

Supplementary Information

Remediation of the alluvial aquifer of the Sardas landfill (Sabiñánigo, Huesca) by surfactant application

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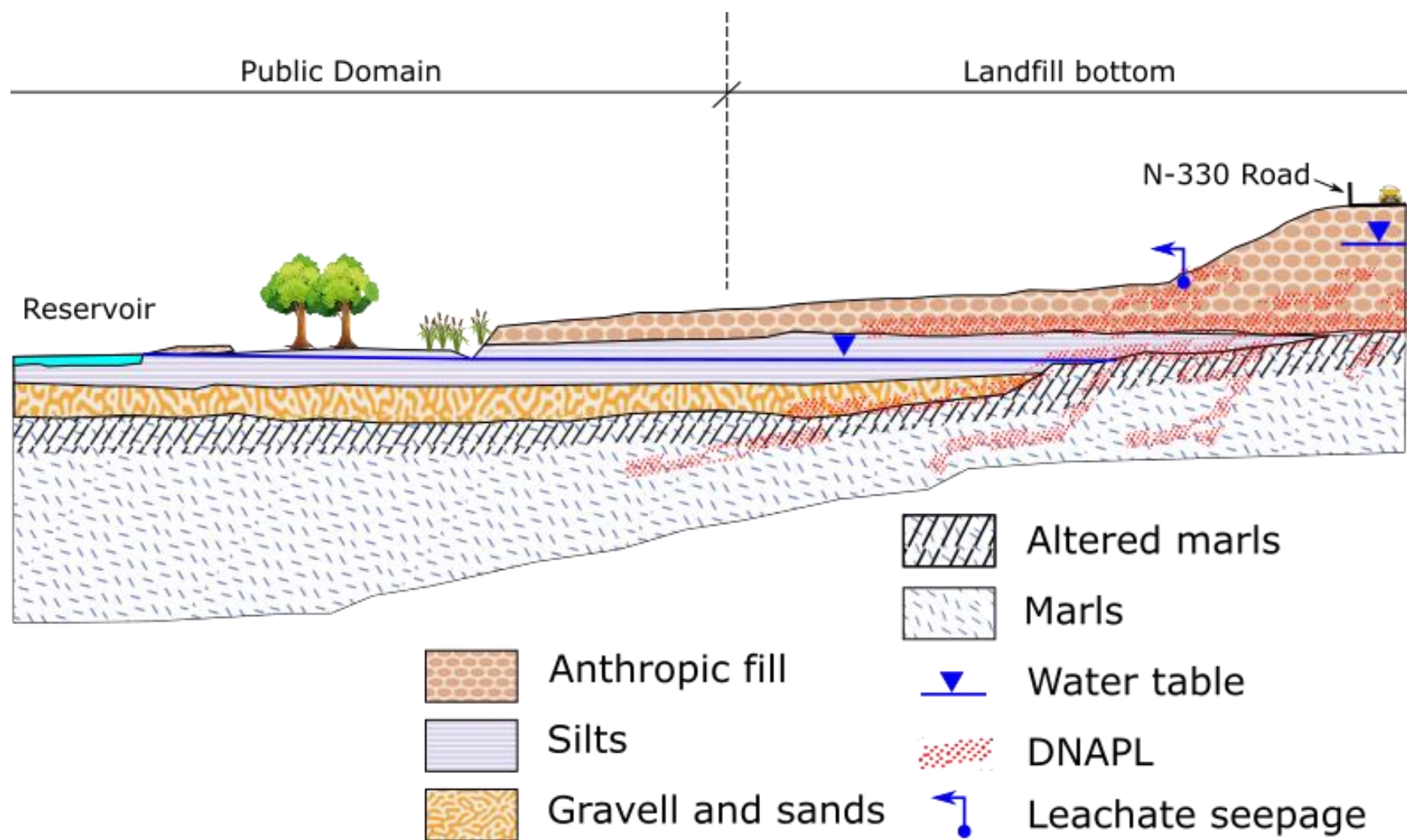


Figure S1. Conceptual model of the subsoil at Sardas landfill.

