	<0,01	<0,01
Ilt	dissolved oxygen	mg/l	0.17	0.36	0.28	0.21	0.18
Alkalinitet, total	Alcalinity, total	mmol/l	i.a.	i.a.	7.67	7.48	8.28
Chloroform	Chloroforme	µg/l	<0.050	<0,050	<0,05	<0,05	<0,02
Trichlorethan	Trichlorethane	µg/l	0.5	0.38	0.47	0.63	0.59
Tetrachlormethan	Tetrachlormethane	µg/l	<0.020	<0,020	<0,02	<0,02	<0,02
Trichlorethylen	Trichlorethylene	µg/l	2.1	1.8	1.4	1.7	1.4
Tetrachlorethylen	Tetrachlorethylene	µg/l	25	18	12	15	8.4
1,1-dichlorethylen	1,1-dichlorethylene	µg/l	<0.10	<0,10	<0,1	<0,1	0.16
trans-1,2-dichlorethylen	trans-1,2-dichlorethylene	µg/l	<0.10	<0,10	<0,1	<0,1	0.04
cis-1,2-dichlorethylen	cis-1,2-dichlorethylene	µg/l	0.47	0.56	0.22	0.33	0.14
1,1-dichlorethan	1,1-dichlorethane	µg/l	0.86	0.45	0.44	0.71	0.65
Vinylchlorid	Vinylchloride	µg/l	<0.20	<0,10	<0,1	<0,1	<0,03
Monochloroethan	Monochloroethane	mg/l	i.a.	i.a.	i.a.	<0,1	<0,1
Ledningsevne	Conductivity	µs/cm	1556	1555	1598	1443	2160
pH	pH		6.89	6.92	i.m.	i.m.	i.m.
Temperatur	Temperature	Grader C	13	13.4	12.2	13.4	14.8

