Assessing, Capturing and Utilising Methane from Expired and Non-operational landfills

An EU LIFE+ project for 2012-2015

Monitoring gas at closed landfills

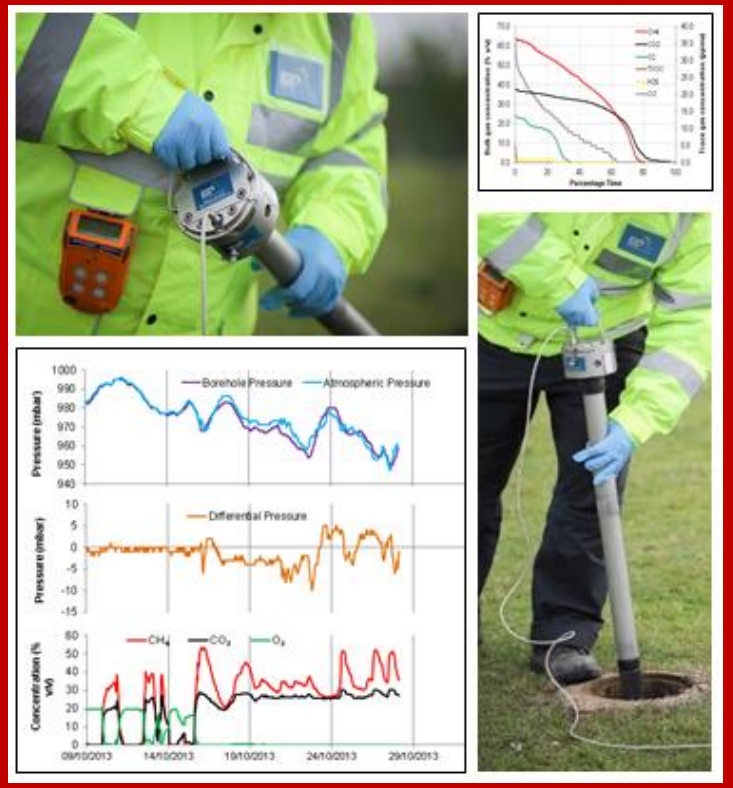
Andrew Brunton (GGS)

LANDSS Landfill Aftercare Forum, 21st October 2015

- Demonstrate a technically and economically feasible approach to capturing, utilising and mitigating methane from closed landfill sites
- A significant portion of the project involved carrying out a comprehensive monitoring programme to establish an initial assessment of methane emissions
- Monitoring undertaken during the project aims to encourage the wider take up of new technologies with which to manage methane emissions

Continuous ground-gas monitoring

- Continuous monitoring will provide a quantitative assessment of landfill gas quality and behaviour
- Collection of time series data can lead to a much more accurate characterisation of the ground-gas regime and gas collection efficiency
- Identifying the dominant processes of gas generation and migration



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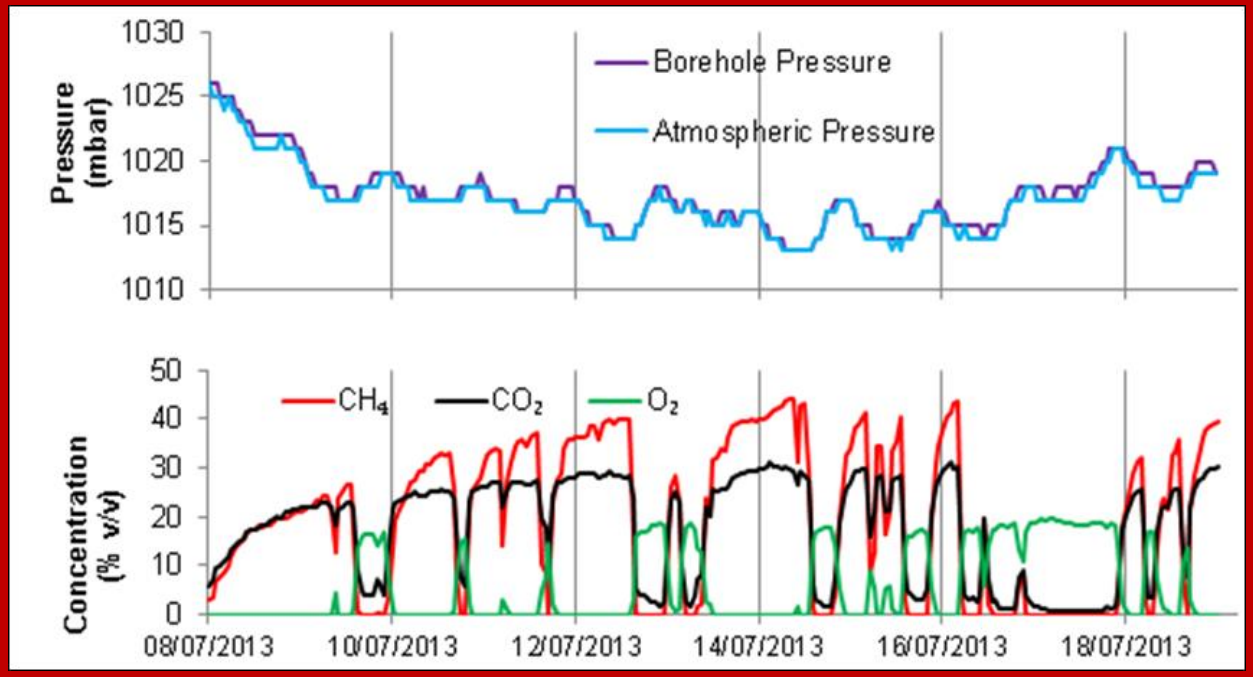
Continuous ground-gas monitoring