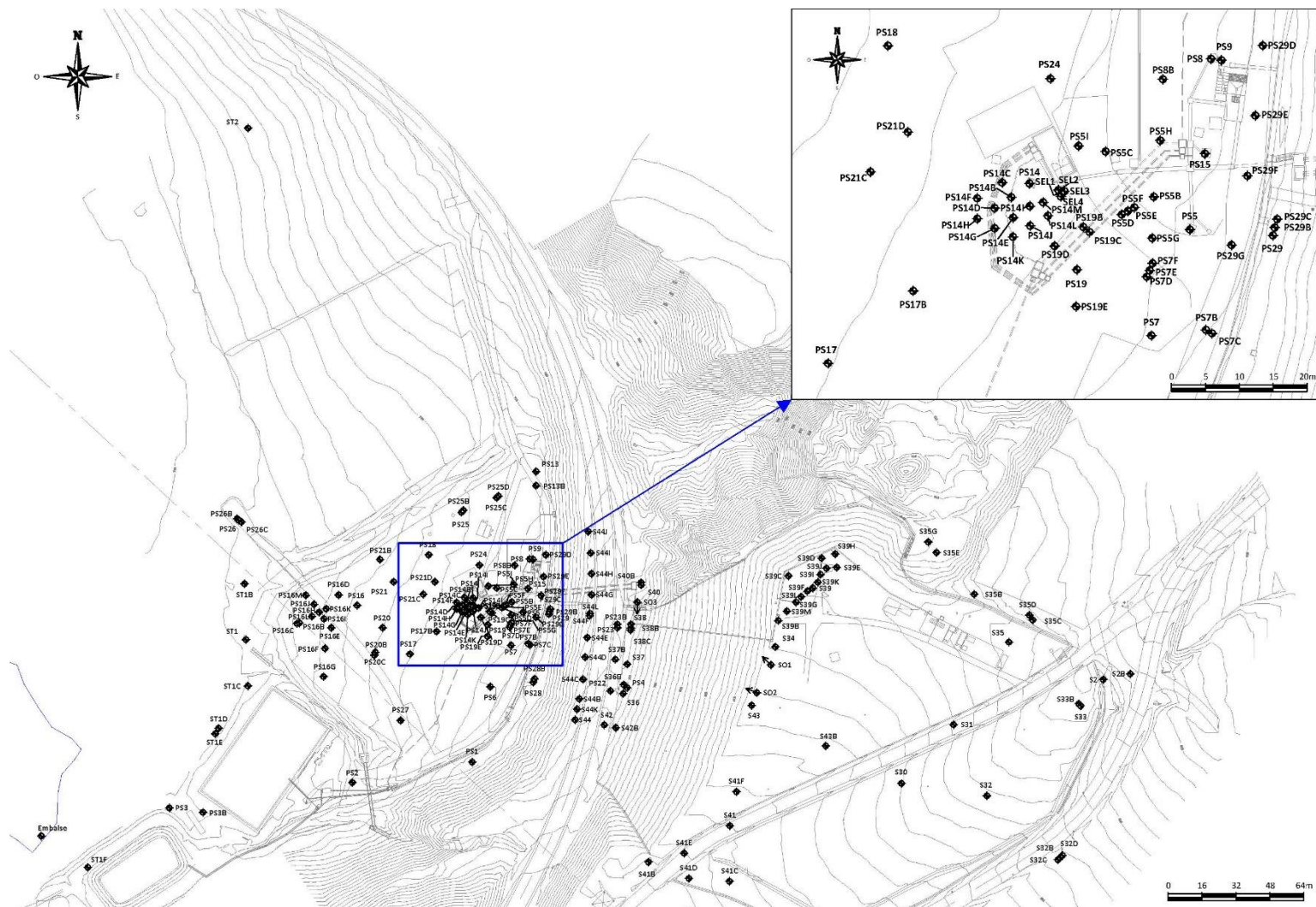


Figure S2. Complete map of wells in the Sardas Landfill



Figure S3. Appearance of GW samples taken at the end of the extraction in the injection event 1 and view of sedimentation tanks.