i.m. = ikke målt

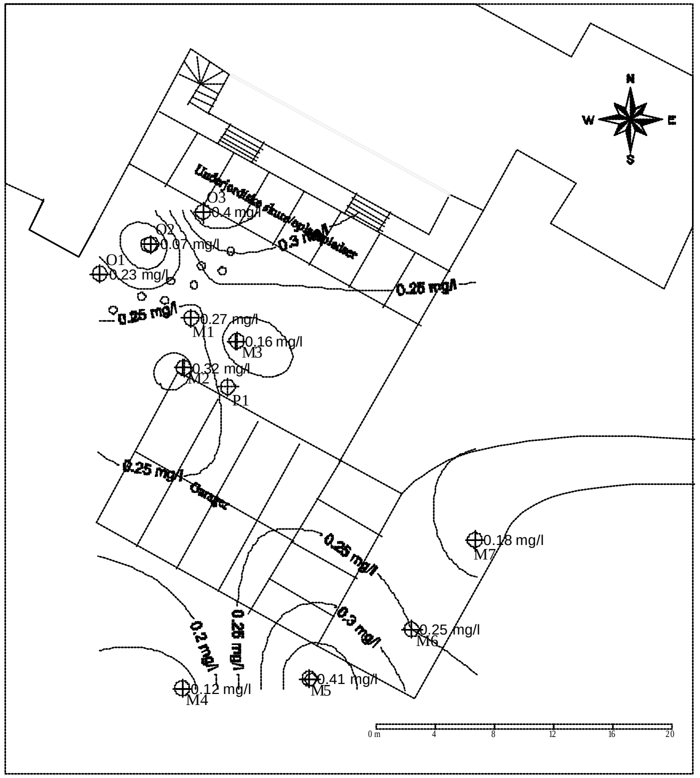
Konturplots

Ilt-koncentration i grundvandet (mg/l) - april 2001

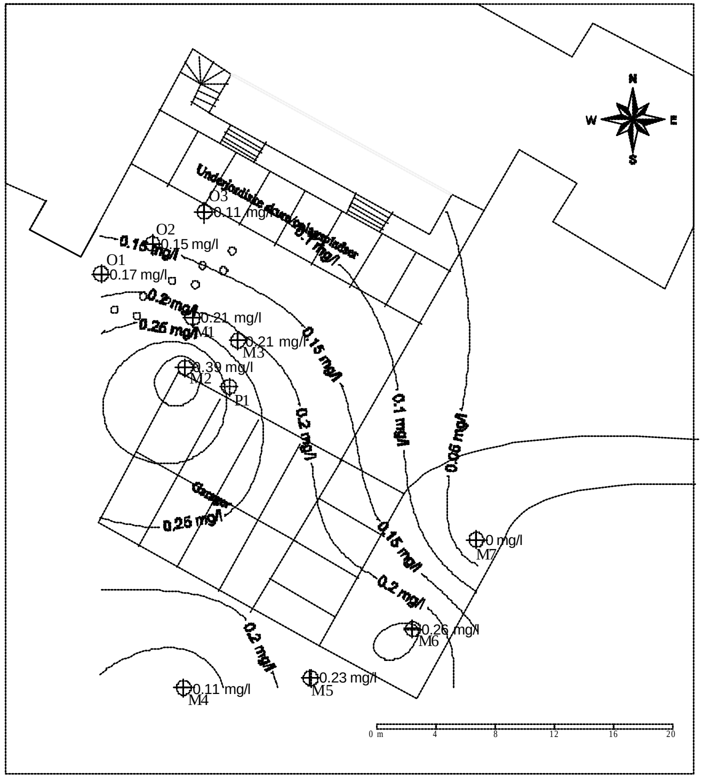
Øvre del



Mellemste del

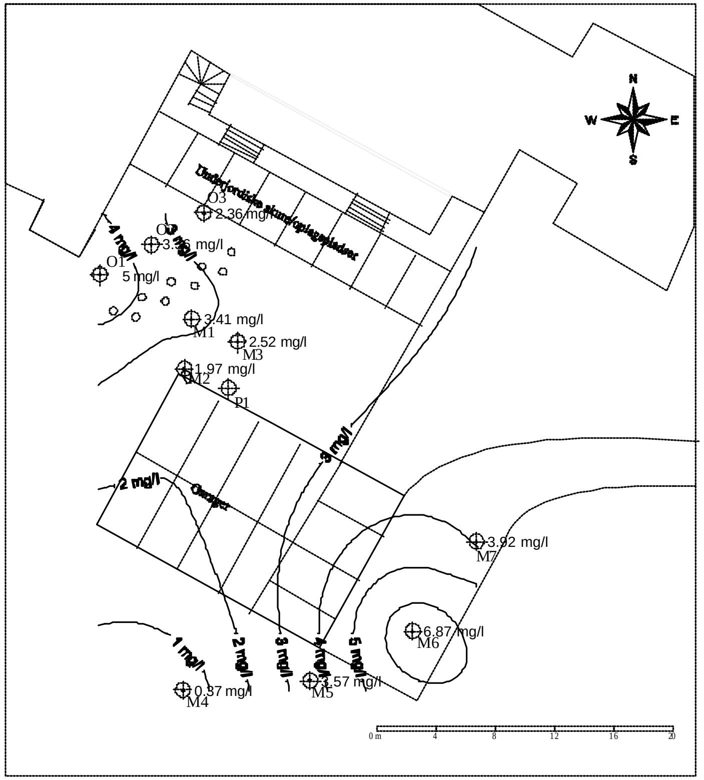


Nedre del

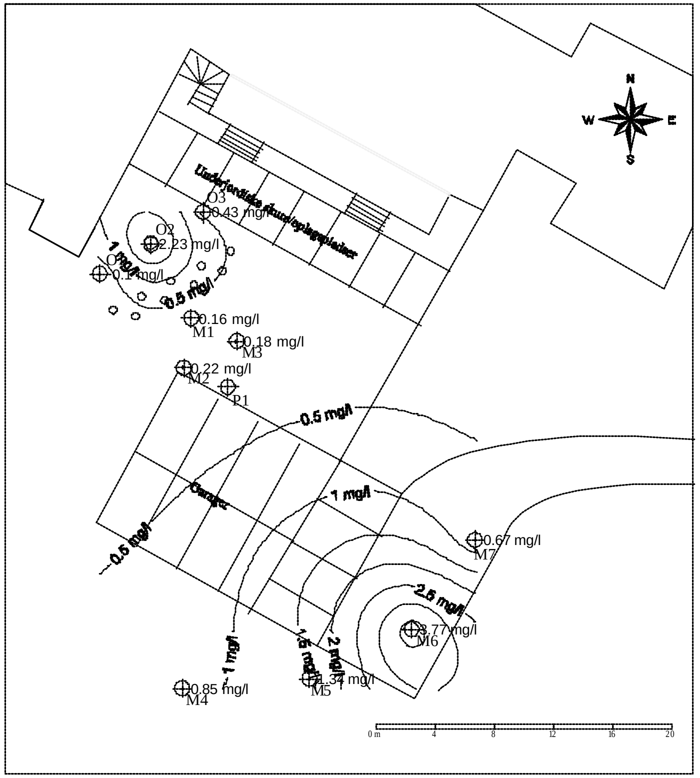


Ilt-koncentration i grundvandet (mg/l) - oktober 2001

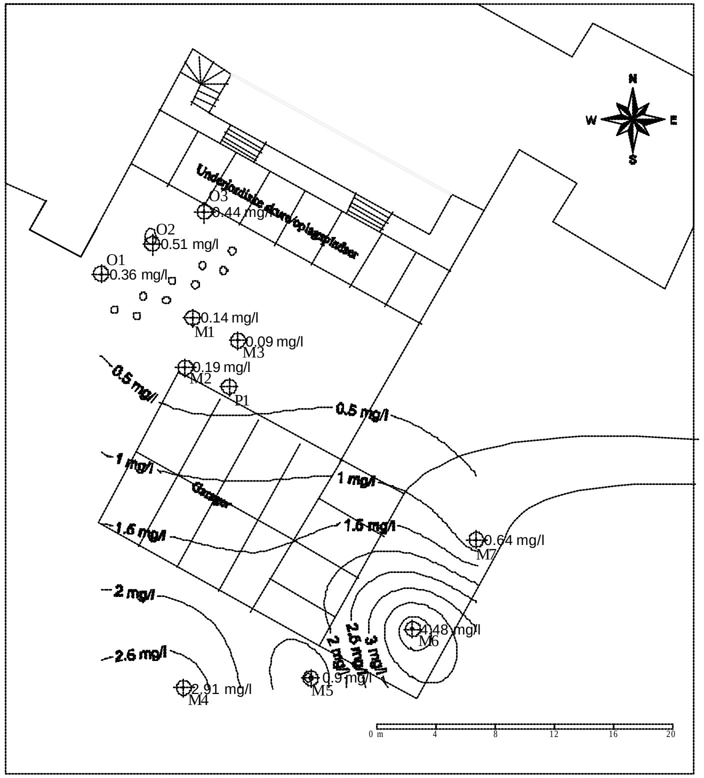
Øvre del



Mellemste del

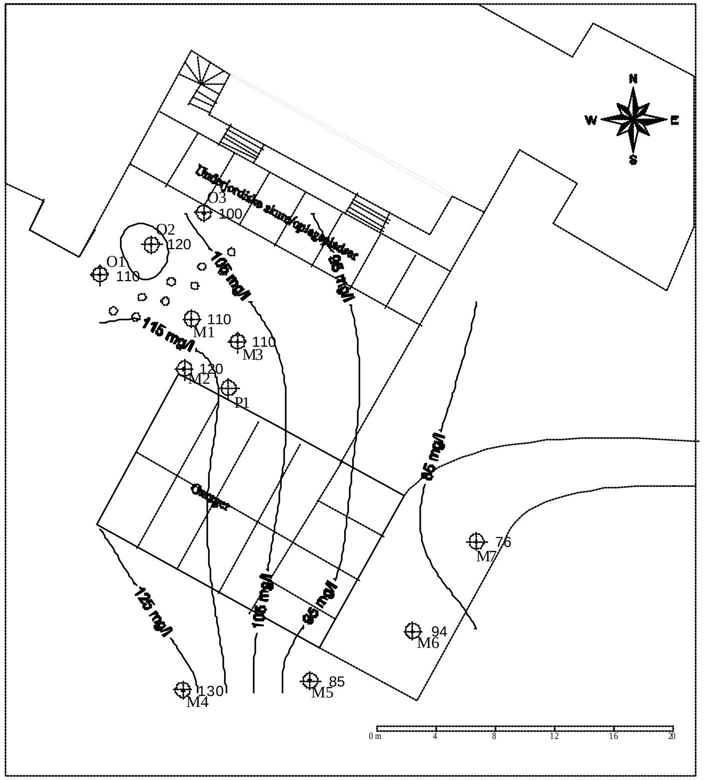


Nedre del

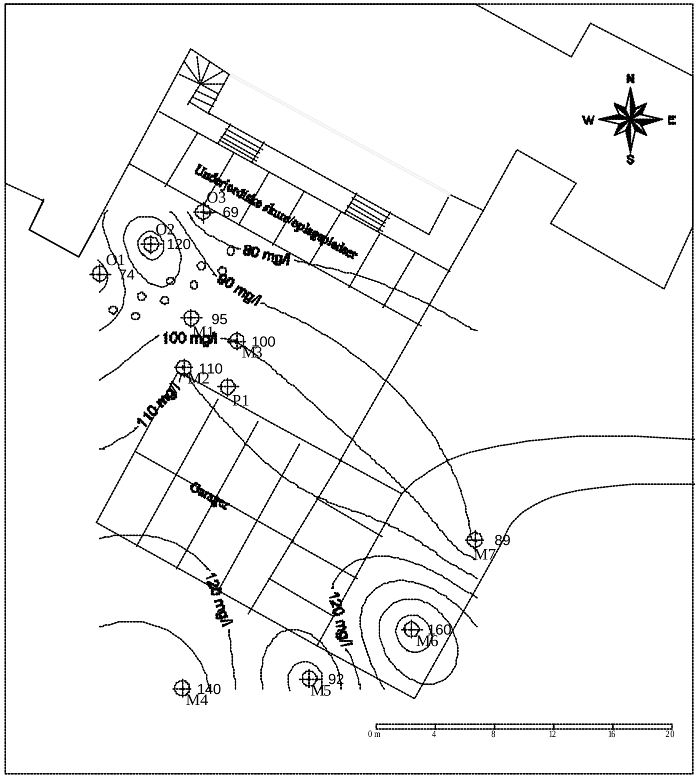


Nitrat-koncentration i grundvandet (mg/l) - april 2001

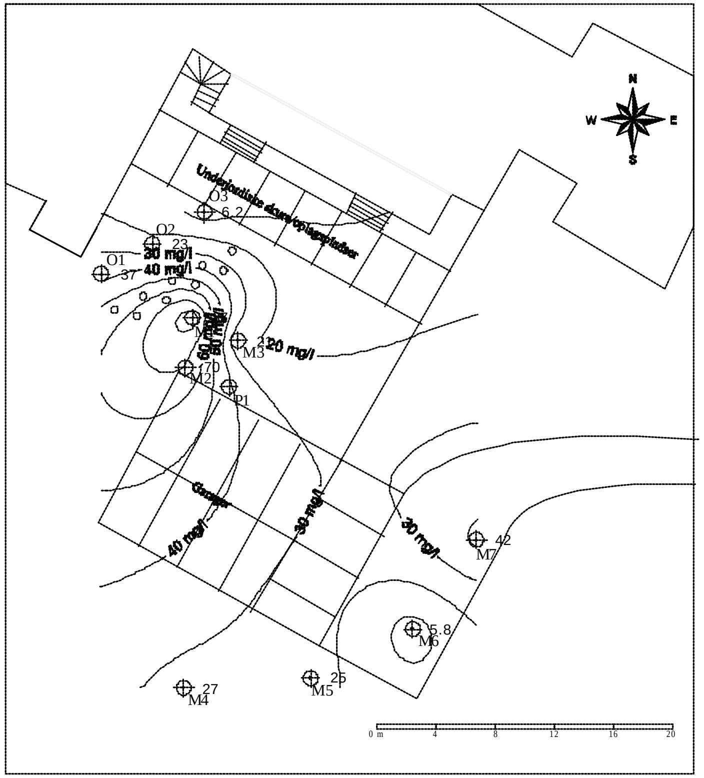
Øvre del



Mellemste del

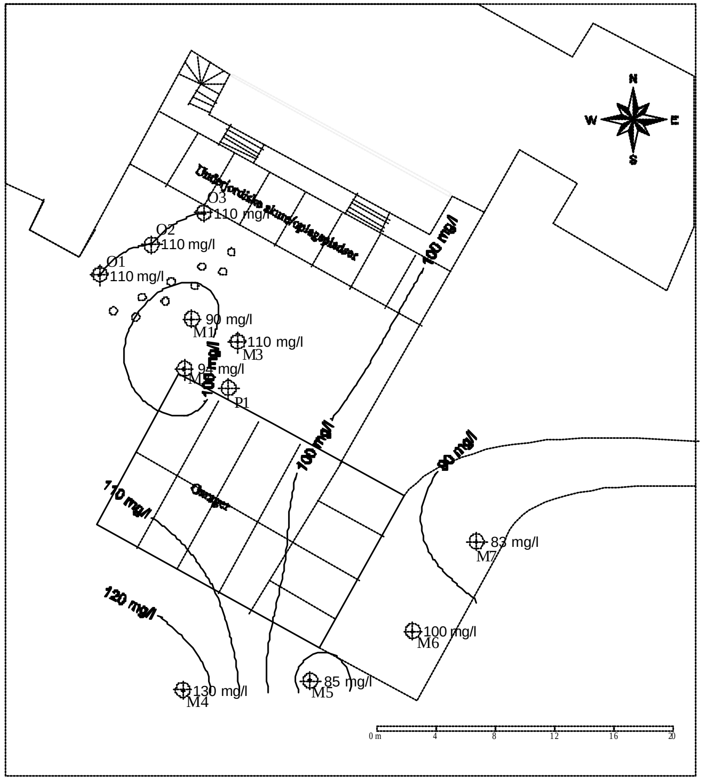


Nedre del

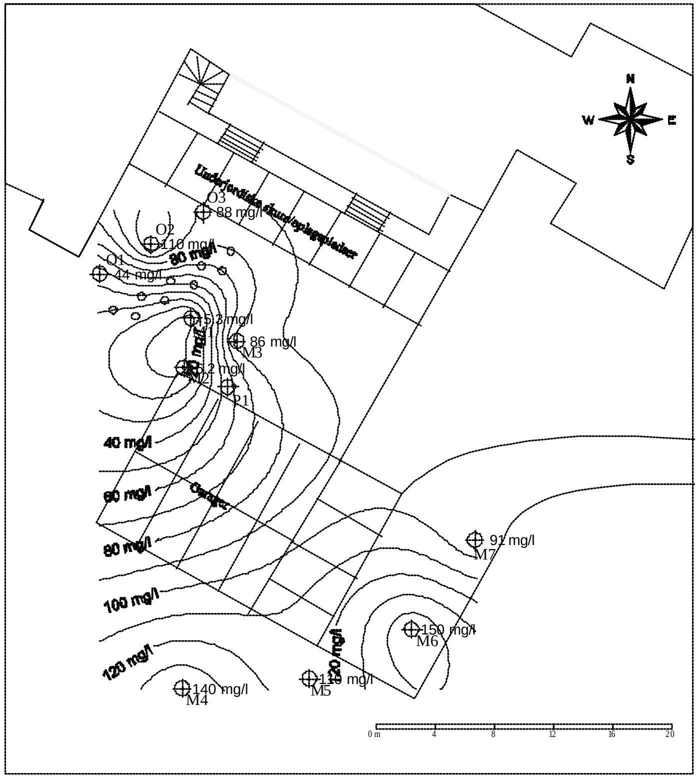


Nitrat-koncentration i grundvandet (mg/l) - oktober 2001

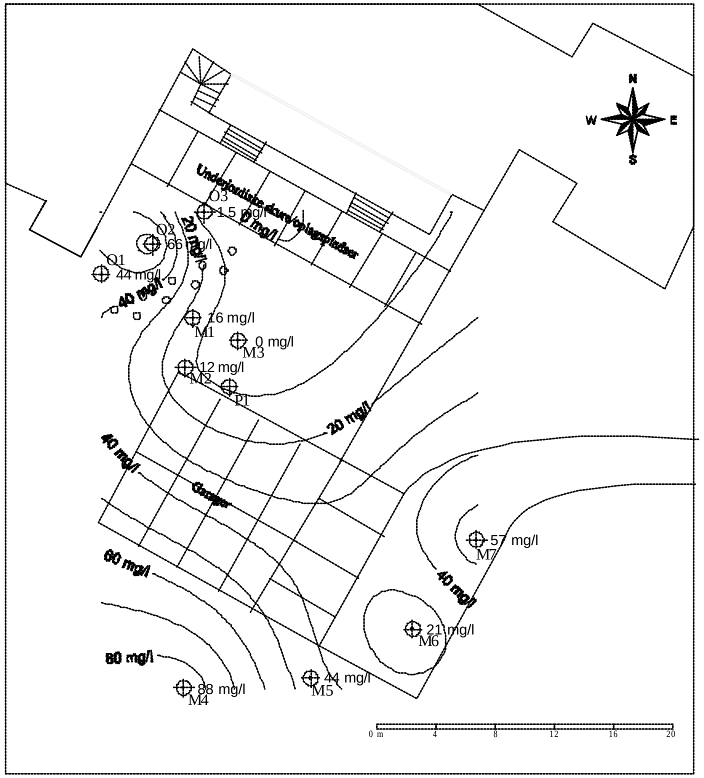
Øvre del



Mellemste del

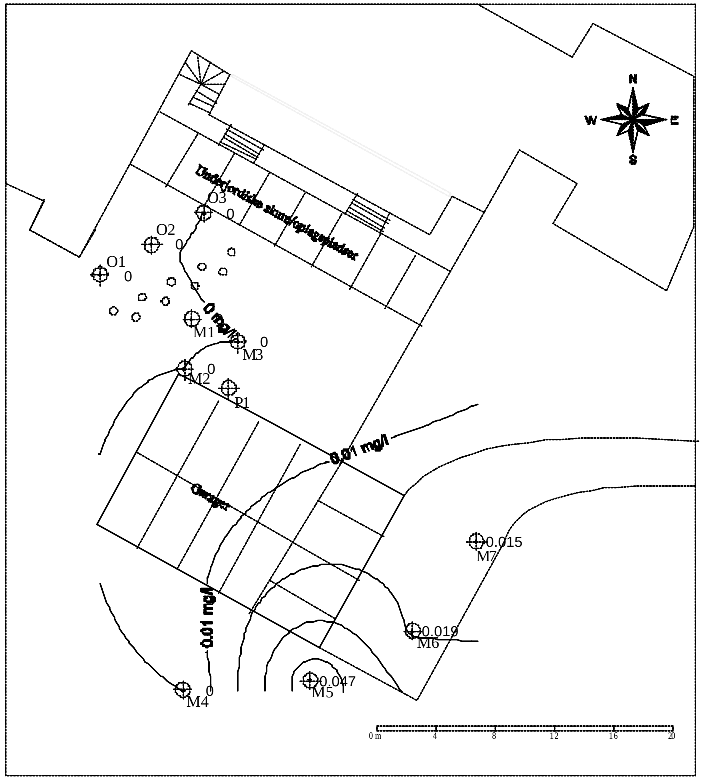


Nedre del

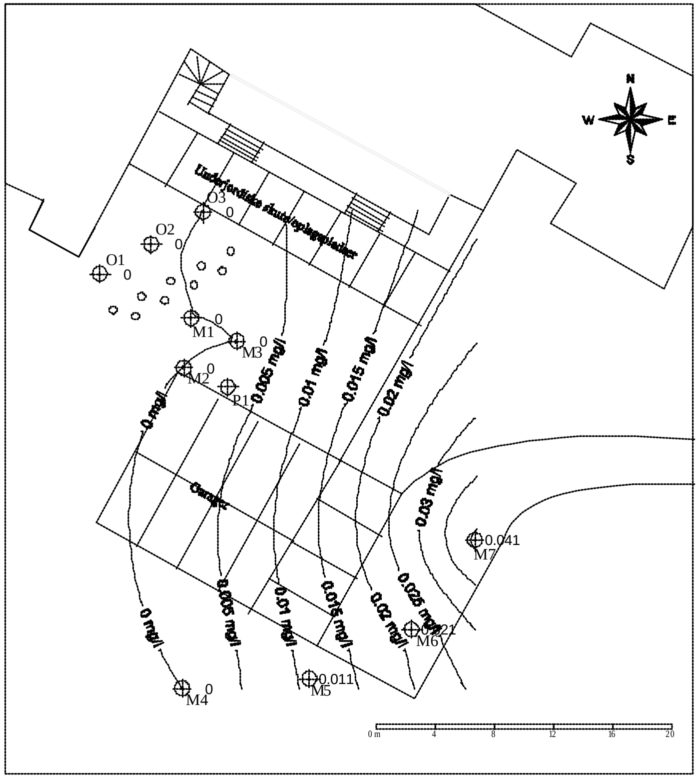


Jern(II)-koncentration i grundvandet (mg/l) - april 2001