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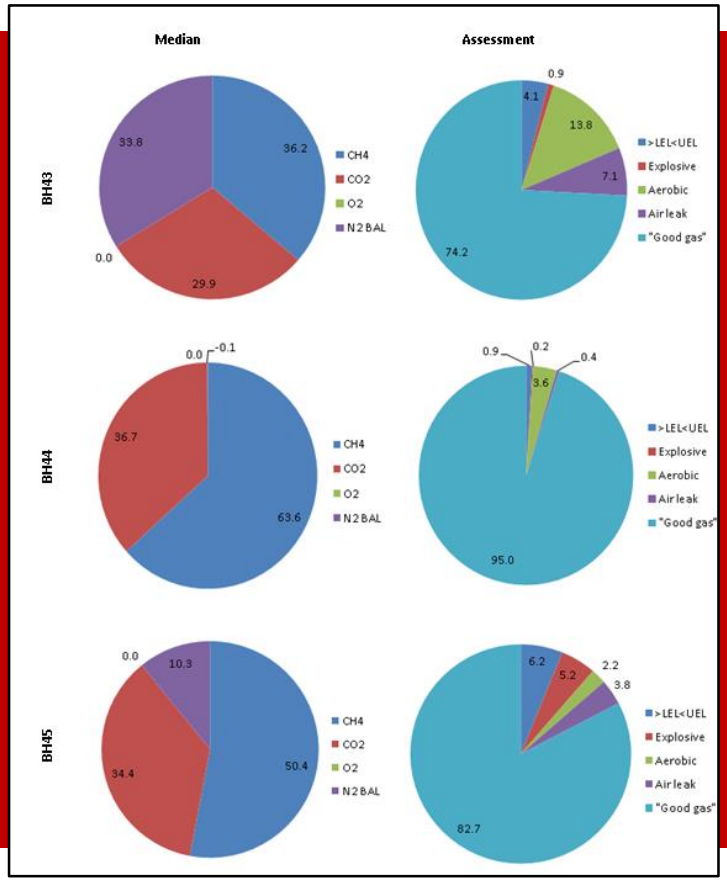
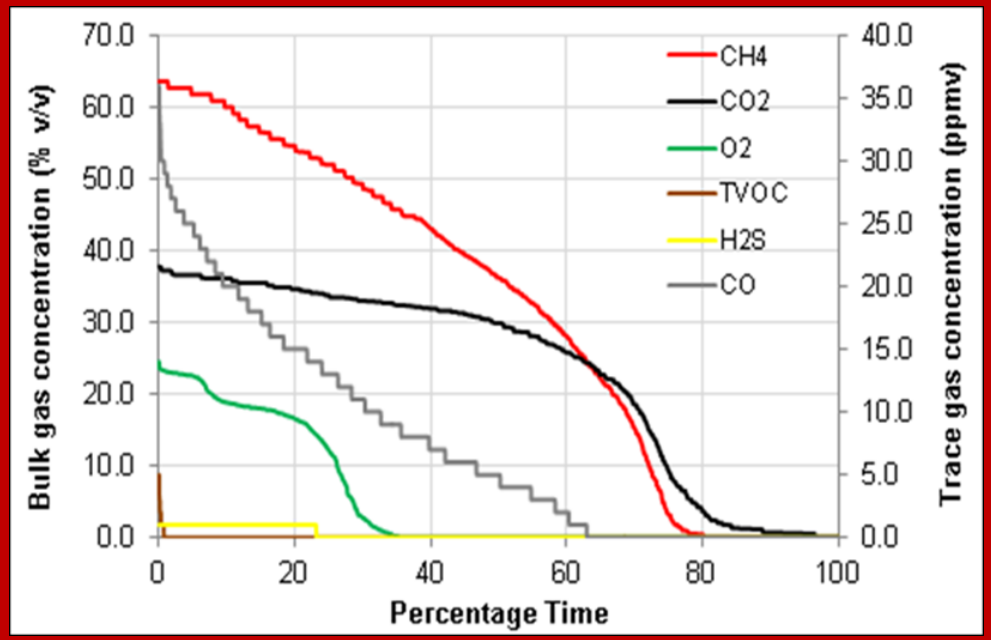
Time series assessment tools





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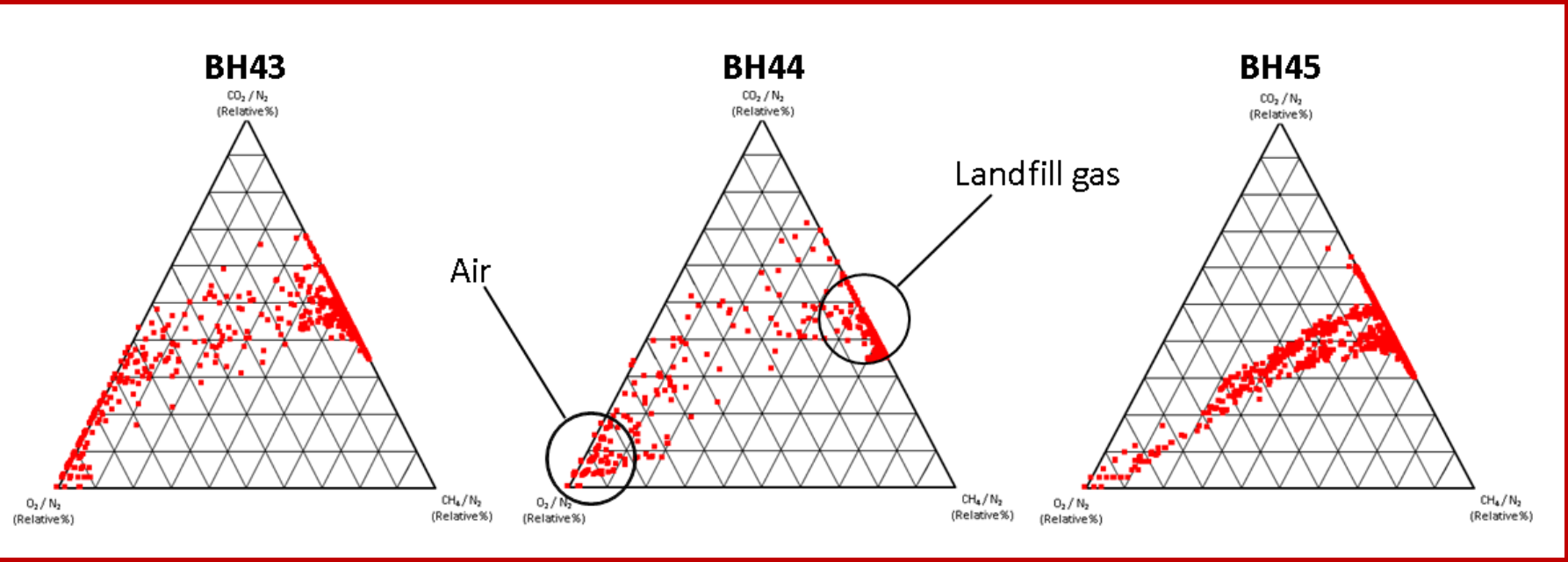

Teasdale, C.J., Hall, J.A., Martin, J.P and Manning, D.A.C. Ground gas monitoring: Implications for hydraulic fracturing and CO storage. Environmental Science & Technology 2014, 48, 13610-13616

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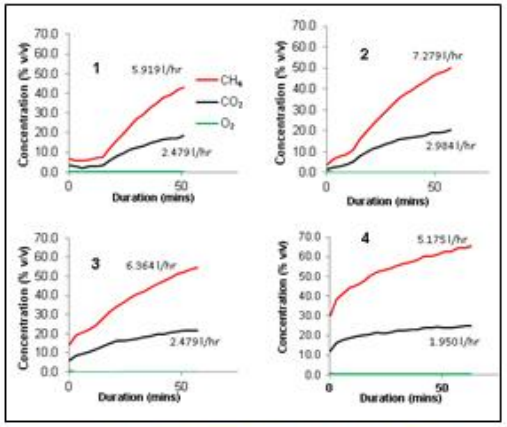
Purge and recovery tests



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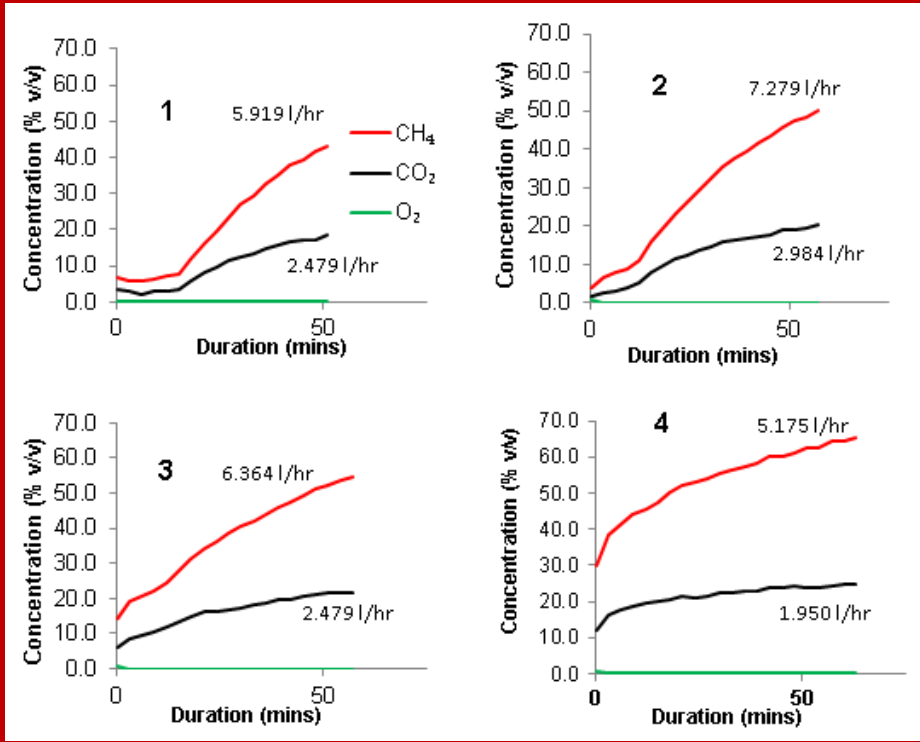

