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Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE 31 MAR 2011		2. REPORT TYPE		3. DATES COVERED 00-00-2011 to 00-00-2011	
4. TITLE AND SUBTITLE New Continuous Monitoring Technologies for Vapor Intrusion, Remediation and Site Assessment. Benefits of Time series Data				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Ion Science LLC,Advanced Gas Sensing Technologies,33 Commercial Drive,Waterbury,VT,05676				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Presented at the 2011 DoD Environmental Monitoring & Data Quality Workshop (EMDQ 2011), 28 Mar ? 1 Apr, Arlington, VA. U.S. Government or Federal Rights License					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 36	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



New Continuous Monitoring Technologies for Vapor Intrusion, Remediation and Site Assessment.

Benefits of Time series Data

Dr Peter Morris, Geoff Hewitt



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Why do we monitor Ground-Gas/Vapours?



Health and Safety – range of toxic affects
explosion, suffocation

Contaminated land site investigation and
remediation design – cost implications

More recently green house gas agenda -
Carbon auditing

Ozone depletion



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Objectives of ground gas/vapour monitoring



- Determine the true subsurface vapour/gas regime
- Predict how this may change in the future

Currently achieved by:

Discrete periodic static measurements of vapour/gas concentrations and the vapour/gas regime is inferred



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Flawed approach



- Many environmental parameters show high temporal variability, therefore, their representative measurement requires multiple measurement.
- In the case of vapour/ground-gas risk assessment flaws in the existing multiple measurement approach have been identified explicitly in the literature in the UK (Wilson & Card, 1999) and are subject to continuing correction (e.g. CIEH).



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- The two underlying causes of these flaws are that, whilst accurate quantification of risk requires accurate measurement of vapours,

1. They are not measured directly:

- concentration of vapour/gas in the ground is inferred from periodic (weekly – monthly) sampling of vapour/gas accumulated within a borehole (or soil sample)
- The relationships these inferences are based on will be highly site-specific.

2. Likely to be temporally variable.



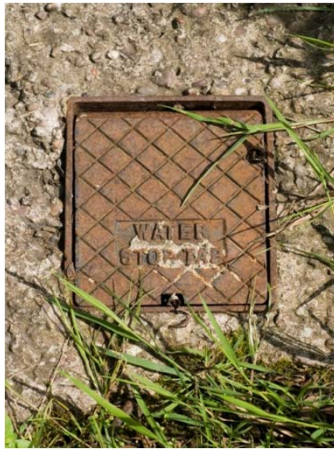
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GasClam - Key features

- Continuous monitoring of VOC, CH₄, CO₂, O₂, H₂S, CO barometric & borehole pressure and water level
- CSA C US approved (Class I, Zone I, Ex d ib IIB T4/ Class I, Zone I, AEx d ib IIB, T4)
- Extended deployment, up to 1 months based on hourly sampling
- Robust stainless steel design
- Fits directly in 50mm borehole (easy to adapt)
- Venting and vented modes
- Easy to use and deploy



Safe and secure



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Easily installed, easily relocated



0:00 mins

Arrive



Install



1:30 mins/s

Go!

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Variable VOC concentrations?



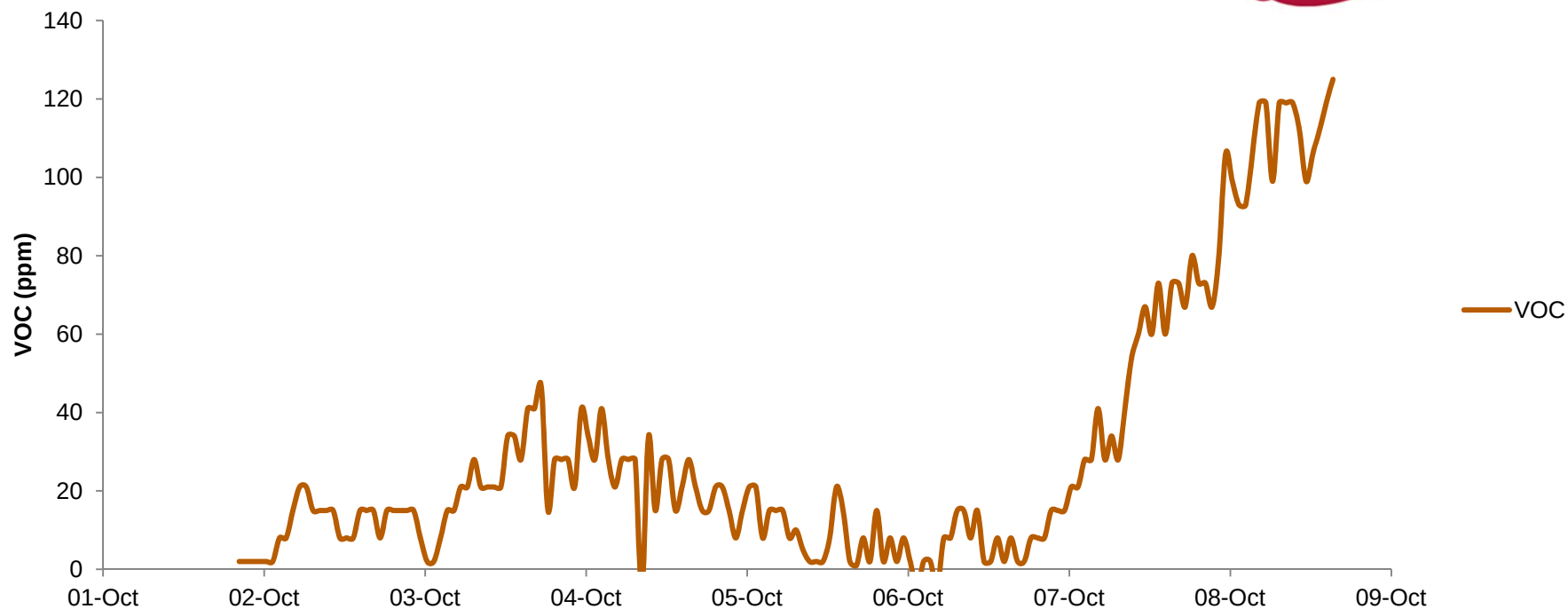
	WS1 June 09	WS1 July 09
Compound	ug/m ³	ug/m ³
Methylcyclohexane	<0.6	150
Methylisobutylketone	<0.5	<0.4
Dimethyldisulfide	<1	<0.8
Toluene	25	370
Butyric Acid	<4	<3
n-Octane	37	580
Ethyl Butyrate	<0.9	<0.8
Butyl Acetate	<0.8	<0.7
Tetrachloroethene	<0.3	<0.3
EthylCyclohexane	<0.4	190
Chlorobenzene	29	550
EthylBenzene	640	1900
m-Xylene + p-Xylene	33	840
n-Nonane	17	780
Styrene	<0.4	150

Variability of VOC's as detected by 'spot' sampling –
suma canister Brownfield site NW UK

Confusing data, problem with sampling?

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Variable VOC concentrations?