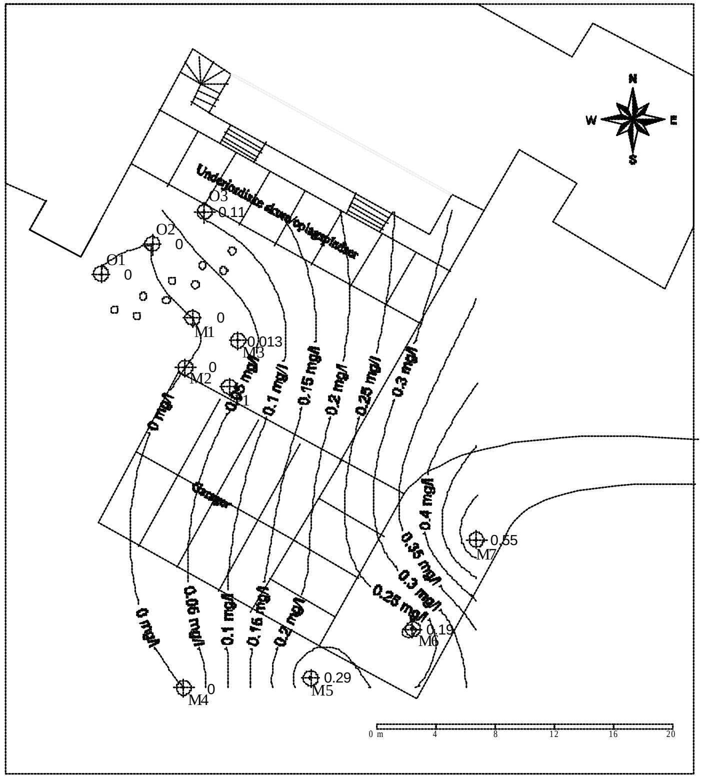
Øvre del



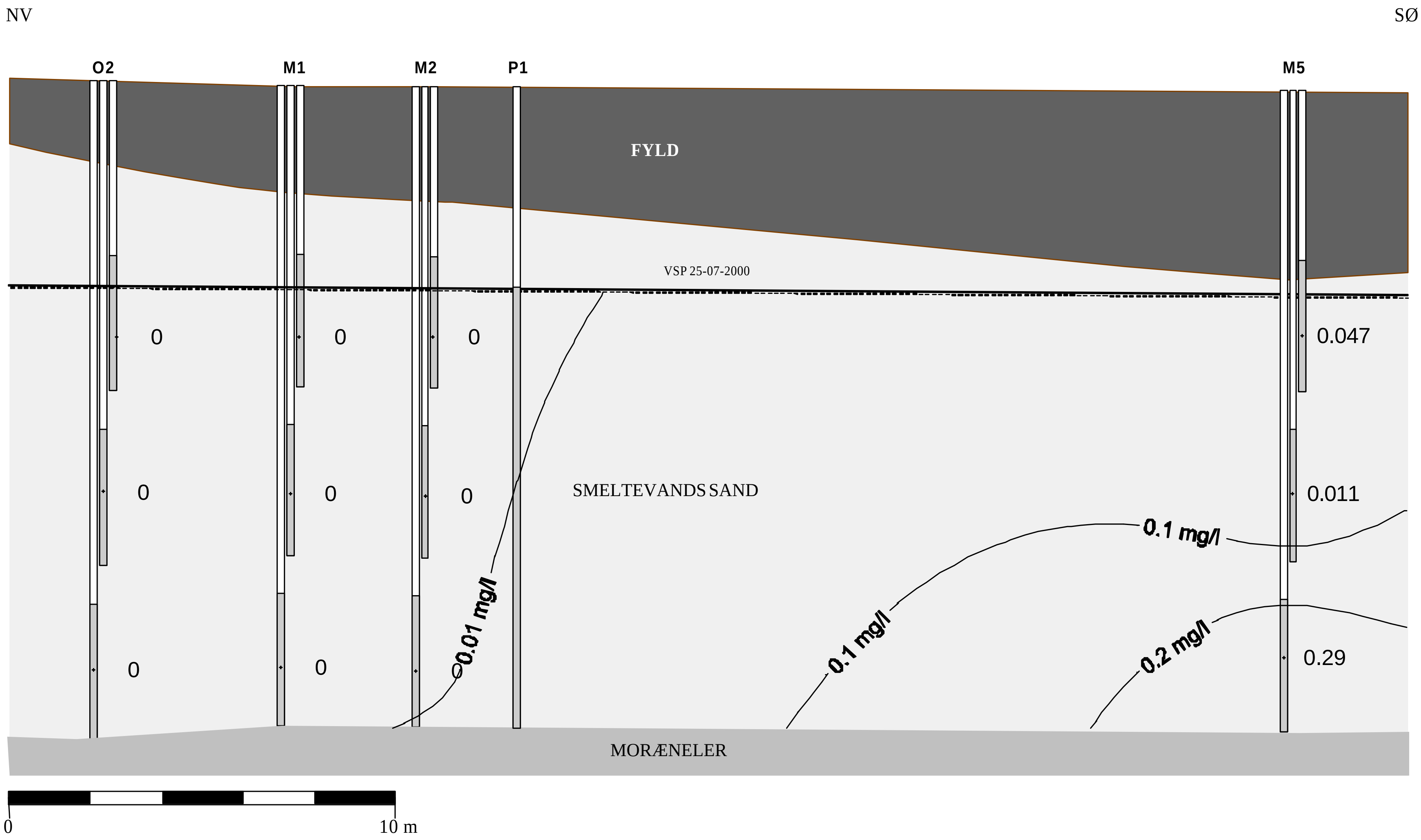
Mellemste del



Nedre del

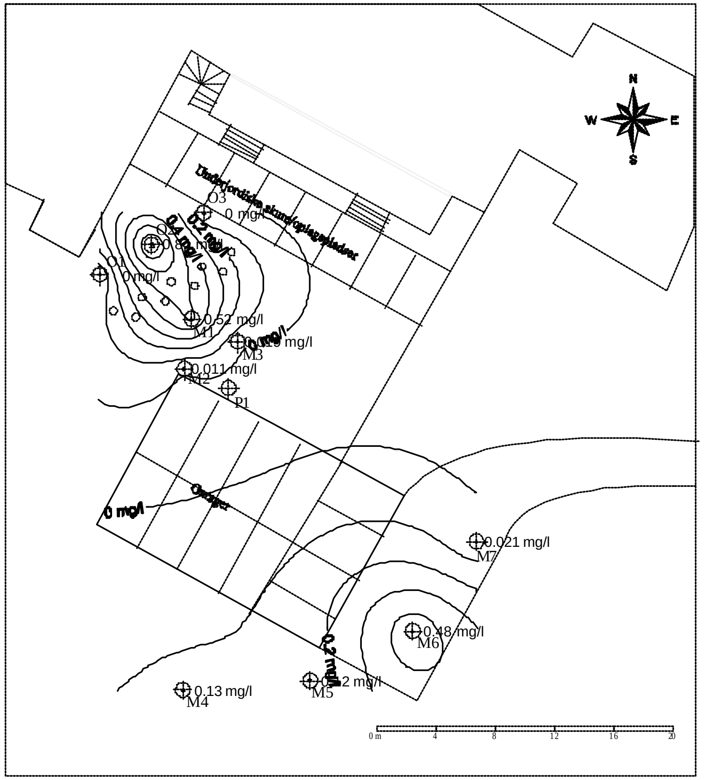


Jern(II)-koncentration (mg/l) - april 2001

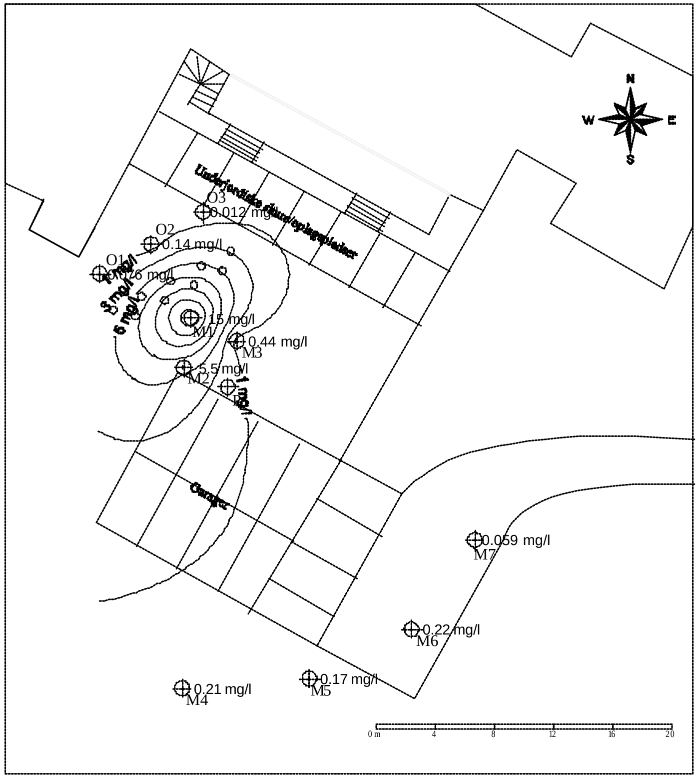


Jern(II)-koncentration i grundvandet (mg/l) - oktober 2001

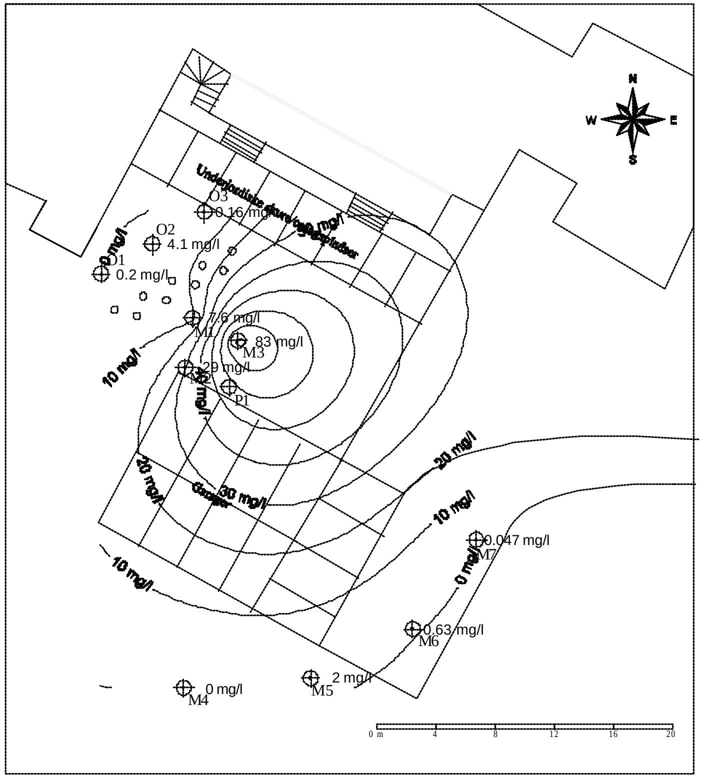
Øvre del



Mellemste del

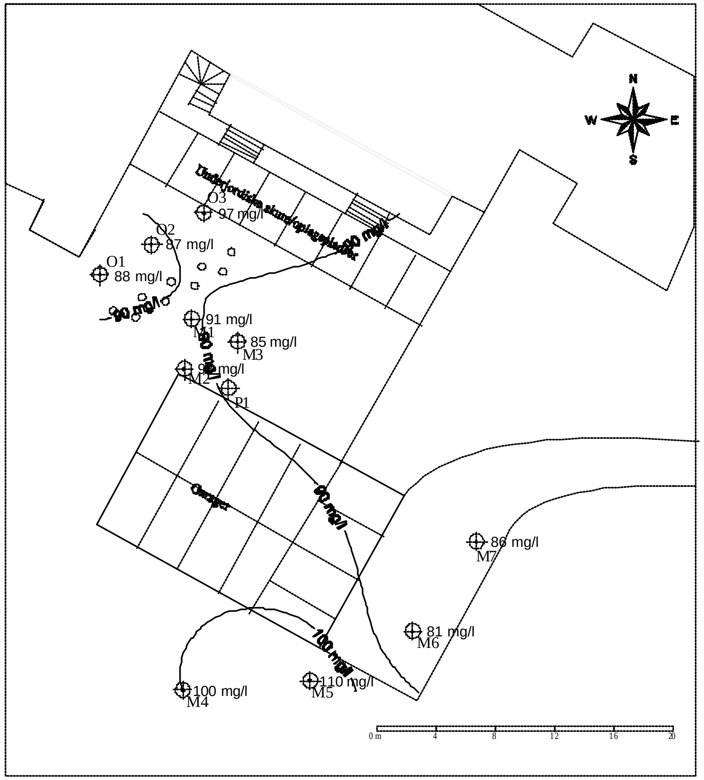


Nedre del

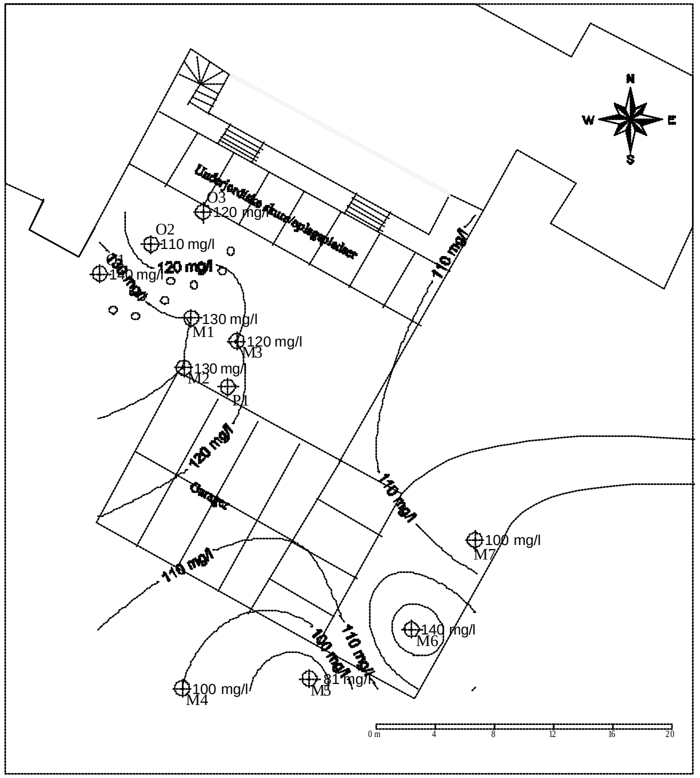


Sulfat-koncentration i grundvandet (mg/l) - april 2001

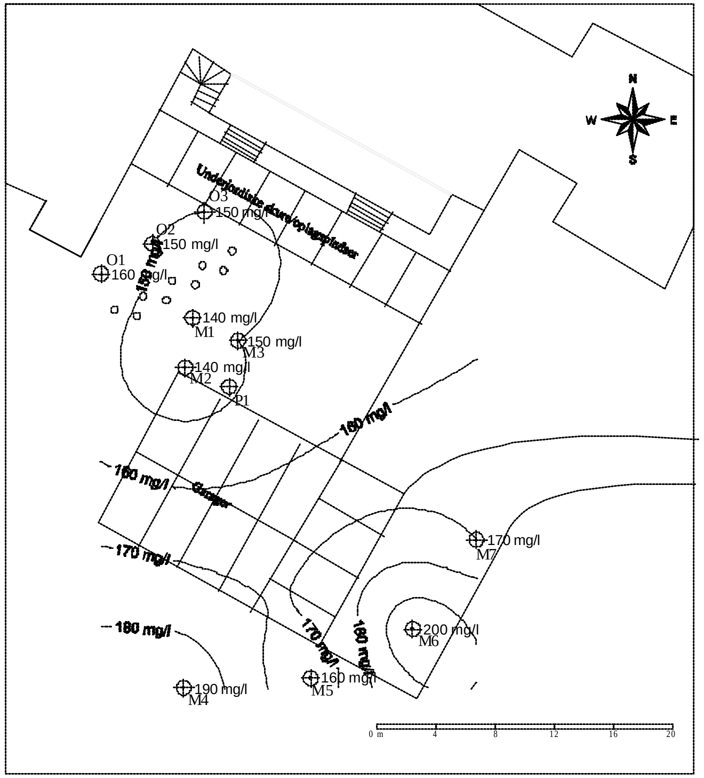
Øvre del



Mellemste del

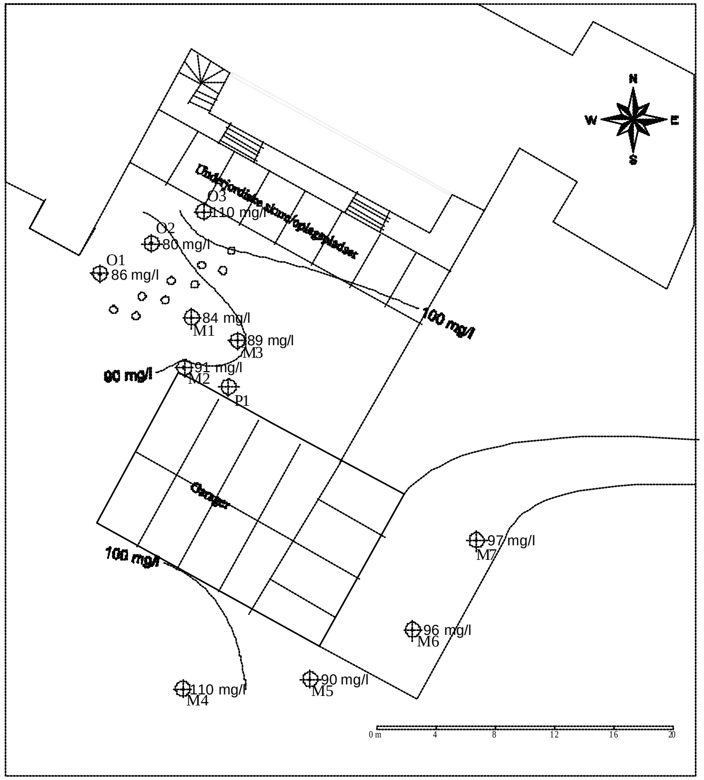


Nedre del

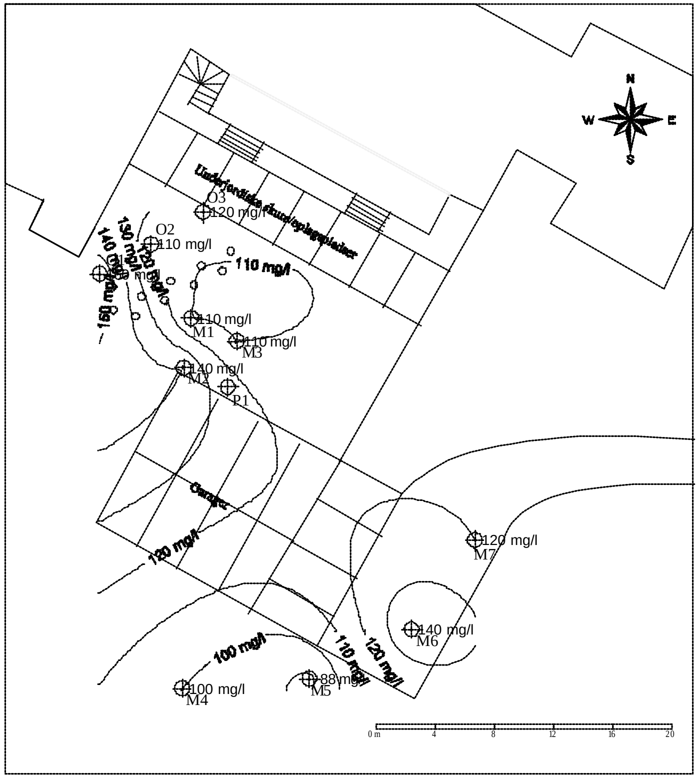


Sulfat-koncentration i grundvandet (mg/l) - oktober 2001

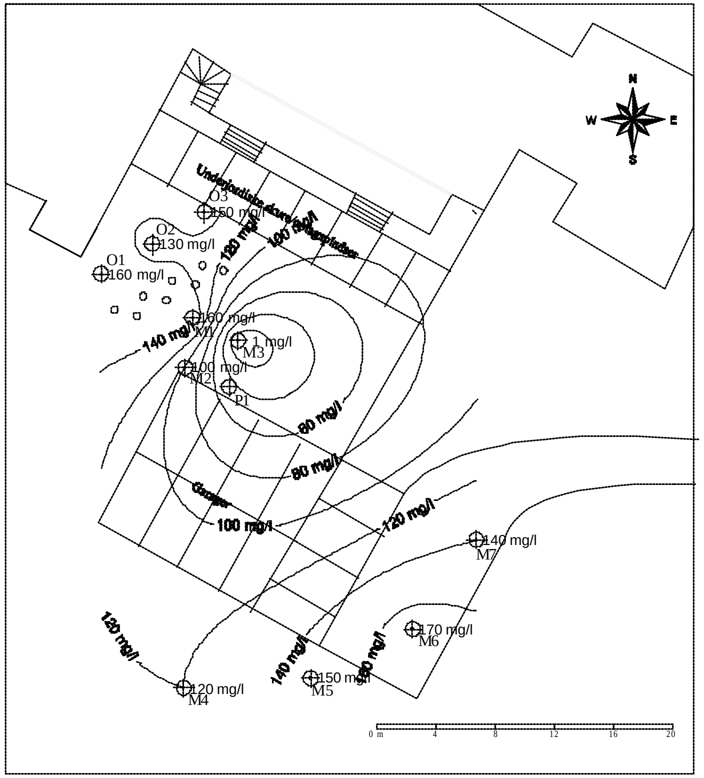
Øvre del



Mellemste del

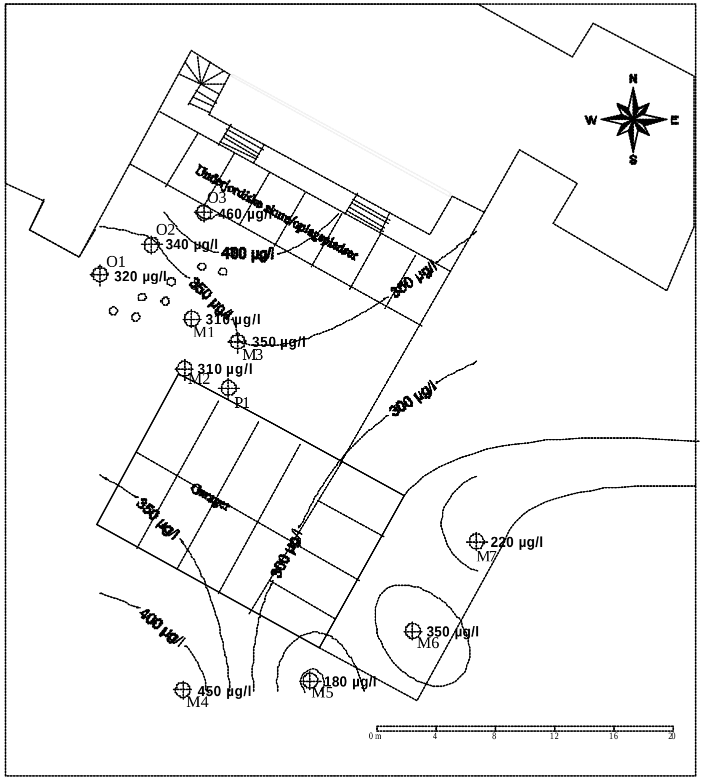


Nedre del

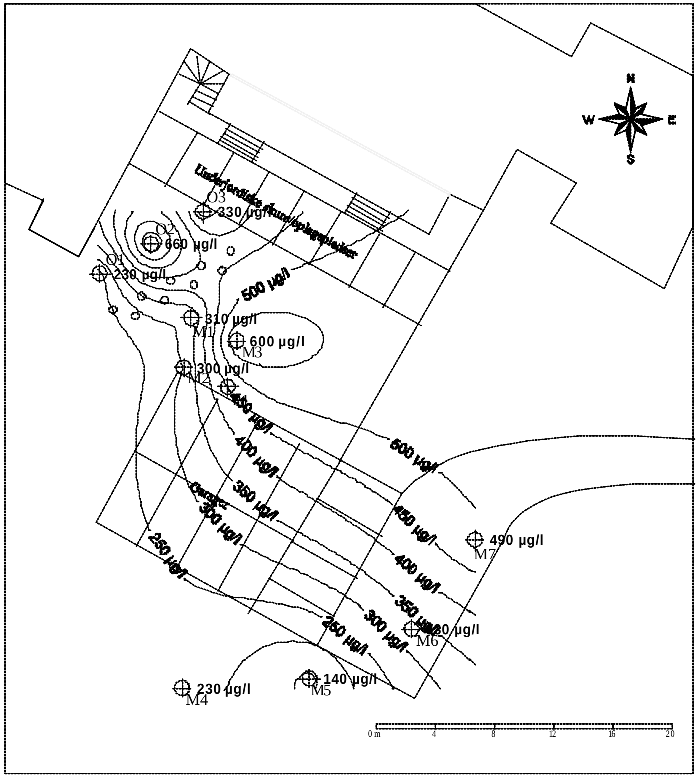


PCE-koncentration i grundvandet (mg/l) - april 2001

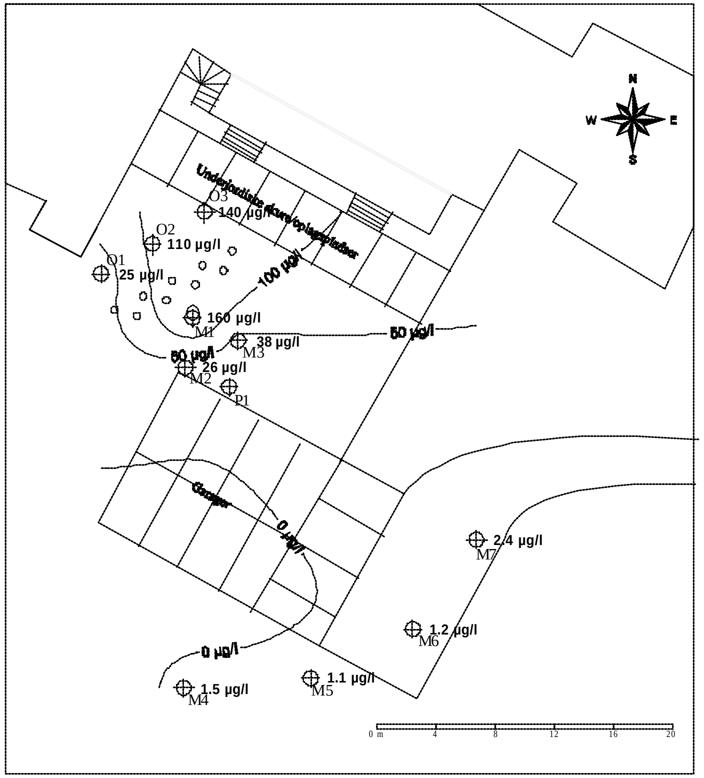