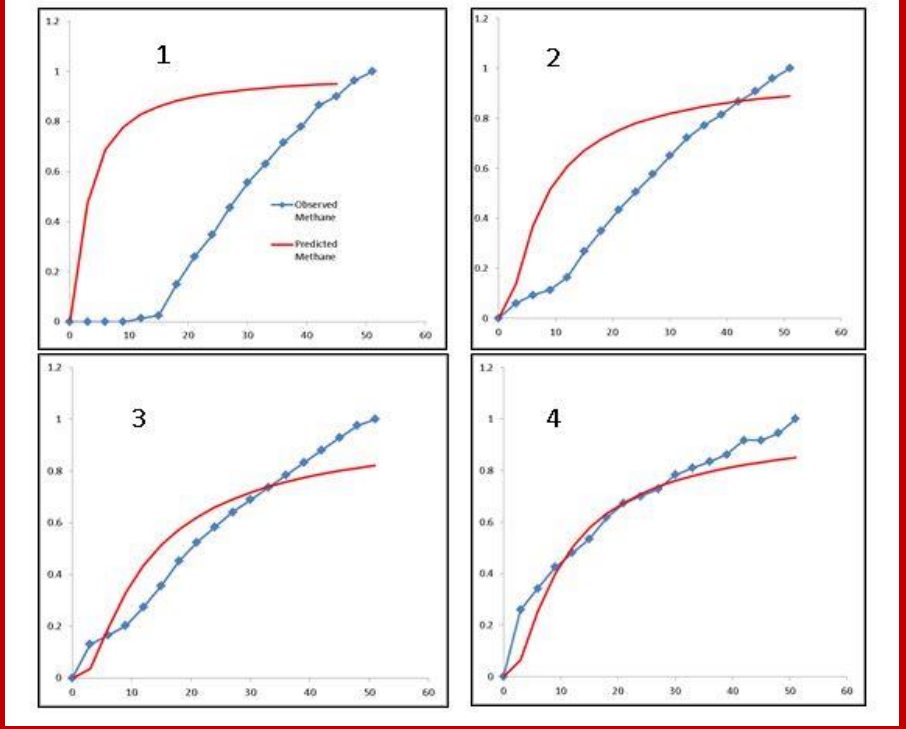

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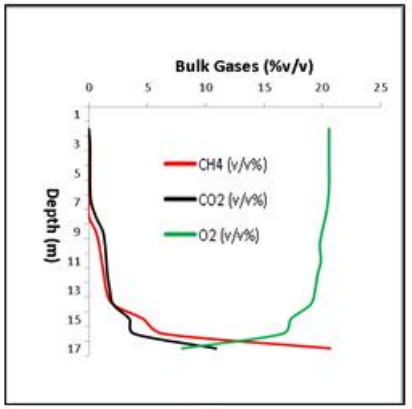
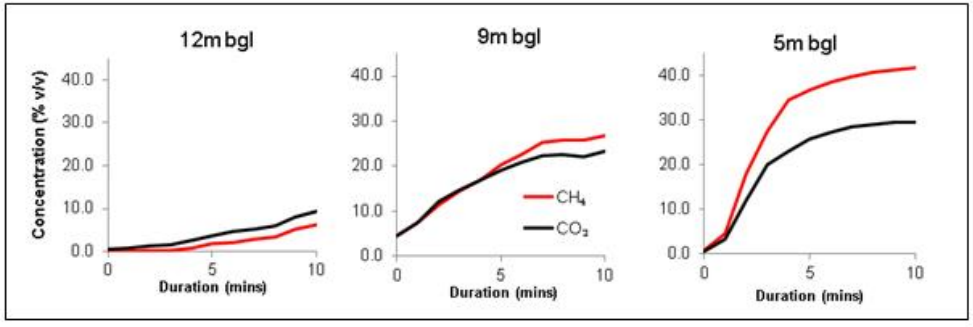
Depth profile monitoring

- Measurement of ground-gas concentration down a borehole
- Can highlight well stratification, stagnant gas and elevated gas concentrations
- ‘line of evidence’ approach for understanding lateral migration issues





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Surface emission survey (SES)

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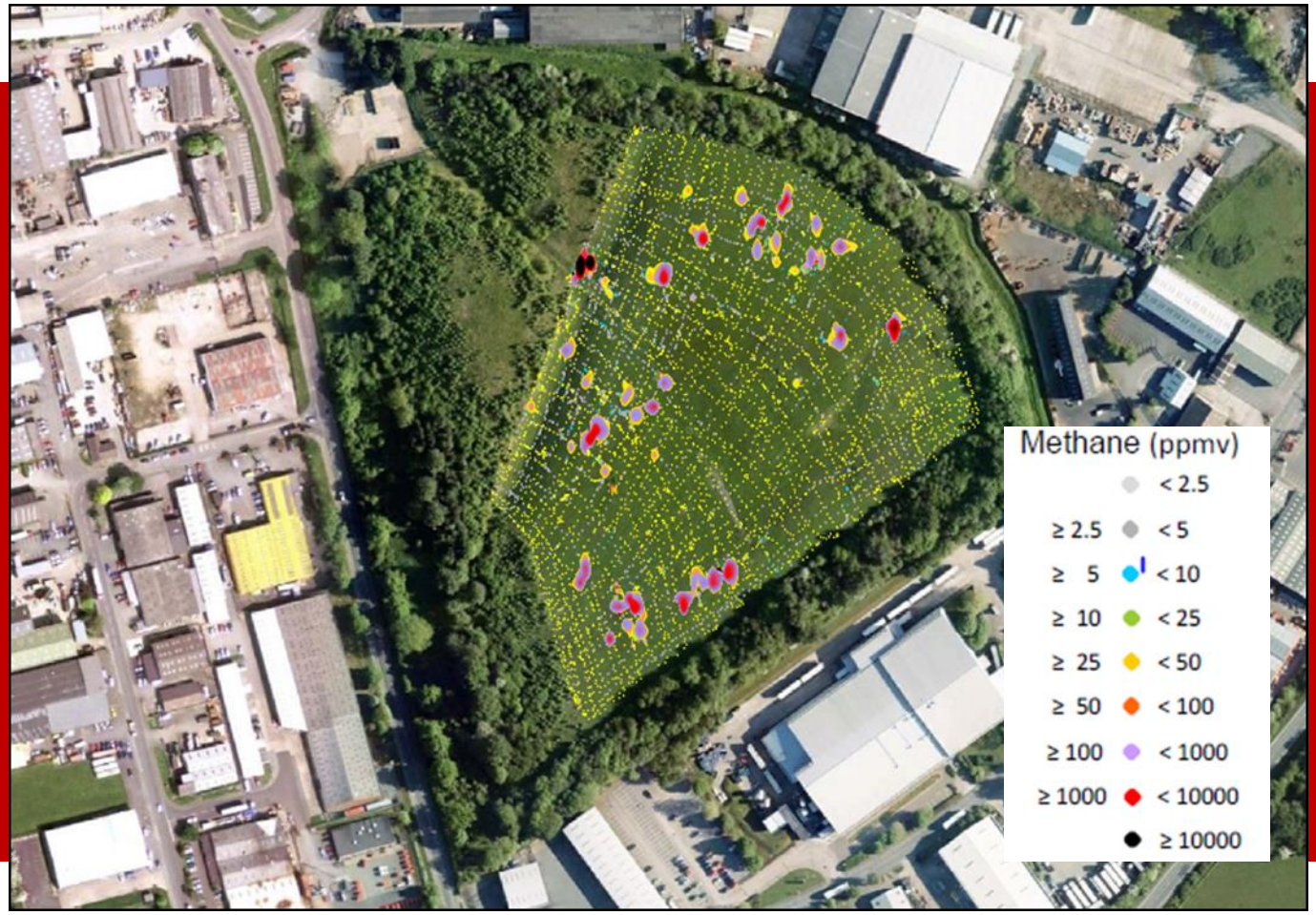

