



NEW ZEALAND
LAND AND GROUNDWATER
CONFERENCE 2024
22 - 24 OCTOBER - AUCKLAND



Continuous Landfill Gas Monitoring

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Paper / Discussion Aims

- Some background and context to LFG monitoring.
- Discussion on LFG/ground gas migration.
- Benefits of continuous LFG/ground gas monitoring.
- What constitutes “worst case” monitoring conditions.
- Practicalities of using continuous monitoring techniques.

Background and Context

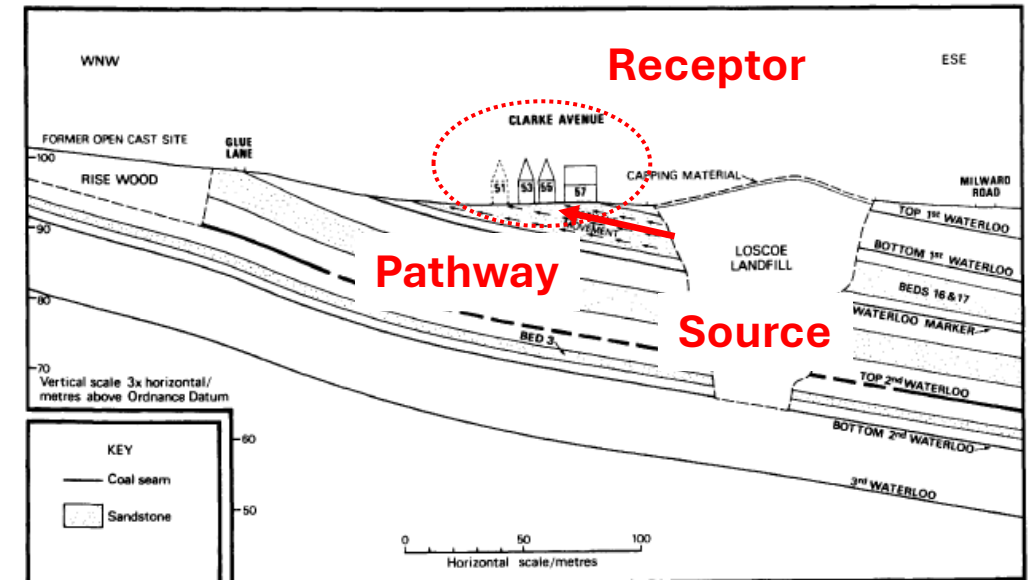


Loscoe, UK - 1986

- Dealing with **short-term acute risk** – NOT a long-term chronic risk.
- Traditional approach "spot measurements" taken on falling barometric pressure events – to estimate "worst case" conditions.
- Worst-case conditions are not defined – prescriptively.
- CIRIA 665 range of recommendations for "spot measurements – 6 to 24 events over 2 to 24 months (for residential properties).
 - NZ practitioners typically aim for 6 events over 2-4 months (depending on the site).

Need a Robust Ground Gas / LFG CSM

- Decision-making needs a robust gas-CSM.
- Various lines of evidence used to develop the gas-CSM and to assess risk – not necessarily all about GSVs.
- “Higher risk sites” will tend to be more complex and typically require more data.



Williams and Aitkenhead. Lessons from Loscoe: the uncontrolled migration of landfill gas. QJEG.1991.

Hazardous ground gas - an essential guide for housebuilders. NHBC Foundation. April 2023.