Øvre del



Mellemste del

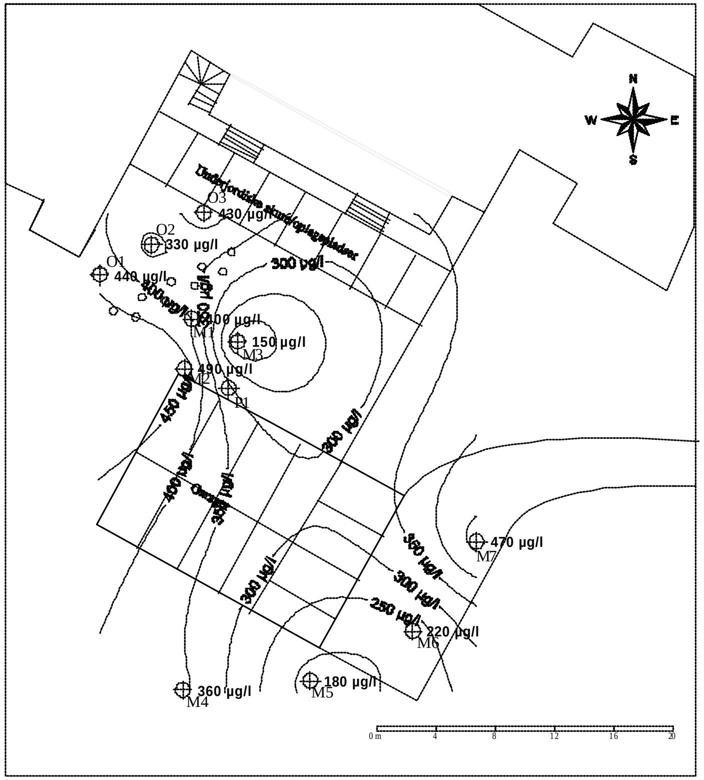


Nedre del

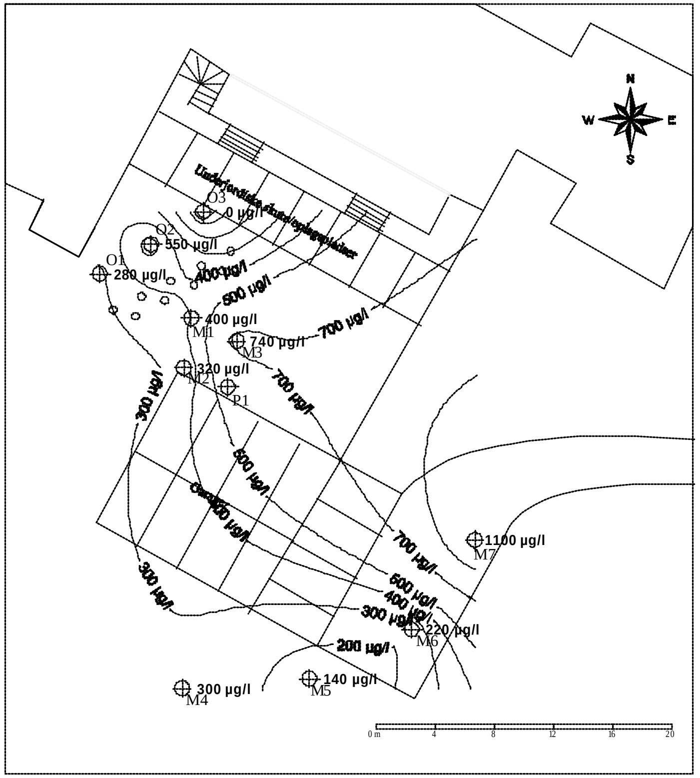


PCE-koncentration i grundvandet (mg/l) - oktober 2001

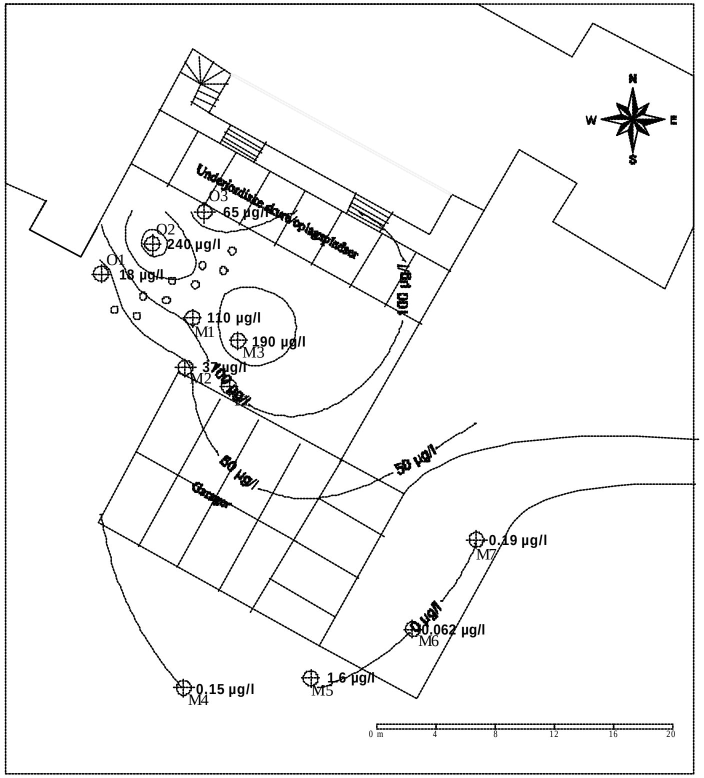
Øvre del



Mellemste del

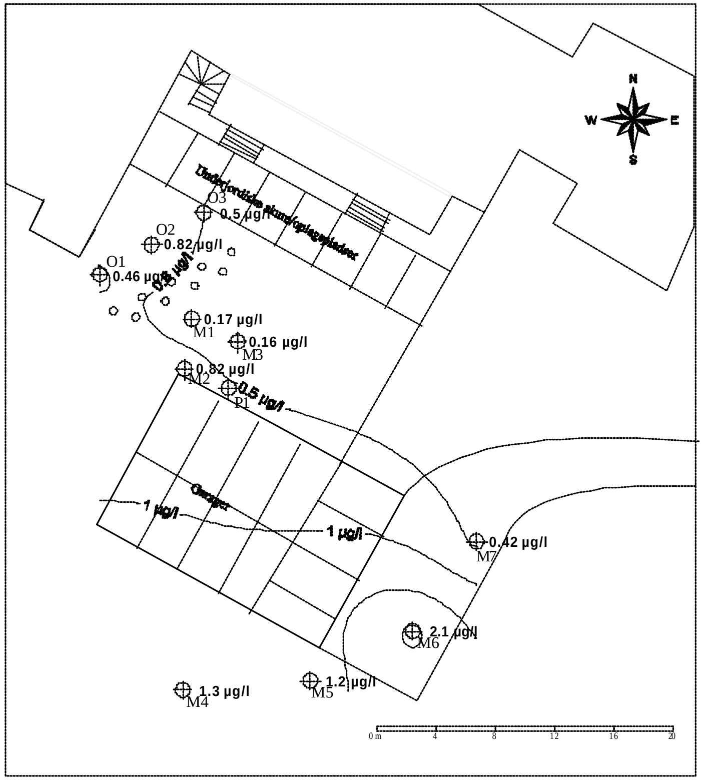


Nedre del

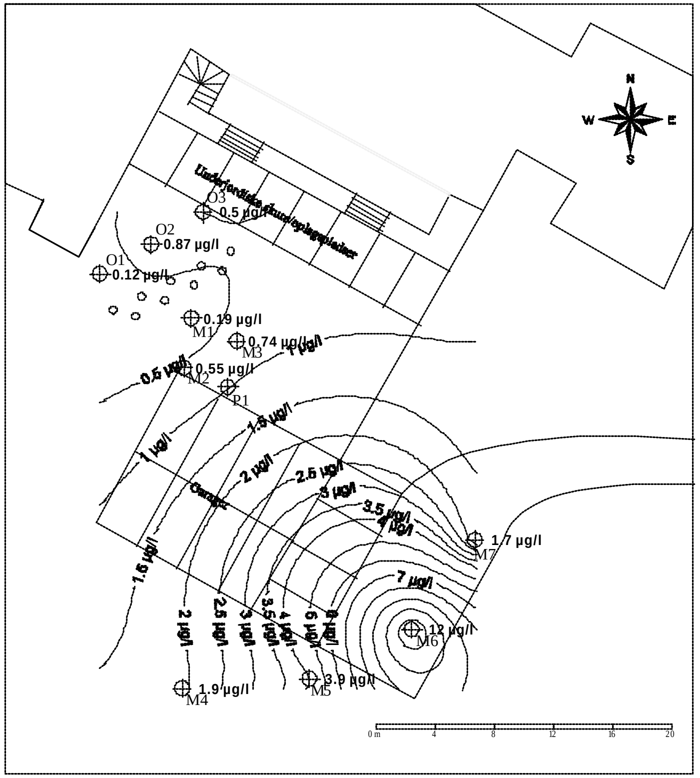


Cis-DCE-koncentration i grundvandet (mg/l) - april 2001

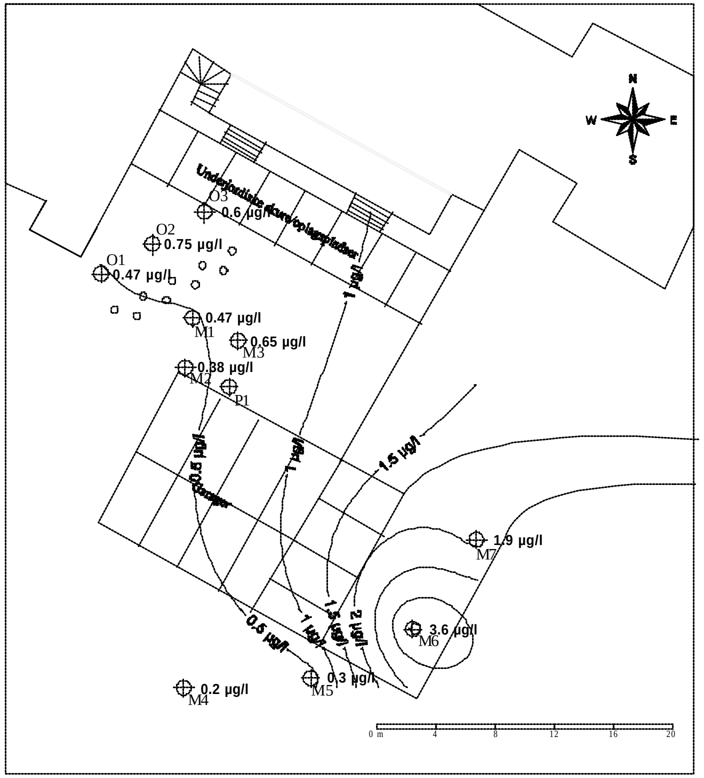
Øvre del



Mellemste del

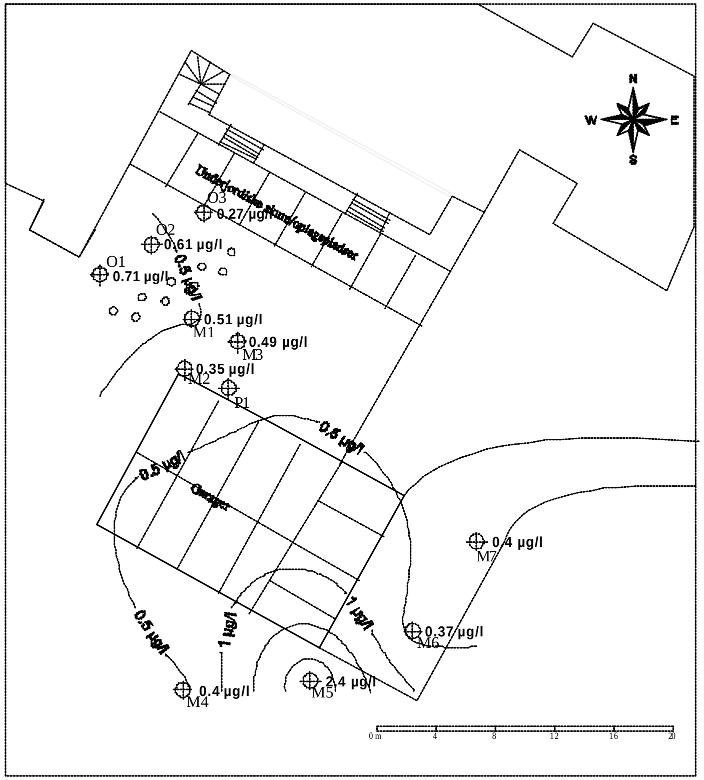


Nedre del

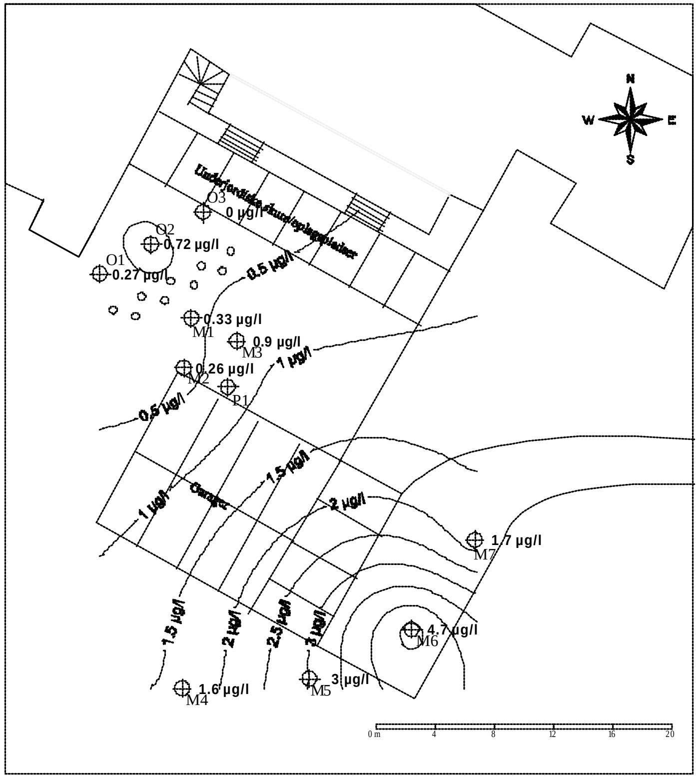


Cis-DCE-koncentration i grundvandet (mg/l) - oktober 2001

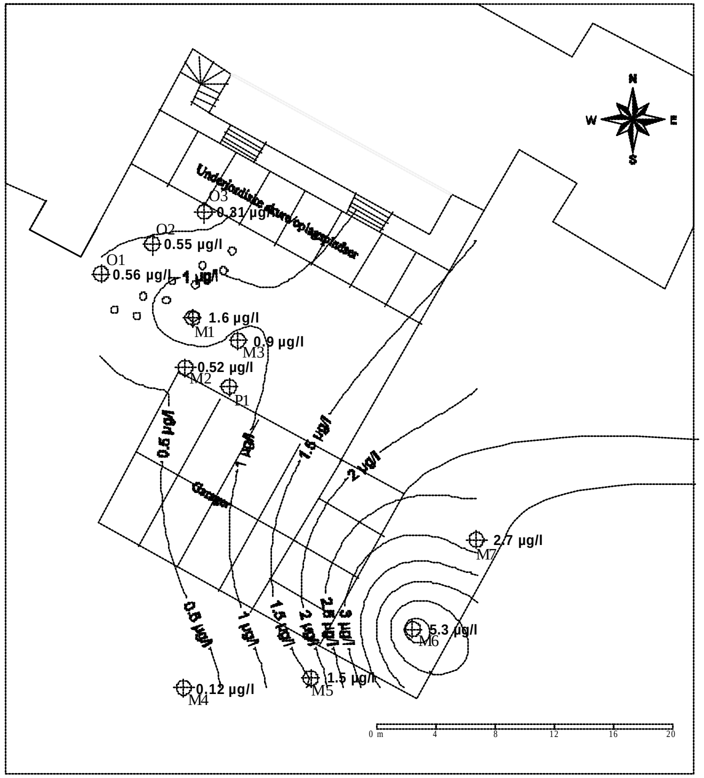
Øvre del



Mellemste del



Nedre del



Regenesis´ kommentarer til rapporten samt økonomisk vurdering af HRC.

REGENESIS

1 April 2003

Christian Mossing
Hedeselskabet
Miljo-og Energidivisionen
Ringstedvej 20
Roskilde, Denmark 4000
Via e-mail: CMO@hedeselskabet.fk