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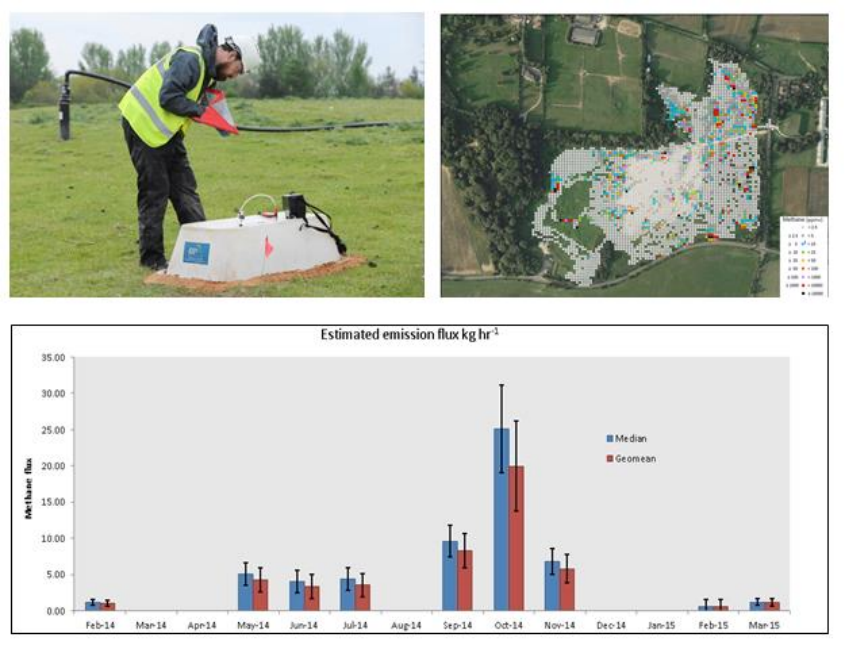
Quantitative surface emission survey (Q-SES)



Three elements of Q-SES

- the surface walkover survey element
- the closed chamber flux tests (flux box tests) element
- the data processing element

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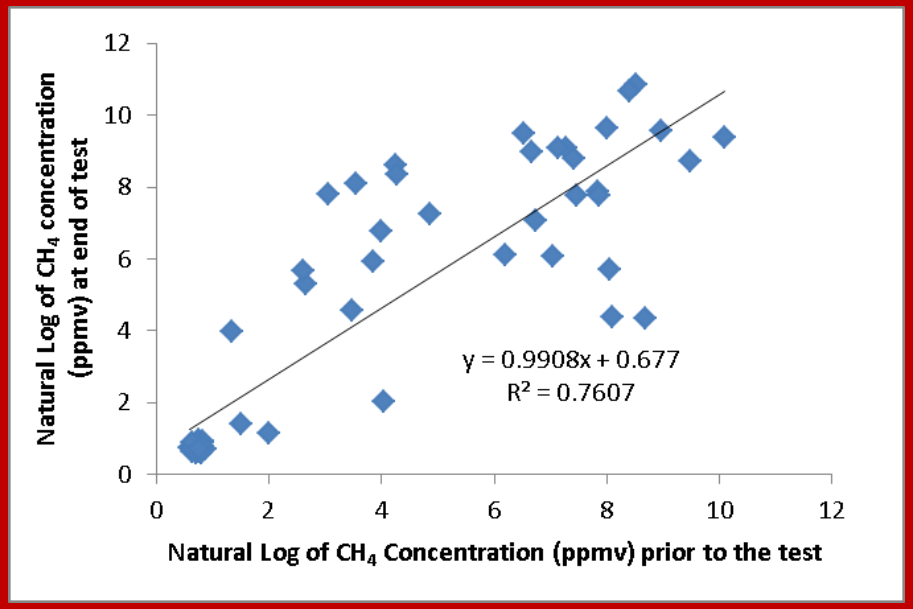