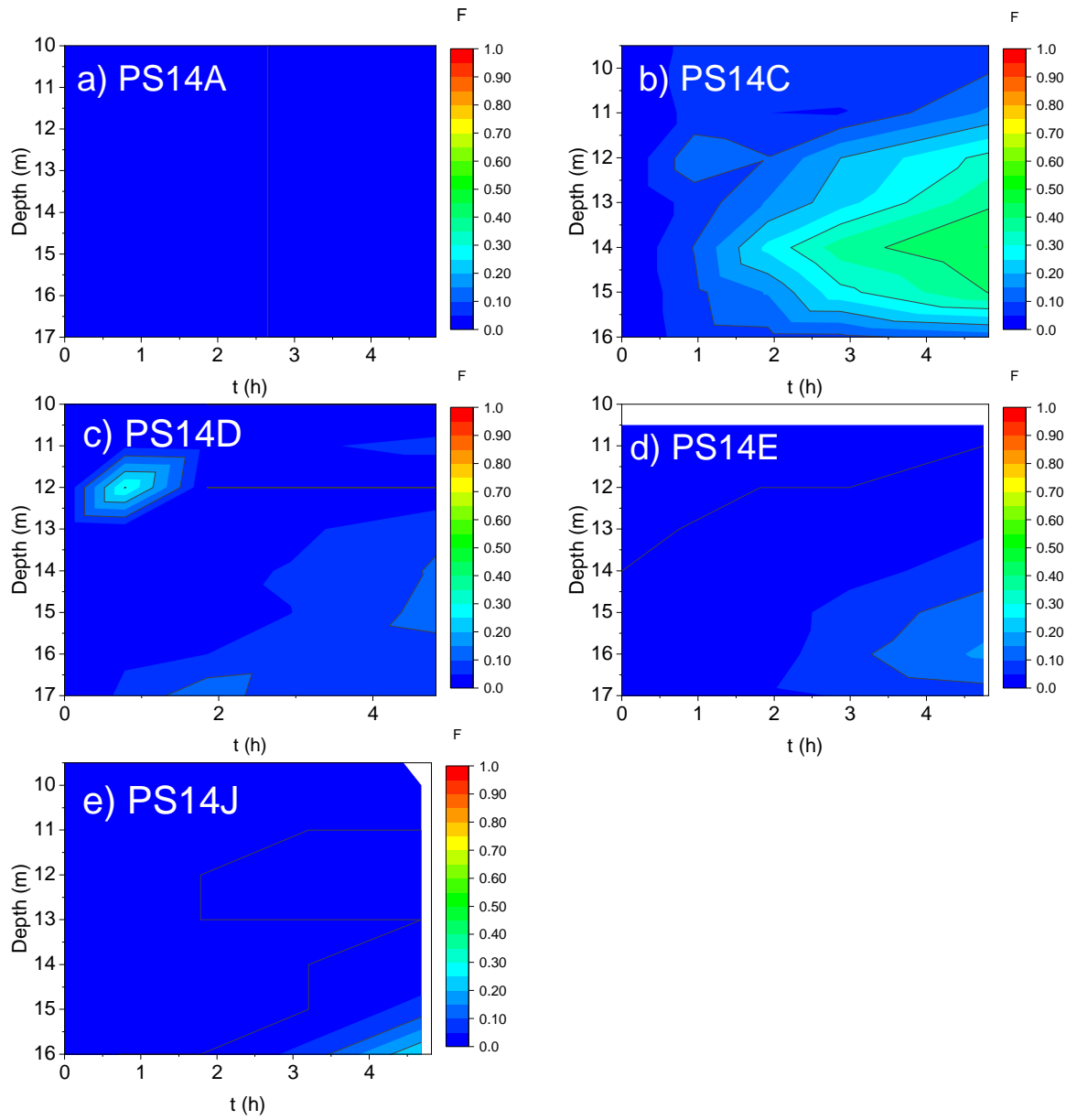


Figure S4. Dimensionless conductivity profiles (F_k , eq 3) with time and depth (m.s.n.s) in wells a)PS14A, b) PS14C, c)PS14D, d)PS14E and e) PS14J.

Table S1. Characteristics of the piezometers in the PS14s area. Reference elevations (msns) and depths (m).