Subject: General Comments on the Hydrogen Release Compound (HRC®) Pilot Test and Report County of Copenhagen Jaegesborge Alle 24 site.

Dear Mr. Mossing:

With the assistance of Gunnar Møller we have reviewed the Jaegersborge Alle 24 report. Many of the issues we have discussed previously are presented in a scientific manner in the report so there is probably no need to go over the details on the technical side. The monitoring network at the site with good vertical control was very nice to have and has revealed some important aspects of working with HRC in this environment. Unfortunately, the monitoring program's sampling frequency and analytes have left gaps in the treatment history and our ability to fully evaluate the performance of HRC. In addition, monthly field data collected did not necessarily correlate with the VOC or geochemical data collected; field parameters are often not an accurate representation of aquifer conditions. Below are some general comments related to this pilot test and HRC in general.

- The test commenced in aquifer zones that were at or above denitrification. Some competing electron acceptor/redox conditions and velocity exceeded the design inputs used for HRC volume estimation. Some dechlorination of TCA and to a lesser degree PCE/TCE may have occurred in the early phase of the pilot; TCA is generally degraded preferentially to PCE/TCE which may explain more evidence of DCA. It is also possible that in the zones where the HRC was evident or injected the treatment zone shifted further downgradient due to the use of the water-soluble HRC Primer, the higher velocity, and redox conditions. It could have been useful to perform additional groundwater sampling via probing downgradient of a treatment barrier at places where there were no monitoring wells.

- The presence of daughter products, cis-DCE and 1,1 DCA, observed in some well samples should be an indication of the presence of reductive-dechlorinating microorganisms. A microbial screening may still be worthwhile to understand the aquifer conditions.