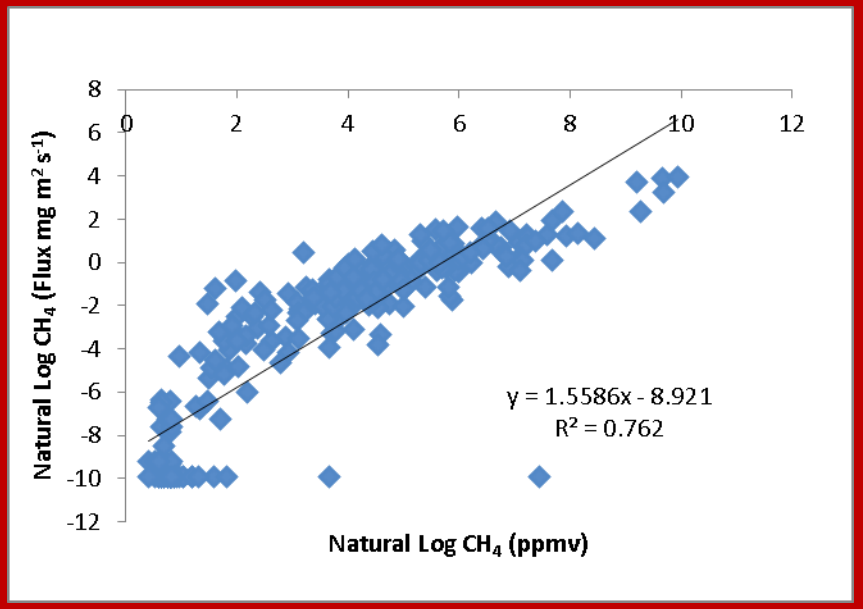

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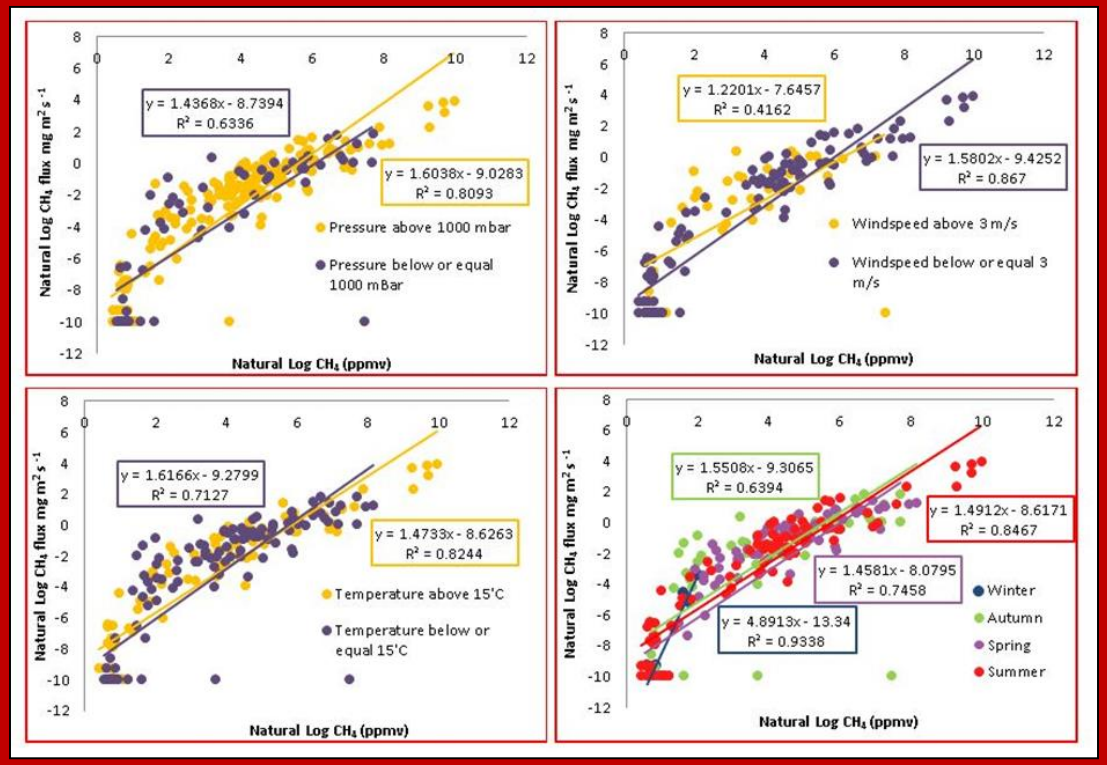

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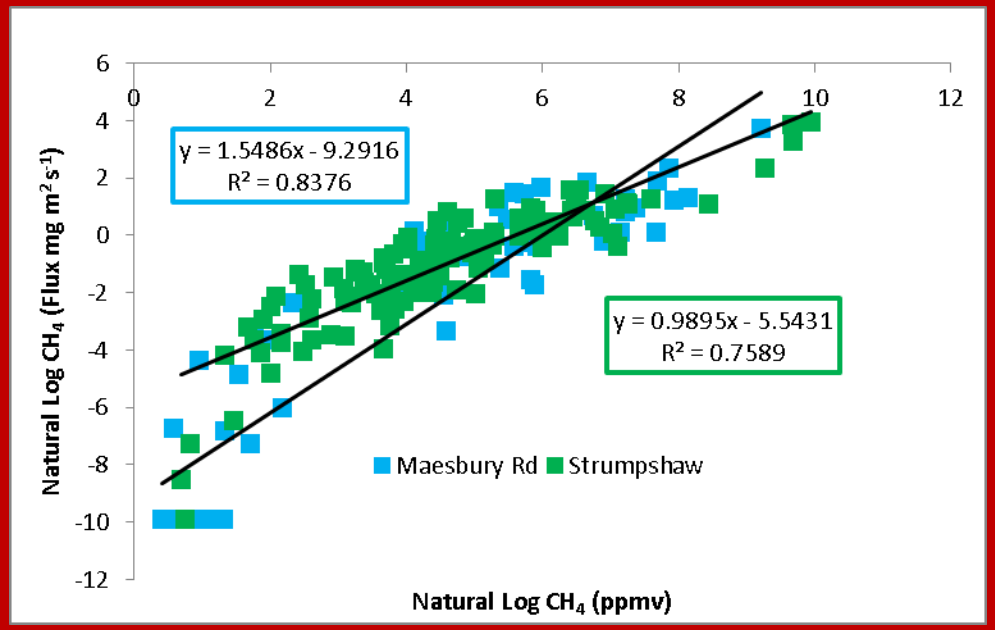

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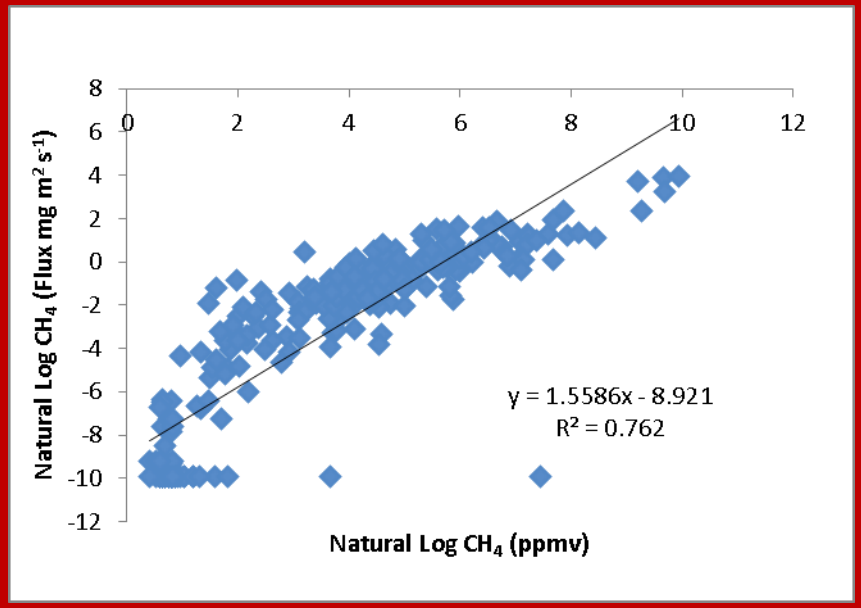
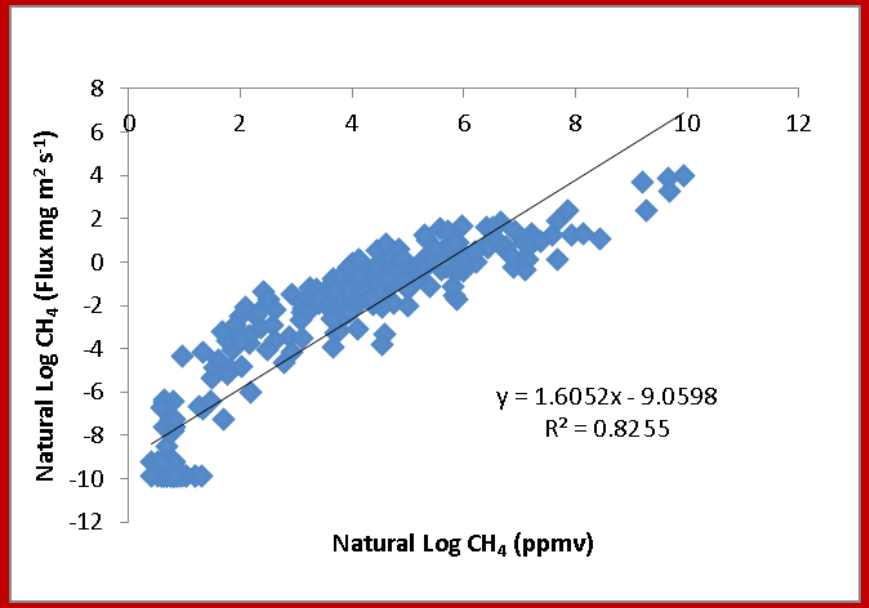
Quantitative surface emission survey (Q-SES)