Piezometers/ injection well	Reference point	Bottom of piezometer	Top depth Gravels	Top depth Marls	Silt-gravel contact depth (ground level)	Depth of silt-gravel contact (piezometer mouth)	Gravel-loam contact depth (ground level)	Gravel-loam contact depth (piezometer mouth)
PS14	774.805	756.155	761.355	758.455	12.800	13.45	15.700	16.350
PS14B	774.287	757.467	761.467	758.467	12.500	12.82	15.500	15.820
PS14C	774.197	757.637	761.637	758.537	12.300	12.56	15.400	15.660
PS14D	774.178	757.058	761.258	757.858	12.700	12.92	16.100	16.320
PS14E	775.239	757.109	761.709	758.109	12.400	13.53	16.000	17.130
PS14F	774.653	756.863	761.863	758.363	12.000	12.79	15.500	16.290
PS14G	774.909	757.569	761.569	758.569	12.500	13.34	15.500	16.340
PS14H	775.069	756.959	761.559	758.459	12.400	13.51	15.500	16.610
PS14I	774.61	757.33	761.23	758.43	12.900	13.38	15.700	16.180
PS14J	774.847	757.607	761.607	758.307	12.600	13.24	15.900	16.540
PS14K	774.827	757.657	761.557	758.457	12.600	13.27	15.700	16.370
PS14L	774.85	757.58	761.08	758.38	13.200	13.77	15.900	16.470
PS14M	774.897	757.627	761.027	758.527	13.200	13.87	15.700	16.370
PS5C	774.414	758.214	761.114	759.014	13.300	13.30	15.400	15.400
PS5D	774.556	758.056	760.856	759.256	13.700	13.70	15.300	15.300
PS19B	774.561	758.432	760.432	759.032	13.900	14.13	15.300	15.529
PS19D	775.075	758.32	761.32	758.82	12.900	13.76	15.400	16.255
PS21C	773.674	757.189	761.889	758.089	11.000	11.79	14.800	15.585
PS21D	773.806	758.001	761.901	758.801	11.100	11.91	14.200	15.005

Table S2. DNAPL Composition.


COMPOUND		M (g/mol)	C (mg/kg)	%w
Name	Acronym			
Chlorobenzene	CB	112.5	96610.1	10.0
1,3 -dichlorobenzene	1,3-DCB	147.0	5954.1	0.6
1,4 -dichlorobenzene	1,4-DCB	147.0	54140.5	5.6
1,2 -dichlorobenzene	1,2-DCB	147.0	43743.0	4.5
1,3,5 trichlorobenzene	1,3,5-TCB	181.5	1812.8	0.2
1,2,4 trichlorobenzene	1,2,4-TCB	181.5	129035.3	13.4
1,2,3 trichlorobenzene	1,2,3-TCB	181.5	20061.7	2.1
1,2,4,5-tetrachlorobenzene / 1,2,3,5-tetrachlorobenzene	TetraCBa (1,2,4,5 + 1,2,3,5)	216.0	52347.6	5.4
1,2,3,4-tetrachlorobenzene	TetraCBb (1,2,3,4)	216.0	72957.8	7.6
γ -Pentachlorocyclohexene	γ -PentaCX	254.0	21236.8	2.2
1,2,3,4,5 Pentachlorobenzene	PCB	250.0	5642.4	0.6
δ -Pentachlorocyclohexene .	δ -PentaCX	254.0	19435.2	2.0
θ -Pentachlorocyclohexene .	θ -PentaCX	254.0	1548.0	0.2
Hexachlorocyclohexene	HexaCX-a	289.0	6762.4	0.7
β -Pentachlorocyclohexene .	β -PentaCX	254.0	2612.6	0.3
η -Pentachlorocyclohexene	η -Penta CX	254.0	1612.2	0.2
Hexachlorocyclohexene	HexaCX-b	289.0	2375.3	0.2
Hexachlorocyclohexene	HexaCX-c	289.0	7274.5	0.8
α -Hexachlorocyclohexane	α -HCH	291.0	38295.0	4.0
Hexachlorocyclohexene	HexaCX-d	289.0	16.8	0.0
β -hexachlorocyclohexane .	β -HCH	291.0	0.4	0.0
γ -Hexachlorocyclohexane (Lindane)	γ -HCH	291.0	126985.3	13.2
Heptachlorocyclohexane	HeptaCH-1	325.0	106325.6	11.0
δ -Hexachlorocyclohexane .	δ -HCH	291.0	71041.2	7.4
ϵ -Hexachlorocyclohexane	ϵ -HCH	291.0	16327.8	1.7
Heptachlorocyclohexane	HeptaCH-2	325.0	40659.8	4.2
Heptachlorocyclohexane	HeptaCH-3	325.0	19245.1	2.0
DNAPL from PS14D look				

Table S3. Groundwater monitoring during injection (event 1).