Semi quantitative approach using Total Organic Carbon (TOC) results for very low to low risk sites	Semi quantitative approach using Gas Screening Values (GSVs) for very low to moderate risk sites	Quantitative approach using continuous monitoring data and alternative GSVs for very low to moderate risk sites	Detailed quantitative risk assessment using numerical modelling for very low to high risk sites
Claire RB17	BS 8485	Ground Engineering 2019	BS8485
Increasing complexity and increasing data requirements			

LFG Monitoring - Changed Over Time



Late 1980s

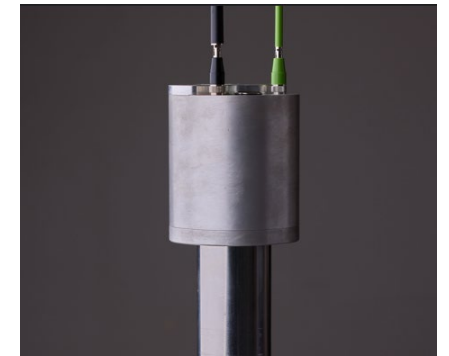


Gas Sentinel



Gas Clam

Miasma Meter



Present Day

LFG Migration / Transport

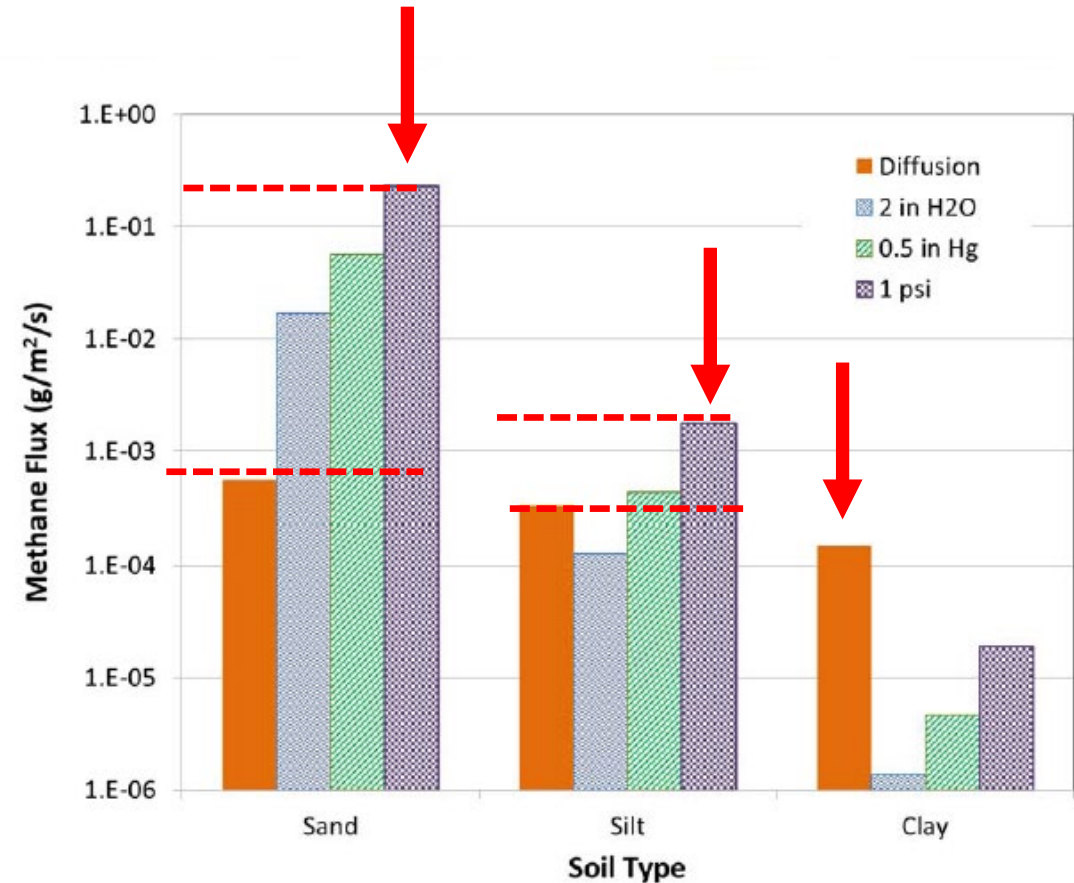
ASTM E2993-16. Standard Guide for Evaluating Potential Hazard as a Result of Methane in the Vadose Zone. March 2016.