Continuous VOC data indicates concentrations are variable

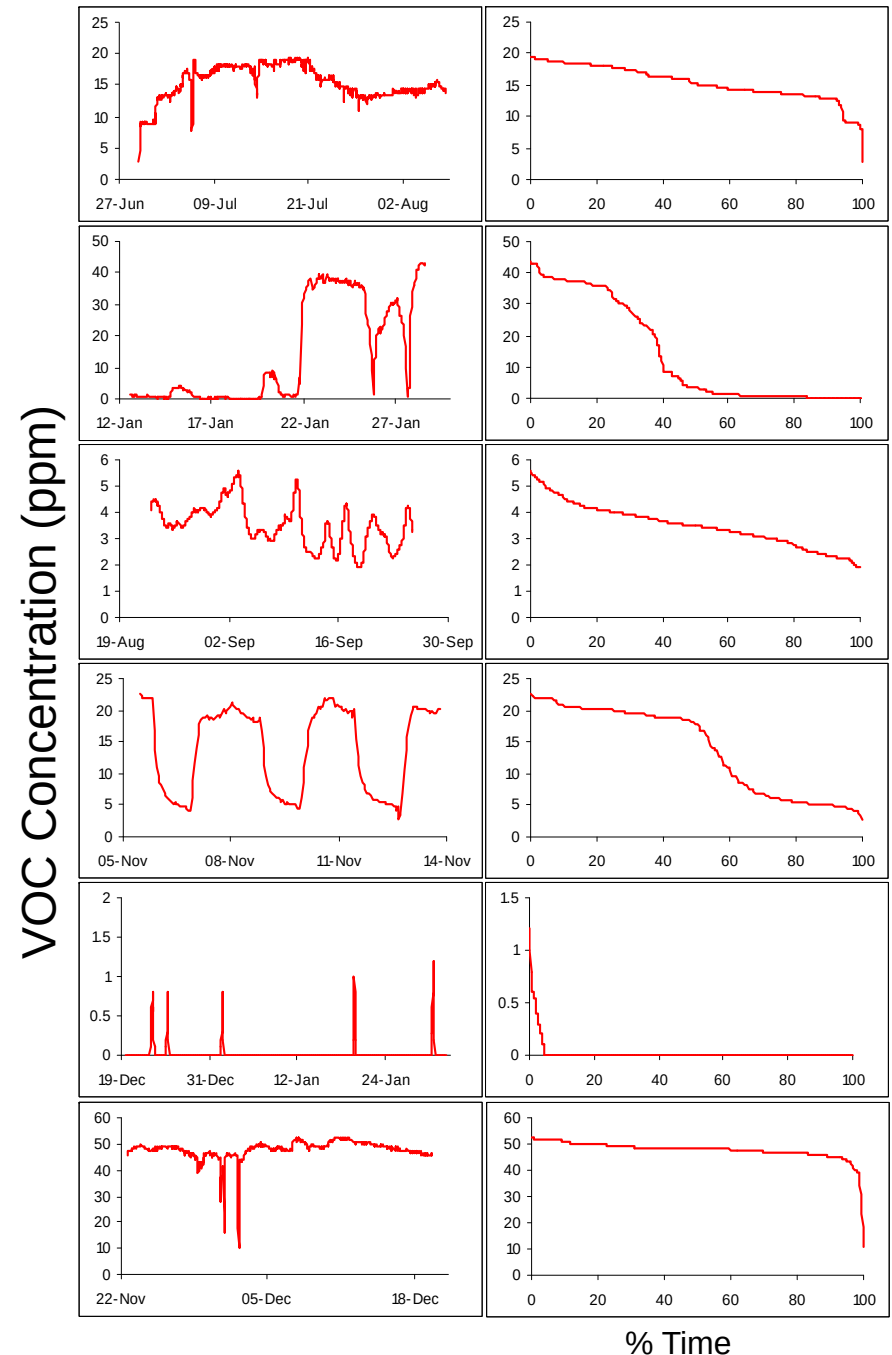


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Detection

- Demonstrates the variability of concentrations from different sites
- The possibility of relevant risk prediction
- However, reduction in interpolation errors but potential for extrapolation error remains



Prediction

- Worst case must be predicted rather than detected
- Understanding of generic processes must be improved in order to increase confidence in prediction

Continuous monitoring improves prediction

because of the increased certainty in recognising and quantifying relationships between gas concentration and other environmental parameters because:

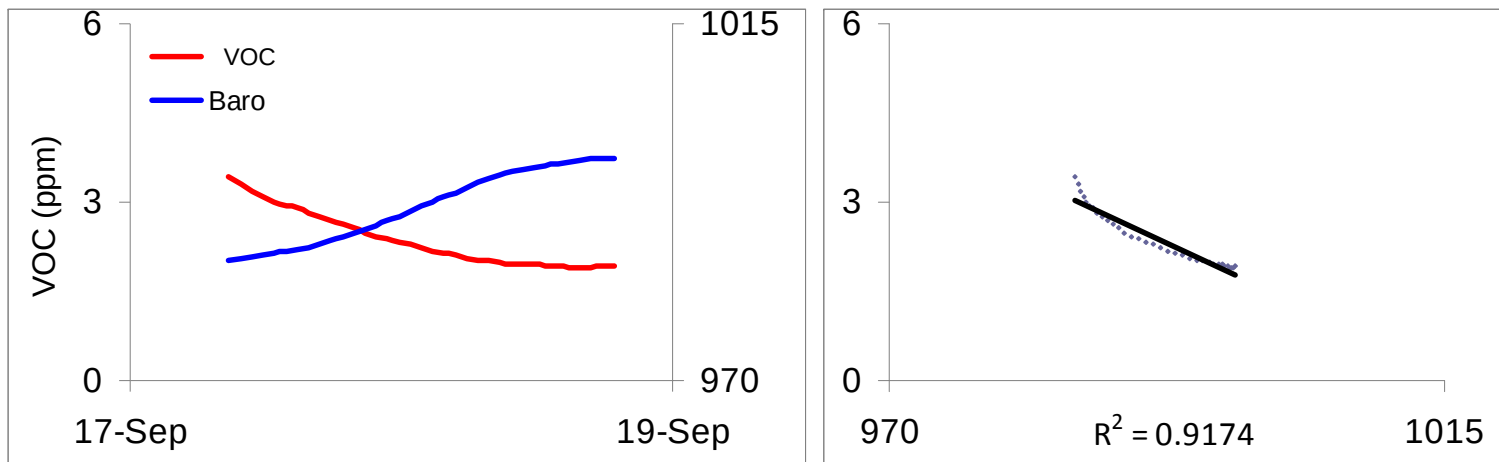
1. many more pairs of gas concentration and environmental data points are available to correlate,
2. sampling frequency matches the variability of the parameters measured so data can reasonably be regarded as a time series and the influence of conditions in altering relationships can be recognised,

Processes controlling intrusion/migration

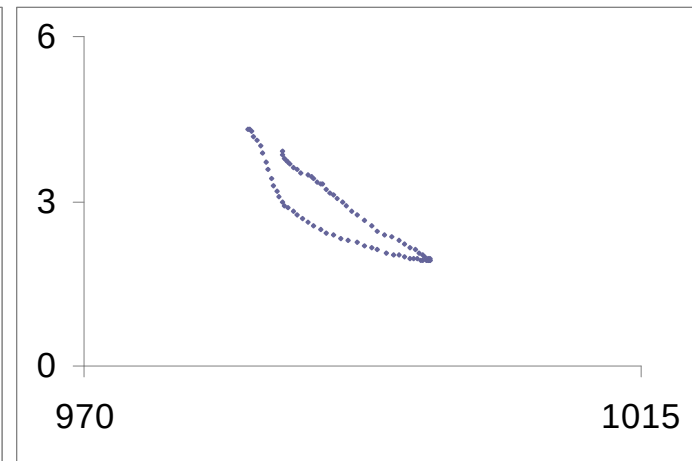
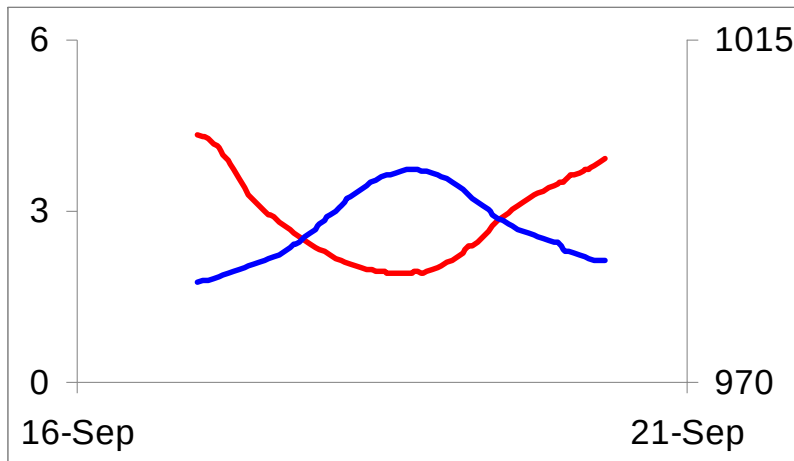
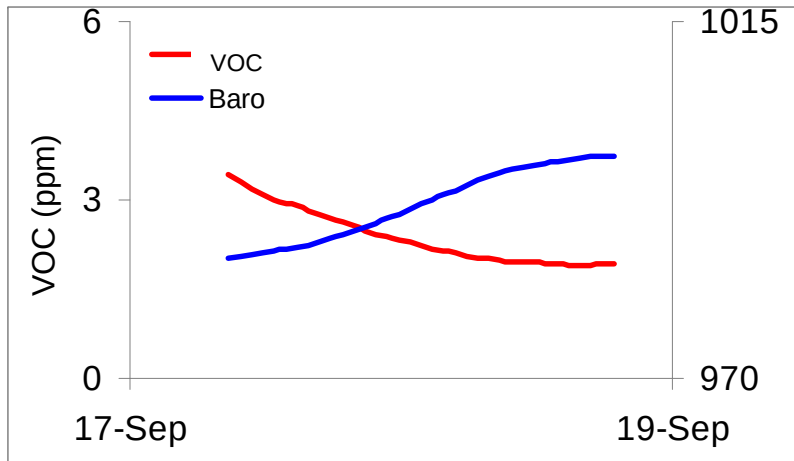
The principal controls on gas migration are:

- Differences in fluid pressure – **atmospheric pressure** and water table changes
- Change in temperature
- ground permeability – vegetation, meteorology, development

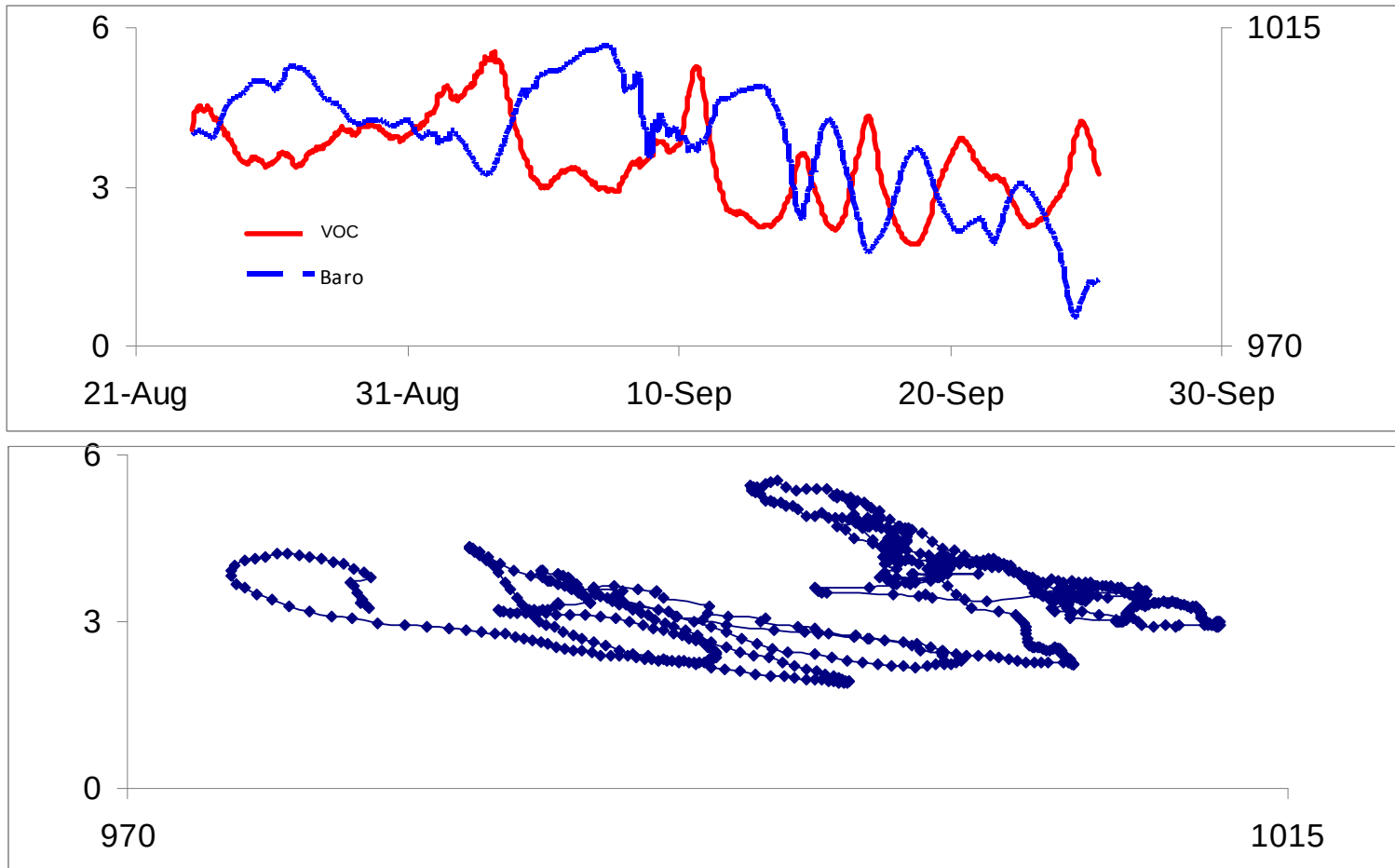
Observing concentration and atmospheric pressure



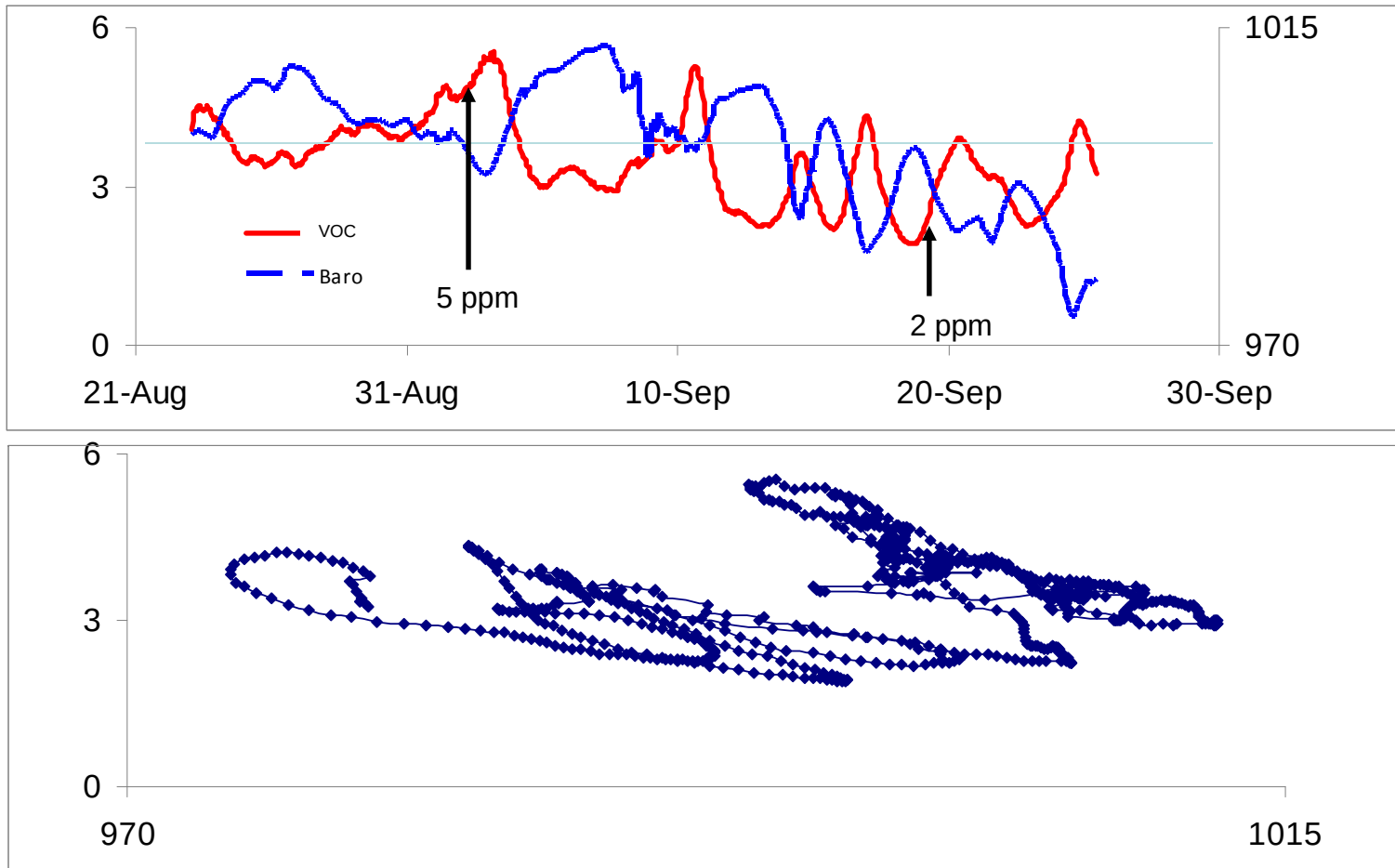
Observing concentration and atmospheric pressure