WELL	Time (h) *	C surf (g/L)	COCs tot (mg/L)	CBs +DCBS (mg/L)	TCBs+TetraCBS (mg/L)	Sum of NAC (mg/L)	C Br (mg/L)	k (microS/cm)	F Br	F surf
PS14	0	0.0	4.6	26.506	16.452	5.484	0.0	5527	0	0
PS14	8	2.6	255.0	255.03	43.66	62	31.2	4380	0.12	0.13
PS14	24	1.3	312.9	312.92	38.18	80.6	93.6	4324	0.36	0.06
PS14B	0	0.0	3.0	17.32	11.1	3.2	0.0	5771	0	0
PS14B	8	22.3	491.6	491.61	70.93	123.4	205.4	847	0.79	1.11
PS14B	24	4.7	1005.3	1005.3	118.7	260.1	234.0	2613	0.9	0.23
PS14C	0	0.0	4.2	21.26	12	5.1	0.0	5780	0	0
PS14C	8	12.3	1821.8	1821.82	256.16	459.3	161.2	2433	0.62	0.61
PS14C	24	6.9	2241.7	2241.76	312.71	565.9	223.6	2801	0.86	0.35
PS14D	0	0.0	3.1	19.5	13	3.4	0.0	6397	0	0
PS14D	8	3.0	705.6	705.5	109.6	174.8	67.6	4996	0.26	0.15
PS14D	24	0.8	230.2	230.3	46.2	54	54.6	6014	0.21	0.04
PS14E	0	0.0	4.0	21	12	5	0.0	6107	0	0
PS14E	8	21.7	791.3	791.2	111.4	199.4	265.2	1030	1.02	1.08
PS14E	24	2.0	339.8	339.8	51.5	84.6	117.0	3350	0.45	0.1
PS14F	0	0.0	3.8	19.9	12	4.1	0.0	5144	0	0
PS14F	8	0.0	15.4	15.4	8.6	0	0.0	5223	0	0
PS14F	24	0.0	7.3	7.3	0	0	0.0	5107	0	0
PS14G	0	0.0	2.3	13.4	8	3.1	0.0	5217	0	0
PS14G	8	4.7	114.9	114.9	19.8	27.9	83.2	3669	0.32	0.24
PS14G	24	0.9	64.8	64.7	15.7	14.4	18.2	4309	0.07	0.05
PS14H	0	0.0	2.2	13.8	9.1	2.5	0.0	5434	0	0
PS14H	8	1.0	110.6	110.5	27.6	24.3	0.0	5037	0	0.05
PS14H	24	0.4	52.2	52.3	14.1	11.2	15.6	5018	0.06	0.02
PS14I	0	0.0	3.5	20.2	12.9	3.8	0.0	5193	0	0
PS14I	8	20.6	610.0	609.9	87.2	153.3	286.0	780	1.10	1.03
PS14I	24	5.6	710.7	710.7	88.7	182.5	247.0	2185	0.95	0.28

WELL	Time (h) *	C surf (g/L)	COCs tot (mg/L)	CBs +DCBS (mg/L)	TCBs+TetraCBS (mg/L)	Sum of NAC (mg/L)	C Br (mg/L)	k (microS/cm)	F _{Br}	F _{surf}
PS14J	0	0	21.2	14	3.8	3.4	0	6394	0	0
PS14J	8	0.27	8.2	0.7	0	7.5	0	6028	0	0.01
PS14J	24	0	3	0	0	3	0	5777	0	0
PS14K	0	0	13.7	9	2.4	2.3	0	5504	0	0
PS14K	8	0.75	4.6	0.4	0	4.2	88.4	3688	0.34	0.04
PS14K	24	3.8	95.8	26	20.5	49.3	122.2	3531	0.47	0.19
PS14L	0	0	9.8	6	2.1	1.7	0	5982	0	0
PS14L	8	0	2.5	0	0	2.5	0	5787	0	0
PS14L	24	0	2.4	0	0	2.4	0	5826	0	0
PS14M	0	0	17.5	10.2	3.9	3.4	0	5155	0	0
PS14M	8	19.45	769.2	91.2	198.9	479.1	267.8	1705	1.03	0.97
PS14M	24	3.86	270.6	48.4	65.2	157	114.4	3481	0.44	0.19
PS21C	0	0	14.7	9.2	3.1	2.4	0	3061	0	0
PS21C	8	0	2.5	0	0	2.5	0	2874	0	0