Model A



Model B



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Quantitative surface emission survey (Q-SES)

Band ppmv	n	Max	Min	Range	[x] Median	[y] Geomean	[z] Mean	Stdev	±	± % [x]	± % [y]	± % [z]
>=10000	5	52.88	10.62	42.26	40.8	31.1	35.8	17.3	7.75	19.0	24.9	21.7
>=1000<10000	18	10.59	0.00005	10.59	2.97	1.47	3.14	2.43	0.57	19.3	39.1	18.3
>=100<1000	65	6.48	0.13	6.35	0.99	1.05	1.52	1.38	0.17	17.2	16.3	11.3
>=50<100	41	1.69	0.022	1.67	0.26	0.29	0.42	0.34	0.053	20.3	18.1	12.9
>=25<50	21	0.51	0.00005	0.51	0.19	0.11	0.2	0.14	0.031	16	28.9	15.7
>=10<25	19	1.58	0.01	1.57	0.095	0.074	0.17	0.35	0.08	84	108	47.3
>=5<10	21	0.44	0.00005	0.44	0.026	0.016	0.05	0.09	0.021	77.9	127	41
>=2.5<5	17	0.29	0.00005	0.291	0.0011	0.0008	0.03	0.076	0.019	1685	2286.3	64.9
<2.5	63	0.002	0.00005	0.002	0.00005	0.00008	0.0002	0.0004	0.00038	90	90	23.1

Q-SES flux values for Model A (n=270)

Band ppmv	n	Max	Min	Range	[x] Median	[y] Geomean	[z] Mean	Stdev	±	± % [x]	± % [y]	± % [z]
>=10000	5	52.88	10.62	42.26	40.8	31.1	35.8	17.3	7.75	19.0	24.9	21.7
>=1000<10000	17	10.59	0.697	9.895	2.97	2.68	3.32	2.37	0.57	19.4	21.5	17.3
>=100<1000	65	6.48	0.13	6.35	0.99	1.05	1.52	1.38	0.17	17.2	16.3	11.3
>=50<100	41	1.69	0.022	1.67	0.26	0.29	0.42	0.34	0.053	20.3	18.1	12.9
>=25<50	20	0.51	0.0007	0.51	0.19	0.16	0.2	0.14	0.031	15.9	19.6	14.8
>=10<25	18	0.25	0.01	0.24	0.081	0.063	0.091	0.07	0.08	21.3	27.8	19.1
>=5<10	19	0.12	0.0007	0.12	0.026	0.018	0.032	0.03	0.007	27.8	39.8	22.7
>=2.5<5	14	0.016	0.00005	0.016	0.0006	0.0005	0.0032	0.005	0.001	241.3	309.9	42.9
<2.5	63	0.002	0.00005	0.002	0.00005	0.00008	0.0002	0.0004	0.00045	90	90	23.1

Q-SES values for Model B (n=262)

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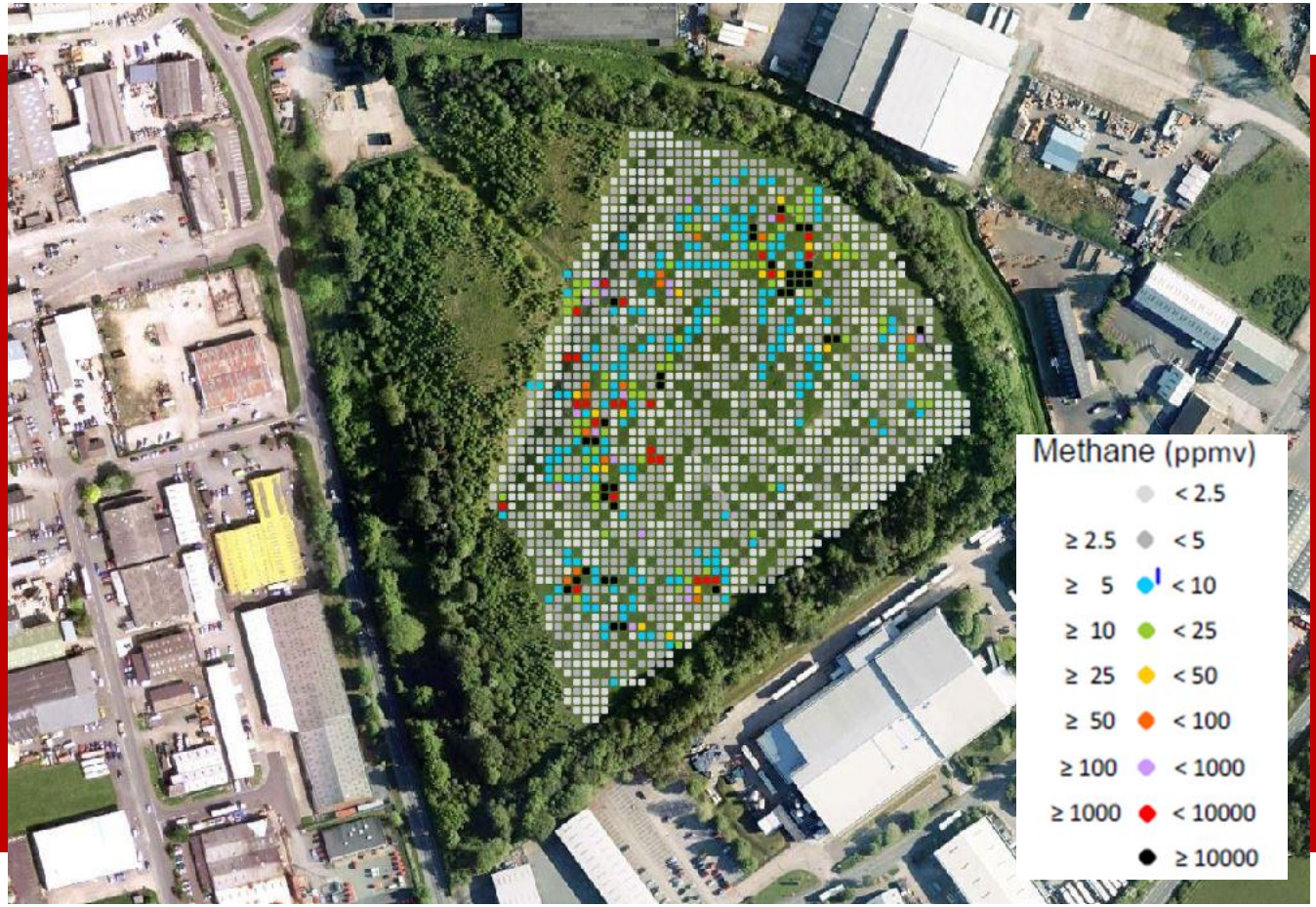
Quantitative surface emission survey (Q-SES)