- The vertical distribution of the redox and metabolic acid data does indicate an uneven distribution of the HRC mostly toward the bottom half of the treated aquifer section. We have observed some uneven HRC distributions in aquifers with distinct permeability differences but not to this degree. Any further probe-injections should use an injection tip that injects horizontally.

9 Bard Avenue, Red Hook, NY 12571♦ph. 845 758 9243♦fx. 845 758 9253
Corp. ph. 949 366 8000♦http://www.Regenesis.com♦dave@Regenesis.com

- Although the substrate lasted 12 months as planned the effect was not only diminished by the uneven vertical distribution from the injection but the rapid release of the HRC Primer. We suspect that in this fast aquifer the HRC Primer's effect may have been distributed too quickly downgradient from the core of the test area. We do find regular HRC lasting as long as 18 months on some low-flow sites.

- If there was 'clogging' of the aquifer the effects are reversible since HRC is completely degraded in the subsurface and naturally aerobic conditions in an aquifer can mobilize the reduced metals after the reductive dechlorination is completed.

- The hydraulic and redox factors can definitely be cost controlling elements in accelerated natural attenuation using HRC for low concentration chlorinated hydrocarbon sites. The role of the redox control in cost is often less important with treatment of higher concentrations. In addition, the type of treatment approach can have an impact on the cost due to the time the treatment is needed. Often traditional systems run for many years and/or reach asymptotic limits. With the application of HRC it is often better to use a grid format and treat large sections of the plume to shorten the treatment time. A similar approach is to use a series of barriers to develop a long treatment zone parallel to groundwater flow for groundwater systems with higher velocities, contaminant concentrations and redox problems.

Attached are some information slides comparing different treatment methods for chlorinated hydrocarbons for both high and low concentration conditions. Also attached is the State of New Jersey's (U.S) HRC-Certification that includes an economic analysis and energy usage. HRC is being tested or used on approximately 450 sites including 35 outside of North America. Numerous 'peer reviewed' scientific papers have been published on the use and success of HRC are presented through the Battelle Institute publications and conventions. These, additional references, and links for papers written by consultants is available on our web site.

If some of the possible application and microbial question are addressed, Regenesis is still prepared to offer HRC at no cost for a re-injection as well as contribute to the direct injection contractors costs. Regenesis appreciates the opportunity to respond the pilot report. Please feel free to contact Gunnar Møller or me if you have any questions or need more information.

Sincerely,

David S. Peterson
Principal Hydrologist

State of New Jersey
Department of Environmental Protection
PO Box 402
Trenton, NJ 08625-0402

DONALD T. DIFRANCESCO
Acting Governor

Robert C. Shinn, Jr.
Commissioner
Tel. # (609) 292-2885
Fax # (609) 292-7695

February 16, 2001

Regenesis Bioremediation Products
1011 Calle Sombra
San Clemente, California 92673

Re: Regenesis Hydrogen Release Compound (HRC)

Gentlemen:

Enclosed is the New Jersey Department of Environmental Protection's (NJDEP) Innovative Environmental Technology Certification based on the New Jersey Corporation for Advanced Technology's (NJCAT) verification of Regenesis' Hydrogen Release Compound. The NJDEP accepts the NJCAT verification of the performance claims and the net beneficial effect of HRC. The HRC has been verified through valid quality control sampling and analytical methods. The evaluation documented a net beneficial effect of the HRC to treat contaminated groundwater in an efficient and effective manner. The evaluation was documented through case studies, lab studies, and peer reviewed literature.

The NJDEP can certify that the performance claims made by Regenesis, verified by NJCAT, are sufficient for the department to determine that the technology has a demonstrated effectiveness as defined in the NJDEP's Guidance Document for the Remediation of Contaminated Soils, Jan. 1998. This documentation of the demonstrated effectiveness of HRC will eliminate the technology validation process that would normally precede an evaluation of the use of an innovative technology at a site. This provides for an immediate review of the site-specific application of HRC within an evaluation of the project design.

In addition to the demonstrated effectiveness as a site remediation technology, HRC was able to document a significant reduction in energy use over typical current proven technologies. In a typical site of 0.25 acres, the use of HRC was calculated to save between 340,000 to 660,000 kWhs of electricity when compared to currently commercial available proven technologies. This results in approximately 220 to 430 tons of avoided CO_2 emissions in the use of HRC. This reduction in the use of energy of HRC results in overall lower air emissions, less wastewater discharges and less waste generated in the use of HRC when compared to typical current proven technologies.

Increasing the use of innovative environmental technologies that have a net beneficial effect and can assist the Department in improving our state's overall environmental quality face a two prong barrier to their commercialization and deployment. One is investors and users of the environmental technology may not have access to third party validated data of the performance and the potential successes of the technology. The other is that investors and vendors of the environmental technology face a fragmented market place represented by 50 individual state approval programs. The New Jersey verification and certification process can, in part, address these barriers.

The NJCAT verification of the environmental performance of your technology, HRC, is of itself a valuable commodity. It provides a high degree of confidence to a private sector developer who is seeking to invest in or install and use new environmental technology that can go beyond compliance with regulatory permits or standards. The key to completing our response to barriers to deployment of new environmental technologies is to link the technology verification to a NJDEP certification as set forth in the recently enacted New Jersey Environmental Energy Technology Verification Act. NJSA 13:1D. The NJDEP certification adds to the reduction of the barriers to the deployment of new environmental technologies by increasing access to valid third party evaluation data. This could assist in increasing investment in and use of innovative environmental technologies that can improve New Jersey's environmental quality indicators as established in the NJDEP Strategic Plan.

In order to multiply this effect, the technology and regulatory connection needs to be further linked to an interstate reciprocity process, which has been developed through the Environmental Council of States with the ETARP program. This means that the environmental and operational data and the overall performance of the HRC process as certified by NJDEP is accessible and useable to other states as outlined in the ETARP Project Strategies Report. This will interconnect environmental technology and regulatory acceptance in a way that we, State environmental agencies, can now respond to the real or perceived barriers to environmental technology deployment.

Again, congratulations on your success. The Department through the Commerce Commission and the Department of Treasury will continue to work closely with Regenesis to provide appropriate assistance through a broad array of market applications. A market assistance program that is immediately available is through the Brownfields and Contaminated Sites Remediation Act NJSA 58:10B-6a. This Act can provide matching funding through the Hazardous Discharge Site Remediation Fund for up to 50% or $200,000 of the project cost to perform the remedial action certified by NJDEP.

Sincerely,

Robert C. Shinn
Commissioner

Enclosure

c: Bob Tudor, Deputy Commissioner
Marlen Dooley, Deputy Commissioner
Susan Boyle, Assistant Commissioner Site Remediation
Dennis Hart, Assistant Commissioner Environmental Regulation
Leslie McGeorge, Assistant Commissioner Environmental Planning and Science

1. Introduction

Regenesis, Inc. has developed a technology called Hydrogen Release Compound, HRC, which is a passive treatment alternative for in-situ anaerobic bioremediation of chlorinated compounds. HRC is a proprietary, polylactate ester formulated for the slow release of lactic acid upon hydration. The lactic acid is the source of hydrogen, which can promote reductive dechlorination in the anaerobic subsurface. The reductive dechlorination process can reduce compounds such as perchloroethylene and trichloroethylene to simple and non-toxic endpoints.

A. New Jersey Department of Environmental Protection Technology Certification Program

There is a number of technical regulatory and economic barriers that have been identified which hinder the acceptance of Innovative Environmental Technologies (IETs). Some of the principle barriers center on regulatory acceptance of IETs. In general, new technologies must overcome a two step approval process. First, they must gain the approval from risk-adverse business managers and responsible parties to specify the use of the IETs, and then they need to gain approval from risk-adverse permit writers. This barrier is then magnified when the technology attempts to gain approval in other states.

Technology acceptance can be enhanced by independent third-party review of performance data. The New Jersey Department of Environmental Protection (NJDEP) in cooperation with the New Jersey Corporation for Advanced Technology (NJCAT) has launched an effort to evaluate IETs. This verification/certification program is designed to allow technology vendors to submit information about their technologies along with specific claims regarding the performance of the technology. This information along with data to support the claims will then be reviewed and verified by NJCAT and when appropriate, certification of the technologies' performance will be issued by NJDEP.

It is anticipated that this verification/ certification process will increase both business and regulators understanding of an IET and that the technology's performance, as independently evaluated, will work as claimed.

Both NJDEP and NJCAT are working with other States and Countries on reciprocity agreements, which could interconnect state permitting agencies by recognizing standard protocols for verification of IETs performance. These protocols would assure that technologies are evaluated in a uniform manner assuring minimum standards for quality assurance and quality control (QA/QC). The certification can be viewed by states as tool to predict similar performance under similar conditions.

This certification process is not a replacement nor should it be viewed or construed in any way as advocating or supporting a reduction in current NJDEP environmental performance standards for air, water or soil end points. The certification is not a site-specific permit or a replacement for a site-specific permit; however, it is anticipated that the certification of an IET may facilitate certain permit conditions. For example, in this case, any evaluation of HRC would begin with the site-specific application, bypassing the initial review of the technology.

Finally, it must be noted that certification of an IET does not in any way endorse the manufacturer or guarantee future performance of the technology. It is a report of an independent, verified application of the technology directly related to a set of performance claims.

B. Technology Verification Report

In January 2000, Regenesis Bioremediaiton Products, 1011 Calle Sombra, San Clemente, California, submitted a formal request for participation in the NJCAT Technology Verification Program. The technology involves the controlled release of hydrogen in the subsurface to allow a passive treatment option for in-situ anaerobic bioremediation of chlorinated substances. This request was accepted and a verification report was prepared and submitted to the NJDEP.

C. Technology Description

1. Technology Status

Early 1997 marked the beginning of product development for HRC. HRC is a source of hydrogen that can function as an electron donor in an anaerobic bioremediation system. The product is designed to remediate groundwater contaminated with anaerobically degradable compounds such as perchloroethylene (PCE) and trichloroethylene (TCE). To date, the product has been applied at over 50 sites, primarily in the United States.

2. Technology Applicability

Regenesis has produced a manual guiding the use of the HRC. The manual describes the demand factors on HRC to determine how much to use and where to apply it. Site specific issues are also discussed which can contraindicate the use of HRC. The manual contents assume that the remediation designer has a background in environmental engineering with an emphasis on aquifer bioremediation, but provides the necessary detail and calculation support to assist in developing a natural attenuation/bioremediation design using ORC or HRC.

Regenesis has also created software to simplify and automate the bioremediation evaluation and design process. This software is free from Regenesis. This software is updated as new knowledge and experiences in its use are gained.

2. Applicant

Regenesis evolved from a company called Plant Research Laboratories (PRL), which made Oxygen Plus Plant Food, a fertilizer that was enhanced with oxygen. The oxygen was derived from a stabilized source of urea hydrogen peroxide. Oxygen Plus was designed to alleviate a condition known as soil anaerobiosis. When soils are subjected to flooding, oxygen is limited to the miniscule amount that is soluble in water, and this has a negative impact on plant growth. In the early 1990's the company realized the potential application of this substance in bioremediation. It was renamed Oxygen Release Compound (ORC).

Incorporated in March 1994, Regenesis was founded to extend PRL's work to develop and commercialize ORC for aerobic bioremediation. After extensive laboratory and field testing, ORC was introduced to the market in the spring of 1995. Early 1997 marked the beginning of product development for Hydrogen Release Compound, HRC.

3. Treatment System Description

The natural biodegradation of chlorinated compounds is far more complex than that of petroleum hydrocarbons, and because the densities of most chlorinated compounds are greater than the density of water, their distribution in aquifers is typically far more complex. Biodegradation of many chlorinated ethenes and ethanes does not occur or is quite slow under aerobic conditions. Other chlorinated compounds do degrade under aerobic conditions whereby the chlorinated compound serves as a substrate or as a co-metabolite. Under anaerobic conditions most chlorinated solvents undergo reductive dechlorination. Reductive dechlorination results in the sequential removal of chlorine atoms, generating a series of intermediate degradation products. Depending upon the geochemical conditions and specific microorganisms responsible for degradation, the process may proceed to completely dechlorinate compounds or terminate after removal of only some of the chlorine atoms. Some partially dechlorinated compounds may be degraded under aerobic or iron reducing conditions.