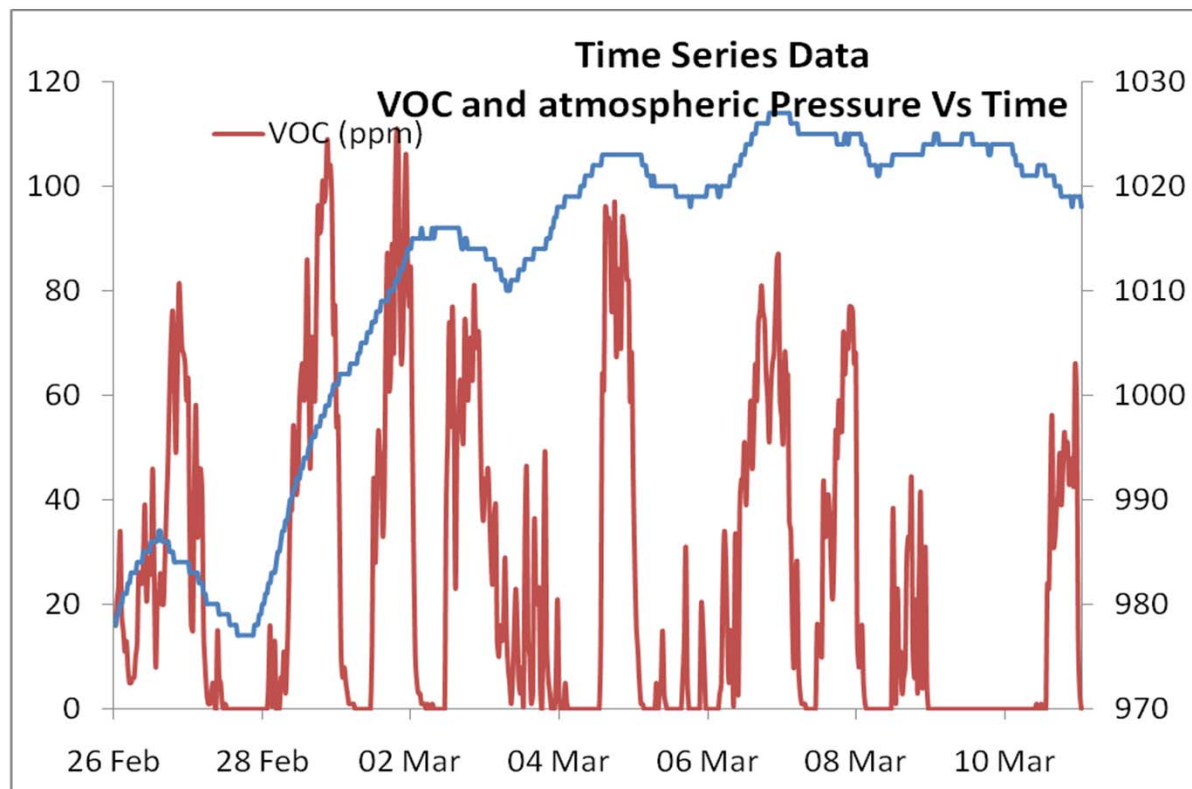
Longer monitoring period



Longer monitoring period



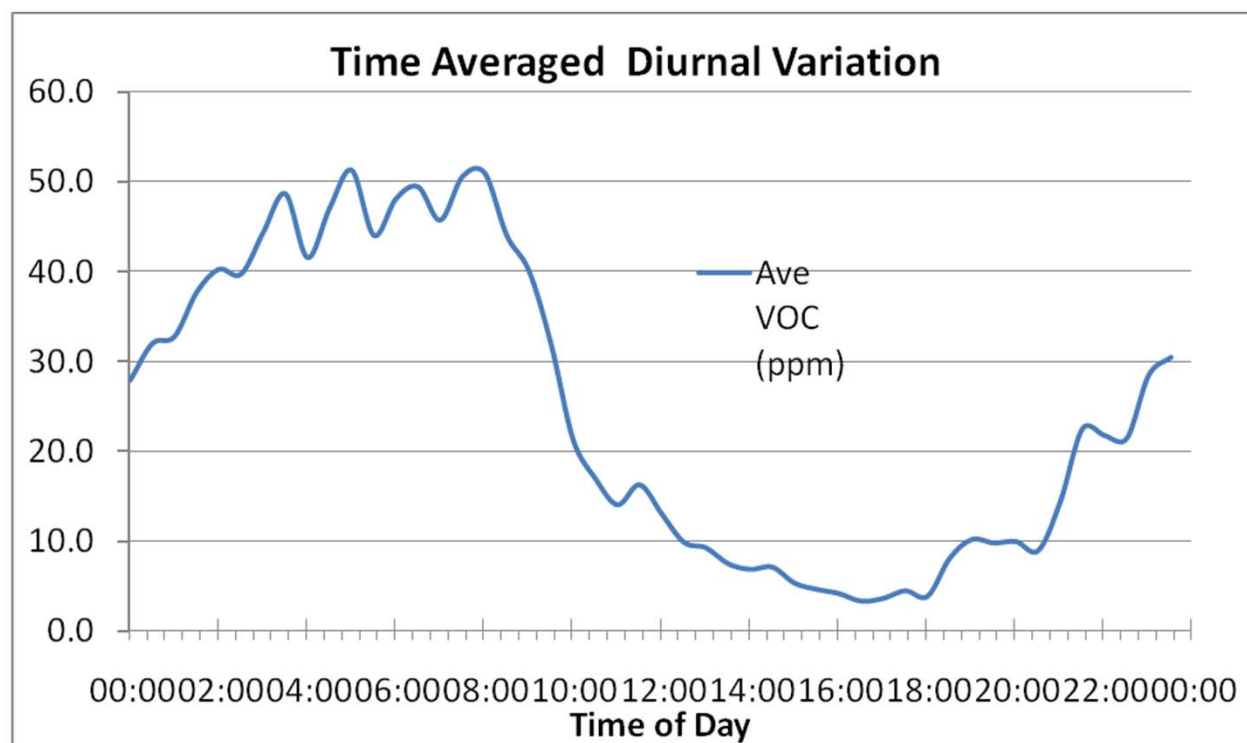
Periods with the inverse relationship with pressure



House adjacent to petrol station – Owner complaining of VOC smell
Local Authority sent in-door air quality team but nothing detected!