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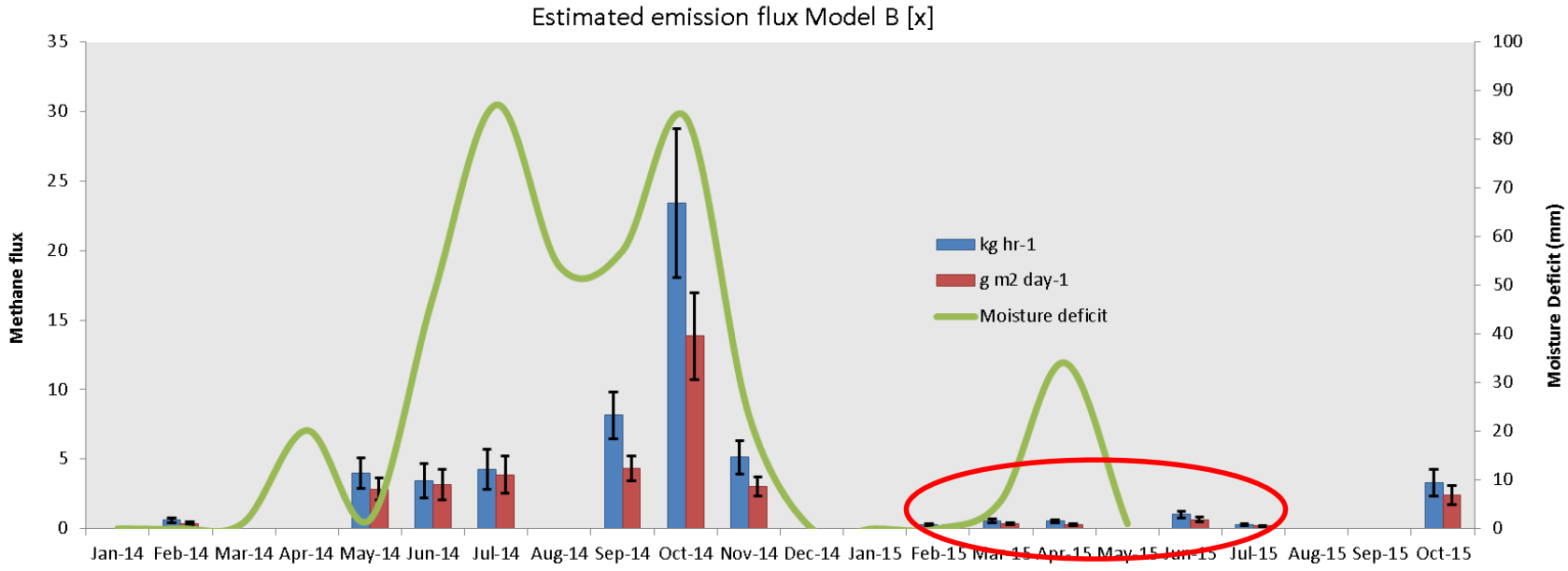
Quantitative surface emission survey (Q-SES)



	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Oct-15
kg hr-1		0.60			3.99	3.44	4.26		8.15	23.44	5.16			0.27	0.57	0.54		1.01	0.28	3.33
g m2 day-1		0.38			2.85	3.14	3.87		4.32	13.84	3.03			0.16	0.32	0.29		0.65	0.19	2.41
Moisture deficit	0	0	1.3	20.2	1.9	47.8	87.1	53.9	57.1	84.6	23.4	0	0	0	5.8	34.1	1			

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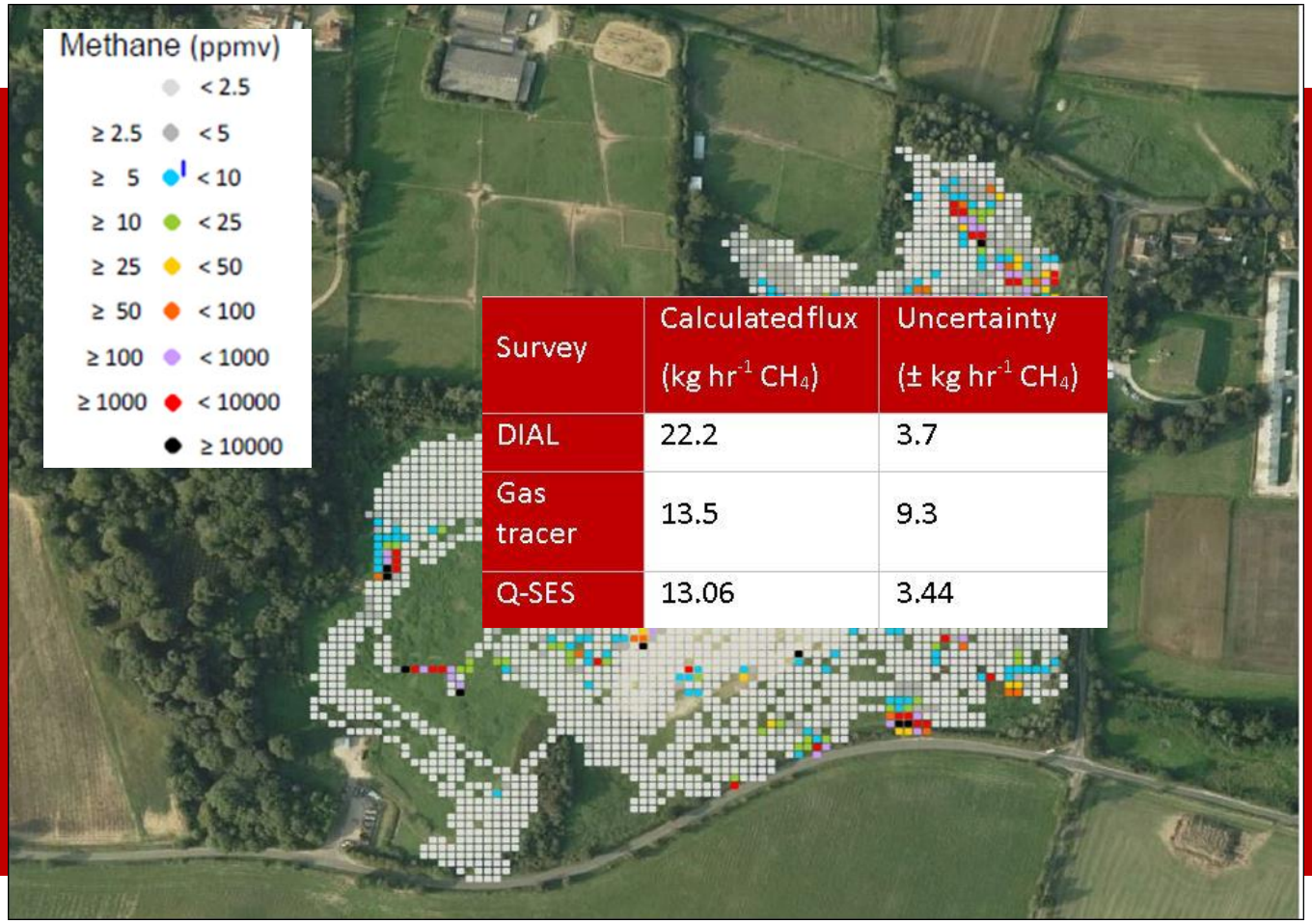
Quantitative surface emission survey (Q-SES)



Survey	Calculated flux (kg hr^{-1} CH_4)	Uncertainty (± kg hr^{-1} CH_4)
DIAL	22.2	3.7
Gas tracer	13.5	9.3
Q-SES	13.06	3.44

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Quantitative surface emission survey (Q-SES)

- Operational and permitted landfill operators to estimate methane losses through their sites' surfaces, perhaps in conjunction with annual compliance walkover surveys or following landfill gas management audits
- Identify, and subsequently verify the remediation of, localised point source features in landfill capping layers
- Local authorities could measure the surface methane emissions from their landfill portfolios, either for inclusion in local authority carbon emission datasets, carbon budgeting or similar exercises

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Quantitative surface emission survey (Q-SES)

- Measure surface emissions at a sufficiently large number of closed landfill sites to improve the accuracy of what the calculated contribution that closed landfill makes to the overall GHGI