The reductive dechlorination processes in which the chlorinated compounds serve as electron acceptors require the presence of electron donors. HRC is a source of hydrogen and hydrogen is an electron donor. The electron acceptor is the contaminant itself-most commonly a higher-order chlorinated hydrocarbon such as perchloroethylene (PCE) or trichloroethylene (TCE). HRC promotes the microbially mediated, sequential destruction of chlorinated compounds under anaerobic conditions. This essentially translates to the removal, under anaerobic conditions, of various numbers of chlorine atoms from the molecule until it is rendered either benign or aerobically degradable, whichever comes first. In a common example of this reaction sequence, one begins with perchloroethylene (PCE), which has four chlorine atoms. Under the influence of HRC, and under the right chemical and biological conditions, PCE is reduced to TCE (three chlorine's), then to dichloroethylene (DCE) (two chlorine's), and then to vinyl chloride (VC) (one chlorine). The VC is toxic and must then be reduced to the chlorine-free ethene skeleton that was originally filled with the four chlorines. The reactions from DCE on down can occur under both anaerobic and aerobic conditions. Usually the HRC application is enough, but sometimes a switch to aerobic conditions is warranted.

Reductive dechlorination describes the anaerobic phase of the mechanism just described and can often bring the molecule to its fully dechlorinated form. In reductive dechlorination, anaerobic microbes substitute hydrogen for the chlorine in the molecule using both the hydrogen and electrons that result from the breakdown of HRC. Therefore, HRC offers a physically passive treatment option for *in-situ* anaerobic bioremediation of chlorinated compounds.

HRC is a proprietary, environmentally safe, food quality, polylactate ester formulated for the slow release of lactic acid upon hydration. The lactic acid is important because it produces hydrogen. Many organic substances can serve as sources of hydrogen through fermentation reactions; however, lactic acid and related volatile fatty acids are some of the best substrates for this task as it pertains to reductive dechlorination.

There are several site-specific parameters that can affect the performance of HRC:

1. It is important to assess that there are microbes in the aquifer soil capable of dechlorination. The sulfate reducing bacteria (SRB) content should be determined. The rationale is that SRBs thrive at a redox potential that is close to the optimum for dechlorination. Although the dechlorinators are not necessarily SRBs, the presence of SRB indicates that aquifer conditions may be suitable for reductive declorination. One must be aware, however, that a high SRB count also indicates a high level of competition for hydrogen so that more HRC will be required.

2. In natural systems, including contaminated aquifers, most H_2 becomes available to hydrogenotrophic microorganisms through the fermentation of more complex substrates by other members of the microbial consortium. The dechlorinators must then compete

with other organisms, such as methanogens and sulfate-reducing bacteria, for the evolved H_2.

3. The concentrations of Competing Electron Acceptors (CEAs) such as dissolved oxygen, nitrate, ferric iron, and sulfate have an effect on the amount of HRC required for enhancing *in-situ* bioremediation. Hydrogen from the HRC is used to reduce these CEAs to create redox conditions that are conducive to reductive dechlorination processes. As a result, the CEA demand for hydrogen (and consequently HRC) must be considered in the specification of the amount of HRC required for a project. Groundwater data indicating the actual site values for these parameters are important in determining an accurate final design for HRC application.

Regenesis has a patent pending in the United States for HRC.

4. Technical Performance Claims

Claim 1 – Pilot and full-scale field demonstrations have shown, depending on site conditions and the formulation of the product, that HRC remains for four months to a year, releasing lactic acid.

Claim 2 – Lactic acid released from HRC, in the presence of indigenous anaerobic microbes, can be fermented to released hydrogen which can serve as an electron donor for biological reductive dechlorination.

Claim 3 – Perchloroethylene (PCE) and trichloroethylene (TCE) have been shown to be bioremediated in the presence of the hydrogen electron donor in microbially competent aquifers.

Claim 4 – During the period that the HRC releases lactic acid, the potential for the enhancement of natural rates of reductive dechlorination exist.

5. Treatment System Performance and Technical Evaluation and Verification of Performance Claims

The NJCAT Technology Verification for HRC is attached as Appendix 1. Based on the evaluation of the results from laboratory studies, field demonstrations and peer-reviewed journal articles there is sufficient evidence to support Regenesis Claims 1,2,3 and 4.

This verification signifies NJDEP's acceptance of these claims, and as such, the department will not require Regenis or the responsible party using this technology at a site to resubmit this type of basic technology information in the future. The acceptance of HRC will allow the Department in subsequent cases to simply review the site-specific application of HRC. This should reduce the workload for case managers and shorten the review time for work plans.

6. Limitations of HRC Performance

The review of this information also indicates that there are some limitations of HRC that should be discussed. HRC is best utilized for the remediation of dissolved phase plumes and the associated hydrophobically sorbed contaminant. The use of HRC for the remediation of free-phase DNAPL is generally not appropriate, since the stoichiometrically required levels of product would be excessive, unless the total mass to be remediated is within the scope of economic feasibility in comparison to alternative treatments.

HRC injected into highly heterogeneous aquifers will not effect dechlorination in contaminated areas that are not hydraulically connected to the HRC injection zone.

In some instances, extremely high background sulfate levels (on the level of several hundred ppm or greater) generate concern, as the reduction of sulfate will consume some of the available hydrogen from the lactic acid fermentation reducing the efficiency of dechlorination during the early phase of the treatment.

Dechlorination (degradation) rates of compounds like perchloroethylene (PCE) and trichloroethylene (TCE) are highest under anaerobic conditions. However, daughter products of PCE and TCE, such as dichloroethylene (DCE) and vinyl chloride (VC) – a known carcinogen, degrade more slowly under anaerobic conditions. The reactions from DCE on down may actually degrade faster under aerobic conditions. Frequently the HRC application is sufficient to degrade the VC to ethylene, a non-toxic compound. Some sites may benefit from a dual phase approach where an electron donor, e.g., HRC and an electron acceptor, e.g., ORC (Oxygen Release Compound) are used either concurrently on separate areas of a plume, or sequentially within the plume area.

7. Net Environmental Benefit

The NJDEP encourages the development of IETs and has established a performance partnership between their verification/certification process and NJCAT's third party independent technology verification program. The NJDEP, using the IETs data and technology verification/certification process will work with any New Jersey-based company that can demonstrate a Net Beneficial Effect (NBE) irrespective of the operational status, class or stage of an IET. The NBE is calculated as a mass balance of the IET in terms of its inputs of raw materials, water and energy use and its outputs of air emissions, wastewater discharges, and solid waste residues. Overall the IET should demonstrate a significant reduction of the impacts to the environment when compared to baseline conditions for the same or equivalent inputs and outputs. The Regenesis HRC process is compared with two existing chlorinated hydrocarbon remediation processes to demonstrate the NBE required by NJDEP.

The two alternative remediation technologies chosen are pump and treat and air sparging with soil vapor extraction (SVE). The NBE comparison is based on the KWhr requirements for each remediation technology, assuming a remediation schedule, e.g., five years, for three different size sites. In addition to the information shown in Table 2, the following assumptions were made:

- Well Installation
  - 400 hp engine drilling-rig
  - Three (3) hours per well installation
- HRC Application via Direct Push Methods
  - 150 hp engine – direct push rig
  - 20 hp injection pump (6 hrs per day)
  - Fifteen (15) injections per eight (8) hours

Table 2 – Design Data for Remediation Technologies Selected for Net Environmental Benefit Determination

Remediation Technology	Site Size		
	50' x 75'	0.25 Acre	0.50 Acre
HRC Enhanced Bioremediation (4 applications)	60 injection pts.	110 injection pts.	220 injection pts.
Air Sparging/SVE (5 yrs. operation)	12 AS/4 VE wells 1-5 hp blower	36 AS/12 VE wells 1-10 hp blower	72 AS/24 VE wells 1-20 hp blower
Pump & Treat (10 gpm, 20 yrs)	2–extraction wells 2-1 hp extraction pumps	2–extraction wells 2–2 hp extraction pumps 1–1 hp injection pump	2–extraction wells 2–3 hp extraction pumps 1–1 hp injection pump

Using the information on well installation and HRC application, along with the design data shown in Table 2, life-cycle energy requirements for the three remediation technologies were calculated and are shown in Table 3. The NBE of HRC remediation is clearly evident. In addition, the HRC remediation process avoids the carbon treatment system reactivation or disposal requirements associated with the other two technologies.

Table 3 – Energy Requirements for Current/Proven Remediation Technologies Selected vs. HRC in KWh

Remediation Technology	Site Size		
	50' x 75'	0.25 Acre	0.50 Acre
HRC Enhanced Bioremediation (4 applications)	15,760	28,760	57,524
Air Sparging/SVE (5 yrs operation)	177,715	369,770	950,680
Pump & Treat (10 gpm, 20 yrs)	263,190	689,825	1,393,030

The significant energy savings reflected in the Table 3 can be converted into estimated avoided air emissions for gases of concern such as CO_2, SO_2, and NO_x. Using data on emission factors for CO_2, SO_2, and NO_x for electricity purchase obtained from the Pennsylvania, New Jersey, and Maryland (PJM) power pool, Table 4 compares the current proven technologies with HRC applications for the pounds of air emissions that will be avoided over the lifecycle time periods required. This same methodology can be used to estimate the particulate emissions reductions for total, PM10 and PM 2.5. It can be used to estimate the specific metal emissions reductions resulting from avoided emission including cadmium lead, mercury or any specific metal emissions.

Table 4 – Avoided Air Emission for CO2, SO2 and NOx from Energy Use for Current/Proven Remediation Technologies vs. HRC (in pounds and (tons-rounded to 1 SF))

Remediation Technology	Site Size								
	50' x 75'			0.25 Acre			0.50 Acre		
	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x
Air Sparging/SVE (5 yrs operation)	210,760 (105.4)	1,623 (0.8)	538 (0.3)	443,773 (221.9)	3,478 (1.7)	1,091 (0.5)	1,162,309 (581.2)	8,949 (4.5)	2,858 (1.4)
Pump & Treat (10 gpm, 20 yrs)	321,993 (161.0)	2,479 (1.2)	792 (0.4)	860,271 (430.0)	6,624 (3.3)	2,115 (1.0)	1,737,961 (869.0)	13,382 (6.7)	4,274 (2.1)

The data from Table 3 can also be related to non-contact non- consumptive cooling water use, wastewater discharges and waste generated in the same methodology as for air emissions. The avoided water use, wastewater discharged and waste generated is assessed based on the avoided use of electricity. The NJDEP methodology of Uniform Cross Media Electricity Generation Evaluation System was developed using data on the externality costs of electricity documented by Pace University in their report, *Environmental Costs of Electricity, 1991*. For example, the 0.25 Acre site using HRC would save over 340,000 kilowatt hours (kWhs) of electricity over a typical air sparging operations/SVE for 5 years and over 660,000 kWhs of electricity over a typical 20 year pump and treat operations.

Utilizing the NJDEP's methodology this would result in the avoid use of 22 and 42.8 million gallons of non-consumptive cooling water use over the lifecycle of the proven technologies of air sparging and pump and treat respectively when compared to the HRC use. It would result in 13,600 and 26,400 of avoided wastewater discharge in the use of HRC when compared to the proven technologies over the lifecycle of their use. Further the use of HRC when compared to the proven technologies over their lifecycles would result in 54,400 pounds (27.2 tons) and 105,600 pounds (52.8 tons) of avoided waste generation. Individually the quantity of the avoided impacts are relatively small but when aggregated at a number of sites across New Jersey these avoided impacts can become significant.