- Transport Mechanisms:
 - **Diffusion** (controlled by porosity).
 - Migration rate too slow to create a hazard (ASTM E2993-16).
 - **Advection** across structure foundation.
 - **Pressure-Driven Flow** – gas pressure + barometric and groundwater influences (controlled by permeability).
 - Hence get pressure and concentration gradients away from the source.
- Fate Mechanisms:
 - Generation.
 - Biodegradation.
 - Dilution.
- Methane concentrations in a confined space cannot be greater than the concentration in the subsurface.

Diffusion vs Pressure Driven Flow

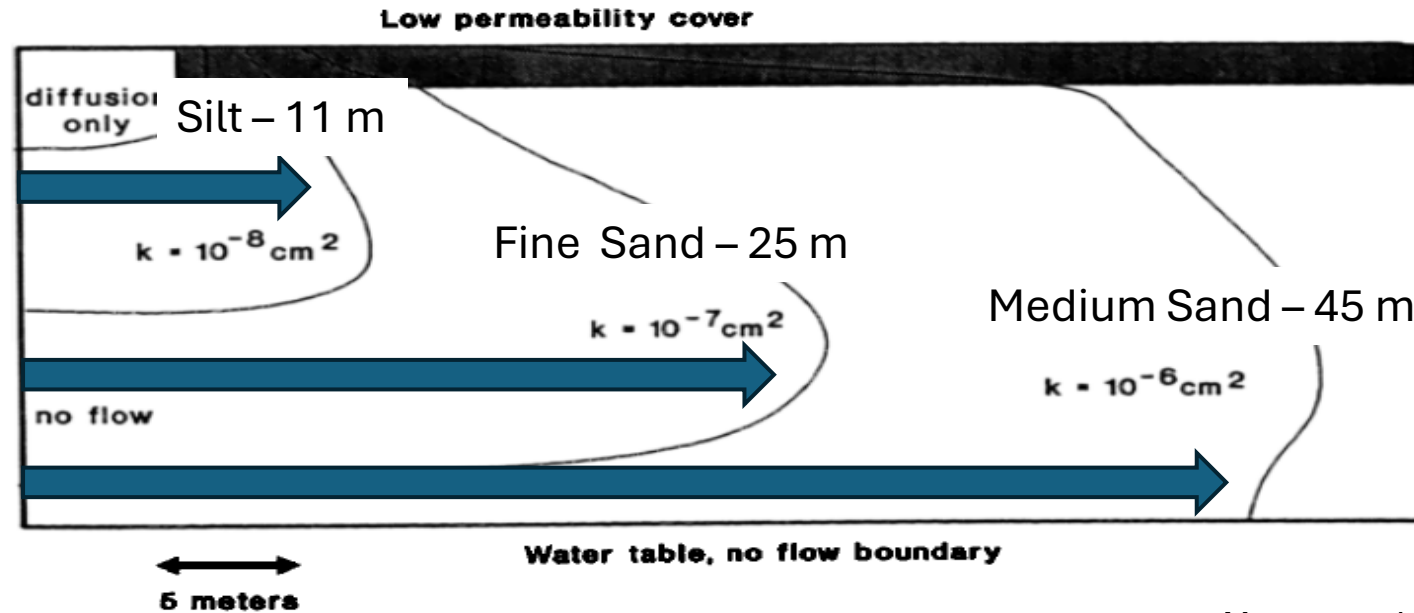
- 1 psi (70 hPa/millibar) pressure-driven flow greater than diffusion by:
 - ~ 1,000 times - Sand
 - ~ 10 times - Silt
- Diffusion is only greater in clay soils.

Model if you must -
Measure if you can!



Ettinger R. and Kerfoot H. Evaluating the Vapor Intrusion Pathway for Methane. AEHS 22nd Annual Conference, San Diego, California, 21.3.12.