- Periodic performance monitoring of bio-oxidation units. Q-SES could be used to quantify performance (i.e. methane removal efficiency) by measuring fugitive emissions

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Biofilter monitoring

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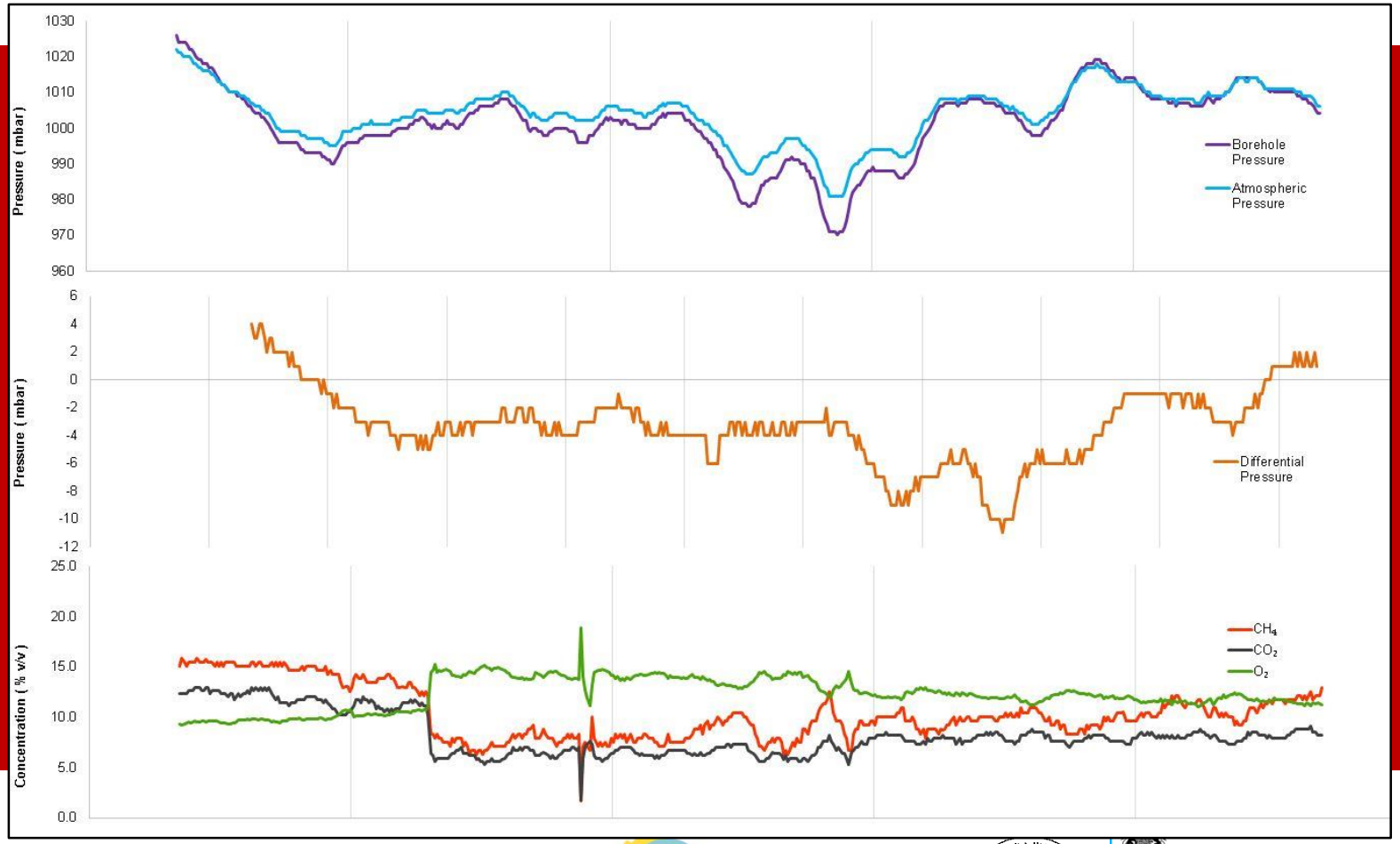
Biofilter monitoring



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Biofilter monitoring

Date / Time	Biofilter inlet			Closed chamber test survey					Flux sheet			Atmospheric Pressure (mBar)	Pressure trend - 3hr/6hr/9hr	
	CH_4:O_2	CH_4 kg hr^{-1}	CO_2 kg hr^{-1}	CH_4 kg hr^{-1}	±	CO_2 kg hr^{-1}	±	CH_4 Re %	CH_4 kg hr^{-1}	CO_2 kg hr^{-1}	CH_4 Re %			
25.02.15 / 15:00	0.54	13.69	28.06	0.71	0.32	4.91	1.97	94.8	#	#	#	1012	0/-1/-5	rising
27.02.15 / 10:00	0.76	13.64	30.23	1.46	0.65	9.50	4.16	89.3	0.70	6.56	94.9	1012	0/-3/-6	rising
22.04.15 / 08:00	1.23	8.71	21.06	2.71	0.31	5.14	0.56	68.9	#	#	#	1033	-1/0/0	stable
22.04.15 / 16:00	1.17	8.32	20.58	2.43	0.48	4.63	0.65	70.8	2.54	6.47	69.5	1030	+1/+3/+3	falling
14.05.15 / 15:00	0.91	4.07	9.23	1.72	0.67	6.39	1.58	57.8	#	#	#	1012	+2/+3/+4	falling
15.05.15 / 08:00	0.62	2.83	7.55	1.44	0.65	8.16	1.91	49.0	#	#	#	1021	-2/-3/-5	rising
23.06.15 / 15:00	0.40	1.19	2.07	0.22*	0.13	1.03*	0.17	81.2	0.19	0.59	84.3	1019	-2/-3/-5	rising
24.06.15 / 10:00	0.43	1.39	2.22	#	#	#	#	#	0.24	0.77	82.9	1019	0/0/+1	stable
24.06.15 / 15:00	0.43	1.39	2.22	1.90	0.64	5.58	1.01	-39.2	0.48	1.04	65.2	1019	0/0/0	stable
25.06.15 / 09:00	0.41	1.10	1.74	#	#	#	#	#	0.48	1.69	56.1	1021	0/-1/-1	stable

# denotes no measurement. CH_4 Re is methane Removal efficiency in %. *closed chamber test was wind affected. Please note: All atmospheric pressure measurements are from a local metrological station to enable comparisons to be made – site specific measurements are not available for all site visits.

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Biofilter monitoring

Survey	Calculated flux ($kg\ hr^{-1}\ CH_4$)	Uncertainty ($\pm kg\ hr^{-1}\ CH_4$)	Calculated flux ($kg\ hr^{-1}\ CH_4$)	Uncertainty ($\pm kg\ hr^{-1}\ CH_4$)
DIAL – Nov '14	2.5	0.7	2.5	0.7
Q-SES* – Nov '14	0.12*	0.03*	0.28#	0.06#
Q-SES* - Feb '15	0.63*	0.12*	1.83#	0.36#
Q-SES* - June '15	1.75*	0.34*	4.65#	0.90#

* denotes 2.5m^2 grid squares

# denotes 1m^2 grid squares

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Summary

- Both traditional and innovative monitoring techniques have been used throughout the project and have helped characterise the gas regime on demonstration sites
- Offer real benefits in understanding gas generation, migration and emissions at closed and historic landfills
- A monitoring programme can provide a cost-effective way to verify and validate gas behaviour on all aspects of landfill gas management

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Questions?