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Highest concentrations at night – low in day time

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Observing Temperature and Concentration



Bangor Gardens, Maine

1960's Military Housing with underground storage tanks

UST were supposed to be removed and replaced with above ground storage tank

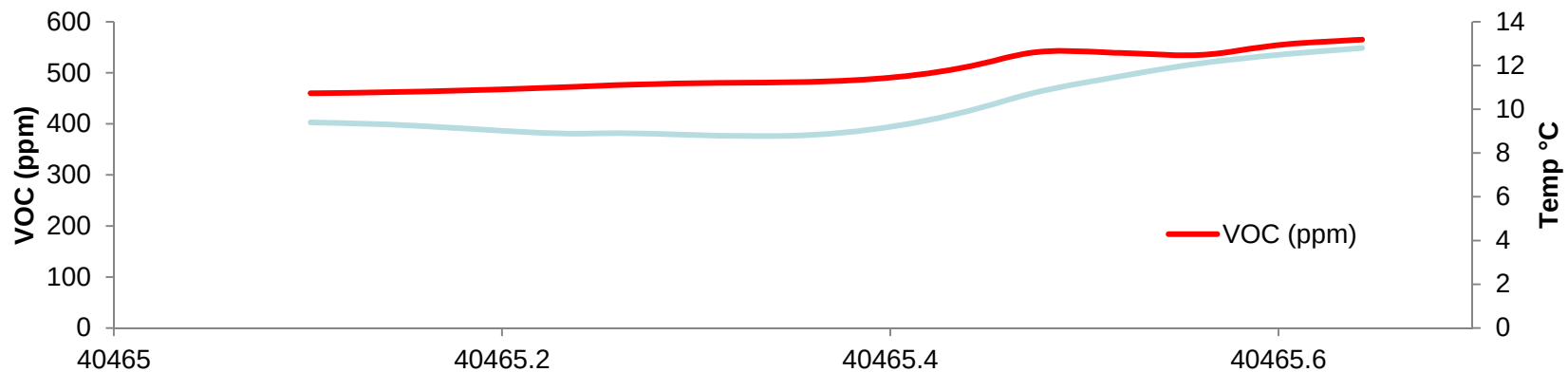
However 2010 VOC leak reported.



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Observing Temperature and Concentration



High VOC concentrations Prior to SVE

Increase concentration with temp



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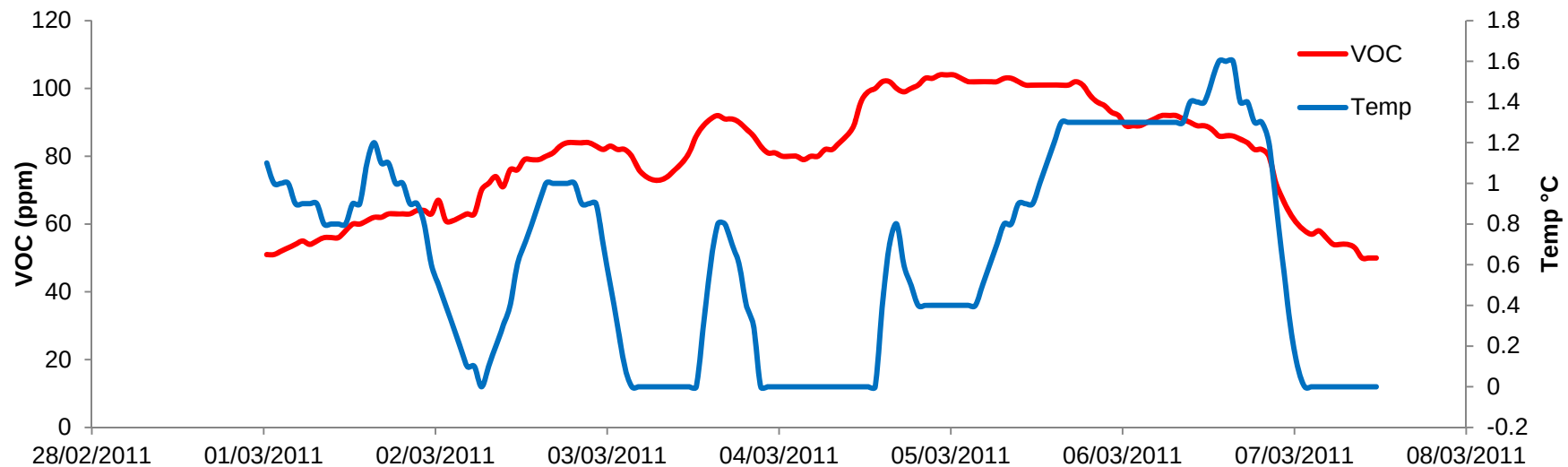
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Observing Temperature and Concentration



Bangor Gardens, Maine – Military Housing
UST leaking

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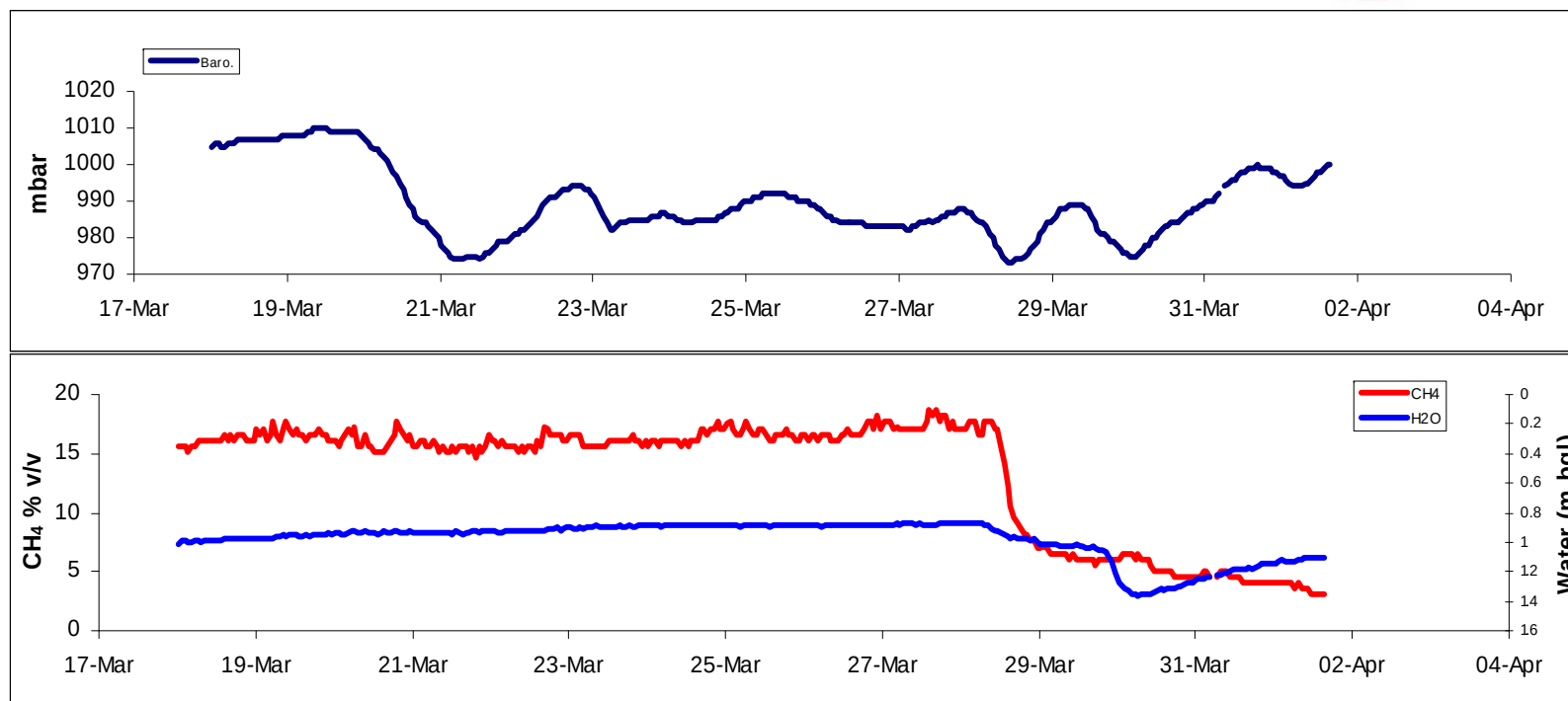


Concentration much lower following SVE but clear dependency on temperature

1°C change results in 35 ppm!