Pressure as Migration Driver

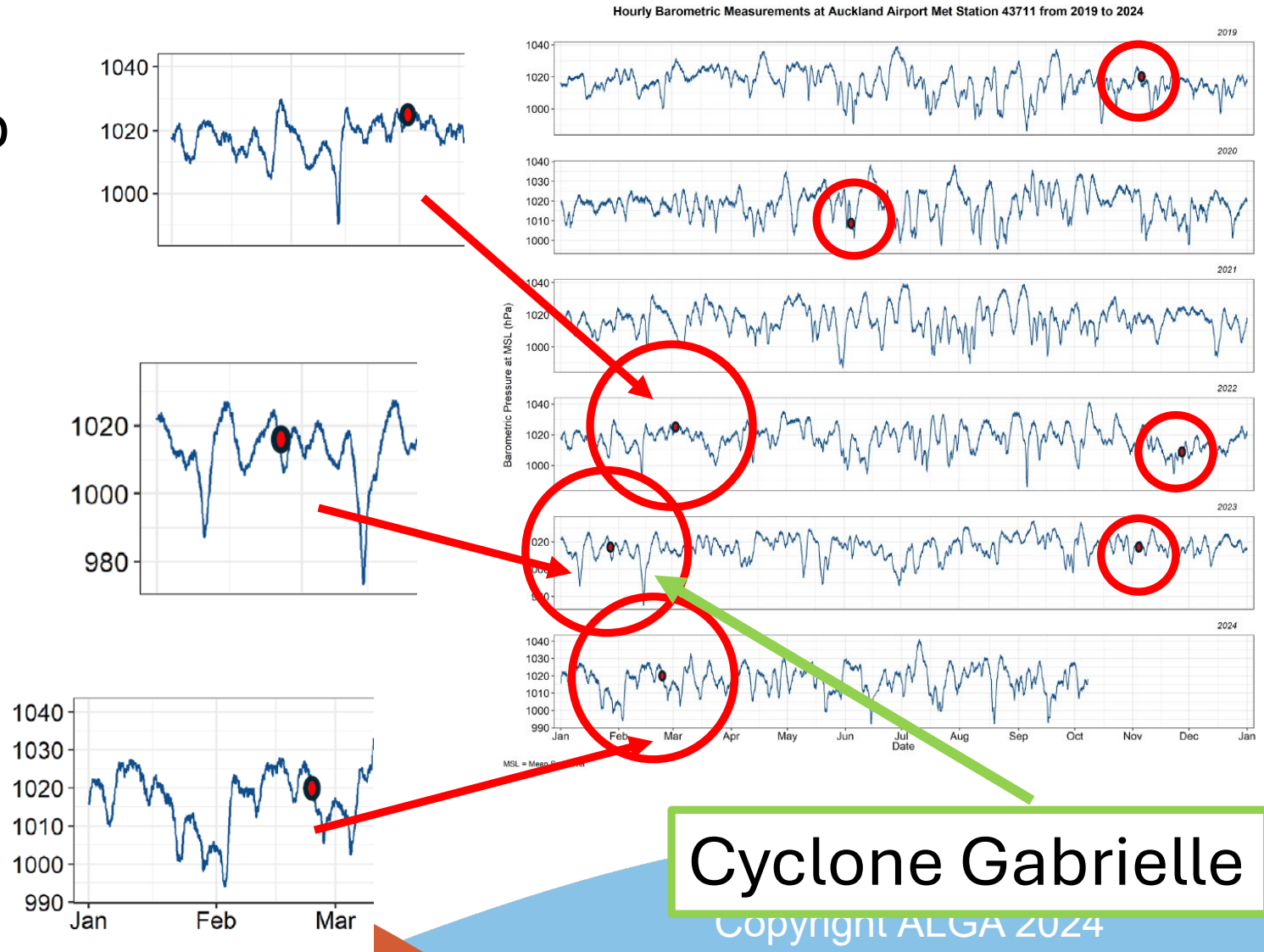


Massmann J. and Farrier D.F. 1992. Effects of Barometric Pressure on Gas Transport in the Vadose Zone. Water Resources Research, Vol.28, No. 3. 777-791.