Table S4. Groundwater monitoring in injection event 6.

WELL	Time (h) *	C surf (g/L)	COCs tot (mg/L)	CBs +DCBS (mg/L)	TCBs+TetraCBS (mg/L)	Sum of NAC (mg/L)	C Br (mg/L)	k (microS/cm)	F _{Br}	F _{surf}
PS14A	0	0	26.69	16.61	5.58	4.49	0	6571	0	0
PS14A	5.65	0	26.3	18.91	4.37	3.03	0	6372	0	0
PS14B	0	0	23.4	16.66	3.31	3.44	17.7	6375	0.03	0
PS14B	5.63	26.15	40.79	9.36	18.86	12.57	539.96	1664	1	0.9
PS14C	0	0	29.25	20.72	4.08	4.45	6.54	6890	0.01	0
PS14C	5.66	0.16	53.84	24.55	13.64	15.65	39.36	6152	0.07	0.01
PS14D	0	0	37.21	27.01	4.81	5.39	12.92	7189	0.02	0
PS14D	5.7	0.17	40.17	21.82	10.29	8.05	16.33	6695	0.03	0.01
PS14E	0	0.01	23.78	18.41	3.09	2.28	12.28	7126	0.02	0
PS14E	5.7	0.98	57.61	27.91	17.45	12.25	44.27	6661	0.08	0.03
PS14J	0	0	26.08	15.5	4.4	6.18	-11.32	6600	0	0
PS14J	5.73	23.62	133.81	35.18	47.95	50.68	533.23	1995	0.99	0.81
PS14K	0	0	7.66	6.77	0.57	0.3	5.22	6960	0.01	0
PS14K	5.73						46.71	5892	0.09	
PS14L	0	0	17.97	12.7	2.3	2.98	-2.56	7271	0	0
PS14L	5.73	0	20.45	12.76	3.48	4.21	3.6	7019	0.01	0
PS14M	0	0.01	18.85	14.85	2.37	1.61		5806	0.02	0
PS14M	5.8	14.36	47.86	18.36	18.64	10.85	317.2	3612	0.59	0.5
PS14I	0	0.01	25.1	16.58	3.81	4.71	-0.44	5724	0	0
PS14I	1.5	4.09	30.46	18.23	7.83	4.39	163.85	5536	0.3	0.14
PS14I	2.37	9.63	49.02	26.55	14.5	7.96	339.06	4764	0.63	0.33
PS14I	3.5	12.1	19.75	6.79	6.72	6.23	284.54	4040	0.53	0.40
PS14I	5.73	13.77	90.58	39.89	30.41	20.27	235.83	4340	0.44	0.47
PS14I	24.07	1.55	52.4	19.62	19.13	13.65	94.61	4621	0.18	0.05
PS14I	43.67	1.52	68.13	24.73	24.6	18.8	131.52	4380	0.24	0.05
PS14I	43.83	1.5	60.49	26.7	20.25	13.55	131.27	4538	0.24	0.05
PS14I	44.33	1.5	57.82	25.32	19.97	12.52	129.18	4550	0.24	0.05
PS14I	44.83	1.48	55.36	26.95	18.62	9.77	127.3	4783	0.24	0.05
PS14I	45.33	0.65	52.06	25.6	17.37	9.07	127.82	4962	0.24	0.05
PS14I	46.33	0.26	35.16	18.34	11.23	5.6	76.52	5116	0.14	0.02
PS14I	47.33	0.14	23.23	15.15	5.59	2.49	46.07	5075	0.09	0.01
PS14I	48.33	1.55	17.46	12.14	3.82	1.48	63.25	5042	0.12	0