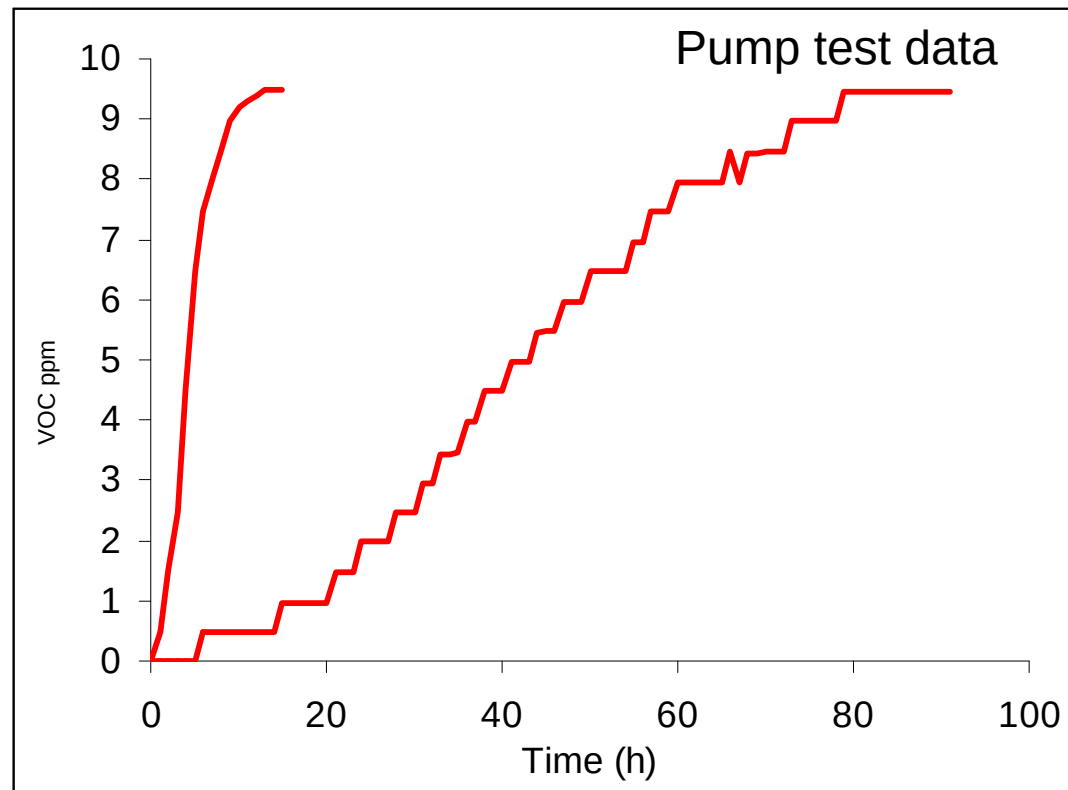
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Sometimes other environmental parameters are responsible for change in gas/vapour regime



Characterising the borehole

What does the concentration I measure tell me?



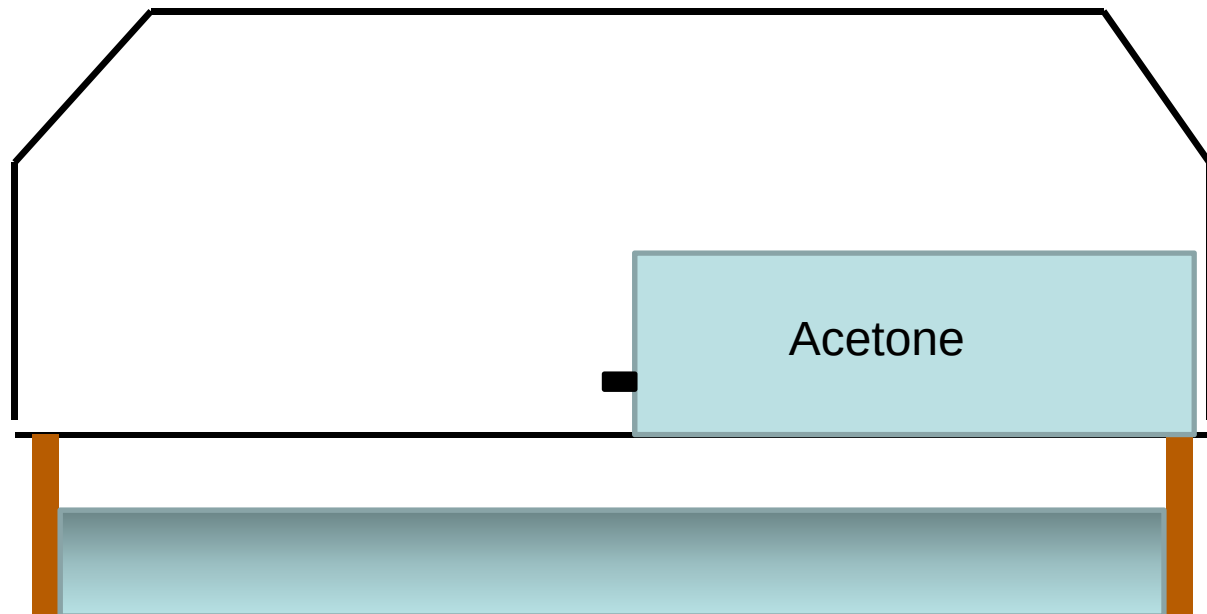
Concentration recovers after a pump test can be very different. The absolute concentration in both cases is the same, but which poses a **greater risk?**



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Site characterisation and Real time monitoring of Remediation



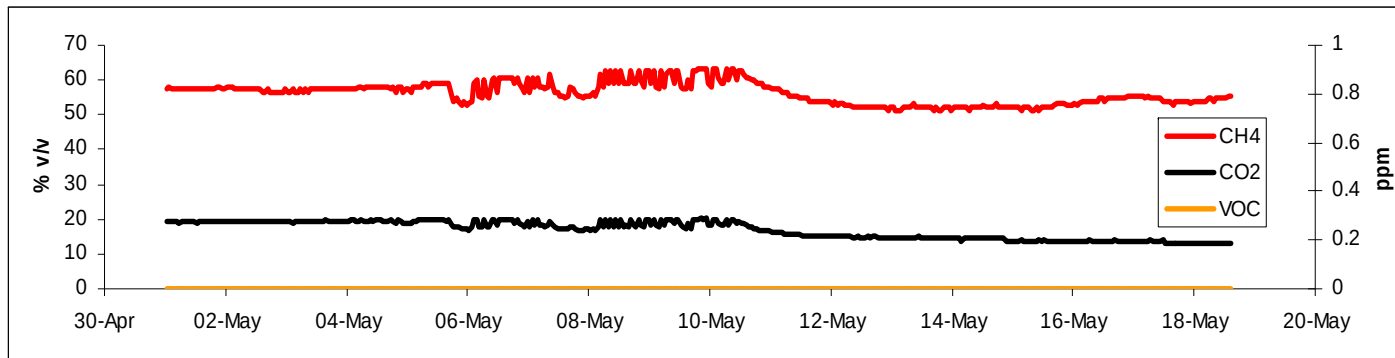
Industrial facility with VOC Leak



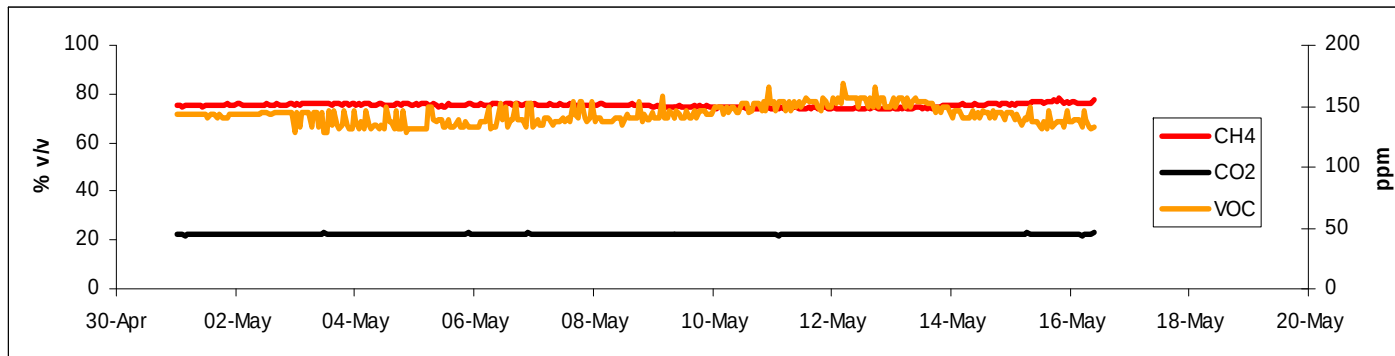
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Site characterisation



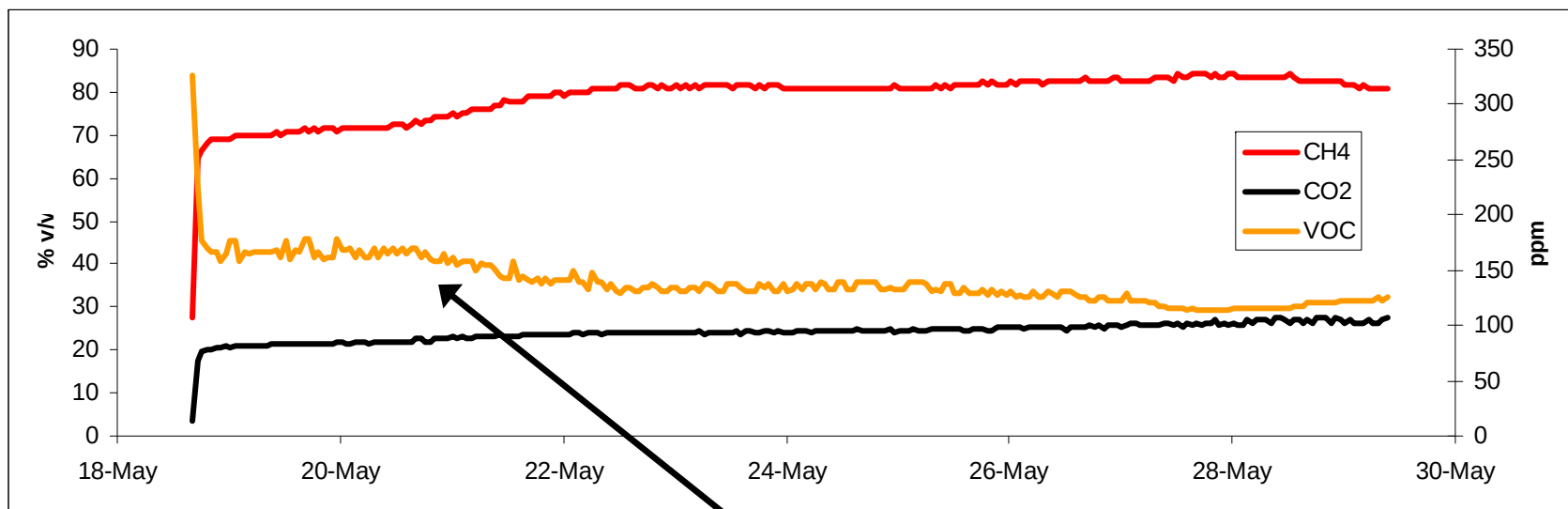
Outside
Building



Inside
foundations

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Real time monitoring of Remediation



Dual Phase Extraction



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Respirometry

to detect and quantify soil contamination
e.g. suppression of aerobic respiration



- Sensitive
- Responds only to bioavailable toxins

BUT

- Only ex-situ;
- findings less representative



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In-situ respirometry



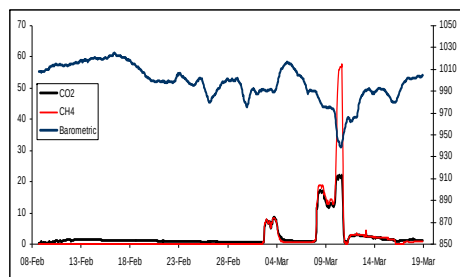
- Gasclam is ideal for in-situ respirometry
- Monitoring health of soil (active aerobic respiration)
- Monitoring contaminant impacts (suppression of respiration)
- Monitoring breakdown of organic contaminants by soil microbiota



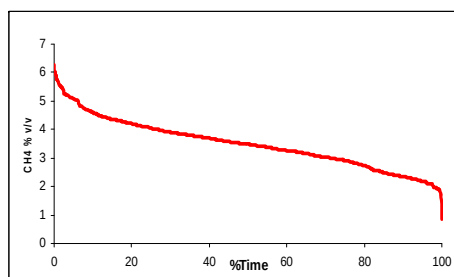
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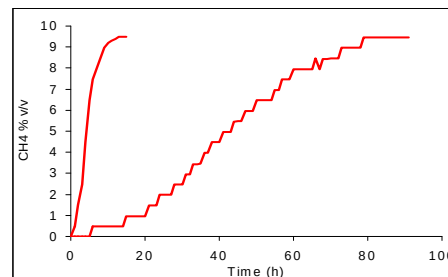
For same resource and effort



Correlations



Concentration duration



Pump Test

Or?

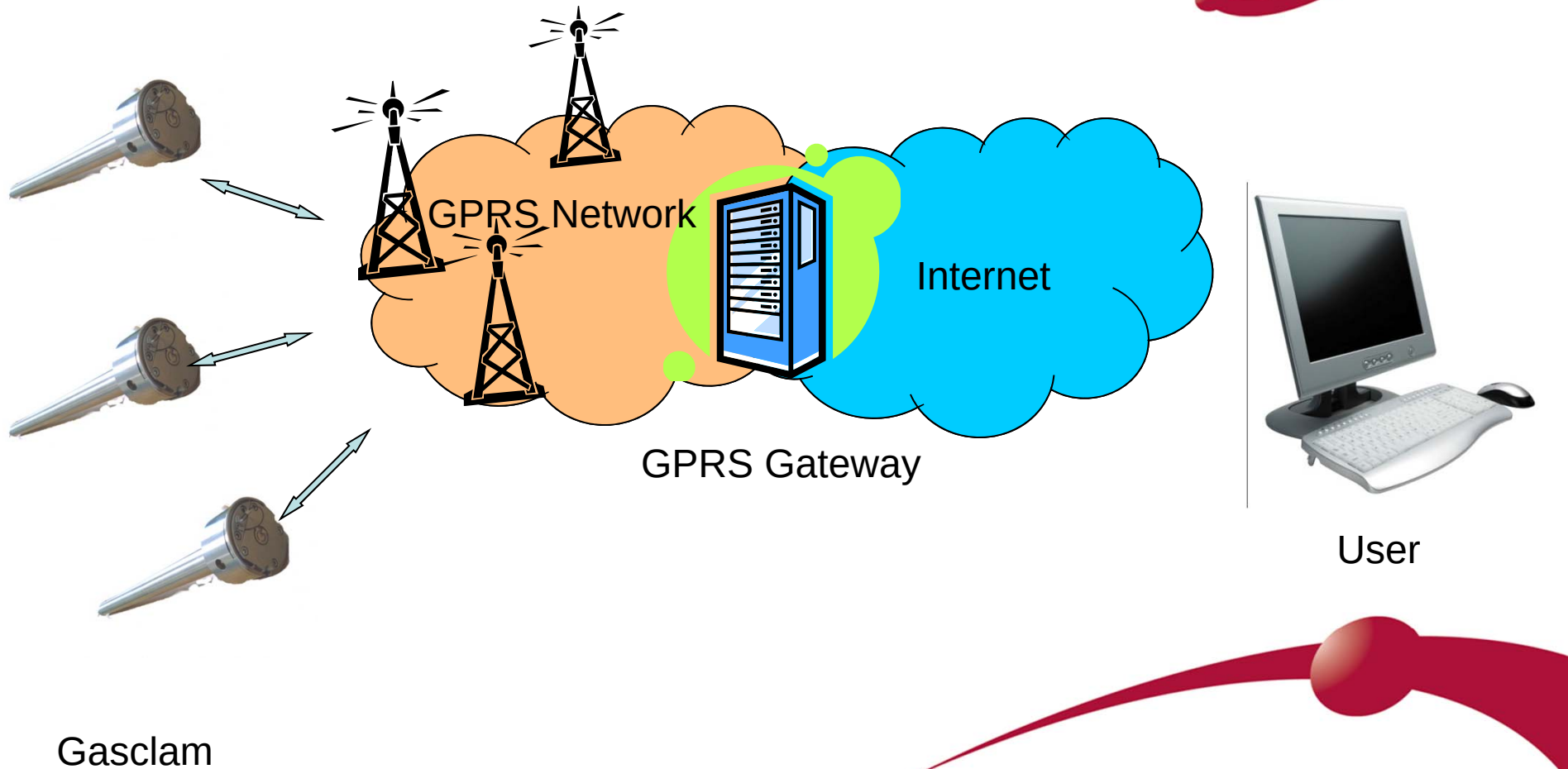
Visit	VOC (ppm)	mBar	Temp °C
1	2	1010	15
2	10	1005	13

You decide!



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Telemetry



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Reporting



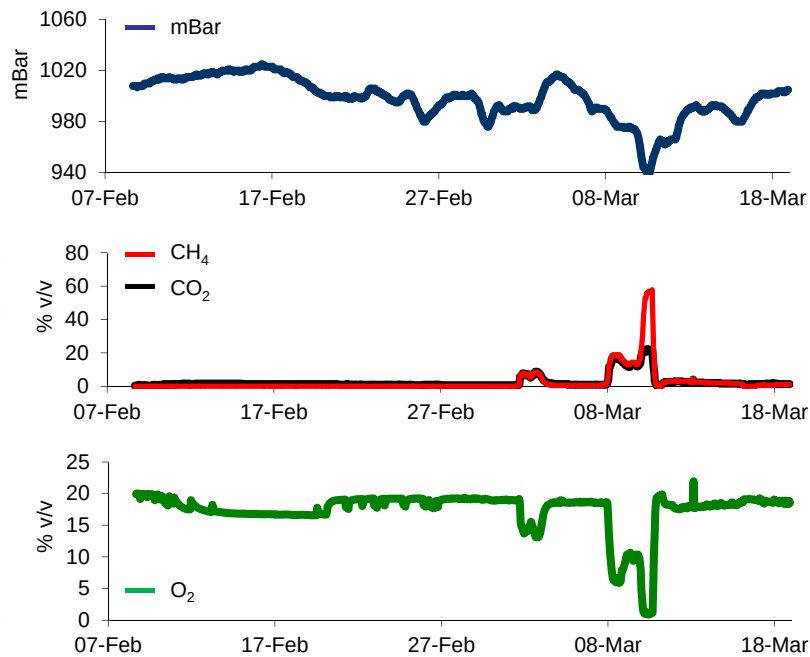
gasclam

In-borehole gas monitoring

HOME

LOGOUT

Summary for GasClam Test (000044/04/10)



Alarm Status



Click To View
Alarm Details

Battery Status



Reporting Period: Last X

Last Week

Reporting Period: Custom

Start: 07-Feb-2010

End: 18-March-2010

Refresh Charts

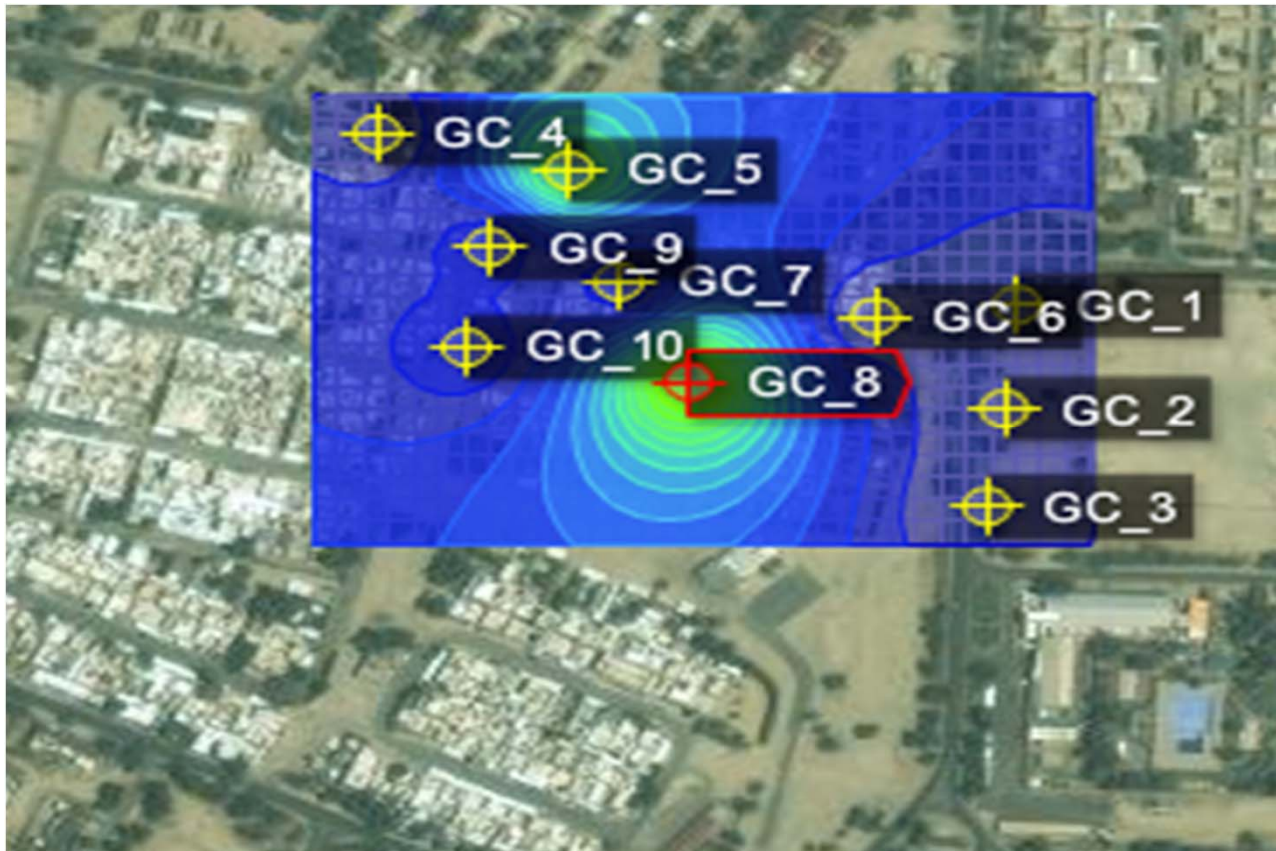
Export Data

Back <<

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Area Monitoring



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Hierarchy of Cost-Benefits

Unmanned data Collection

Efficiency savings in meeting existing legislative requirements.

Reduced uncertainty about vapour regime (improved conceptual model)

Optimisation of design of remediation/vapour protection measures

Optimisation of operations for biogas production/greenhouse-gas emissions.

Pre and Post development condition monitoring with telemetry

Demonstration of low risk by monitoring rather than as a consequence of remedial engineering.

Present -
Reactive

Future -
Proactive



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