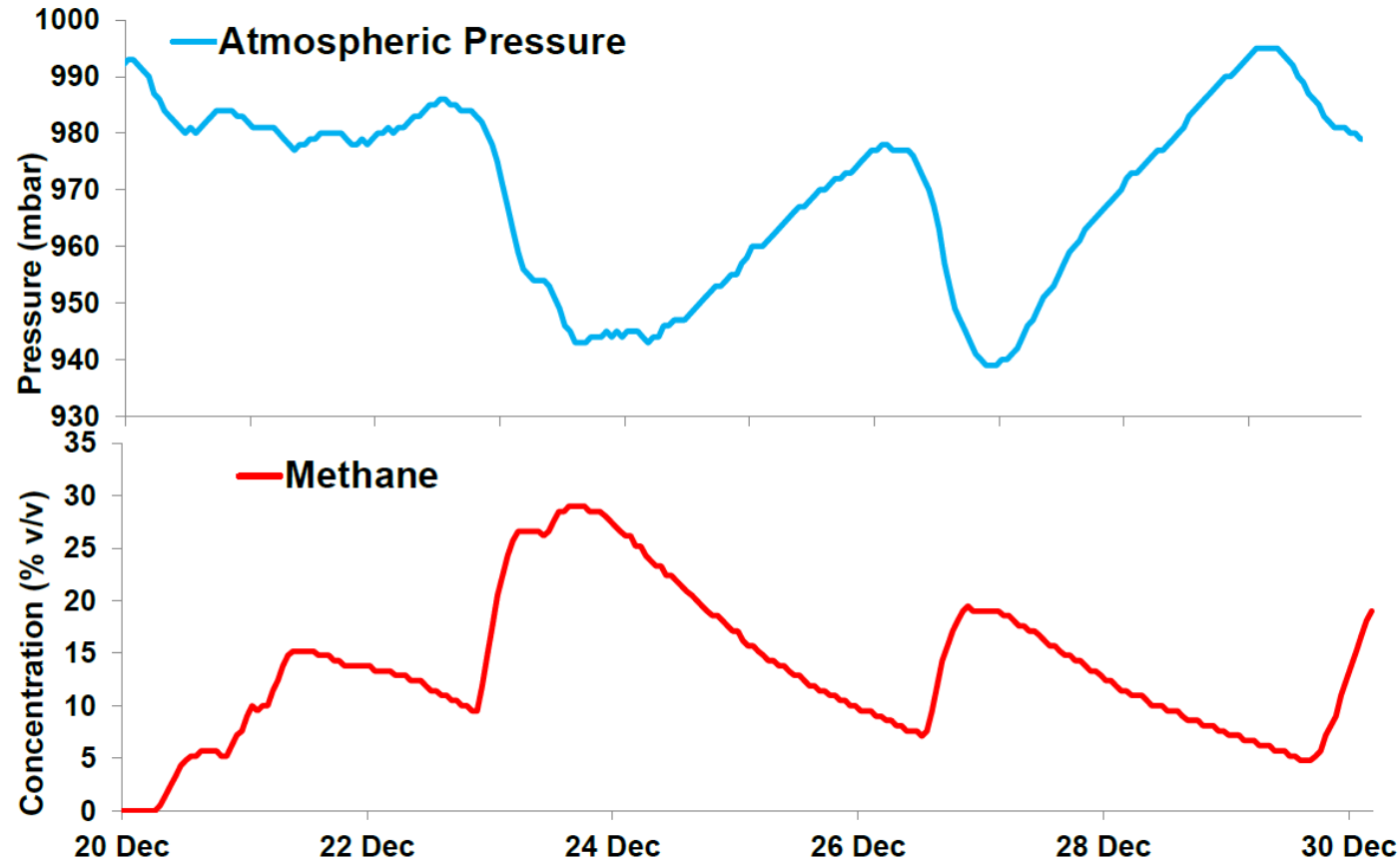
- 2D finite element analysis – 25 mb pressure fall over 24 hours.
- 45 m lateral migration within medium sand.

Spot LFG Measurements

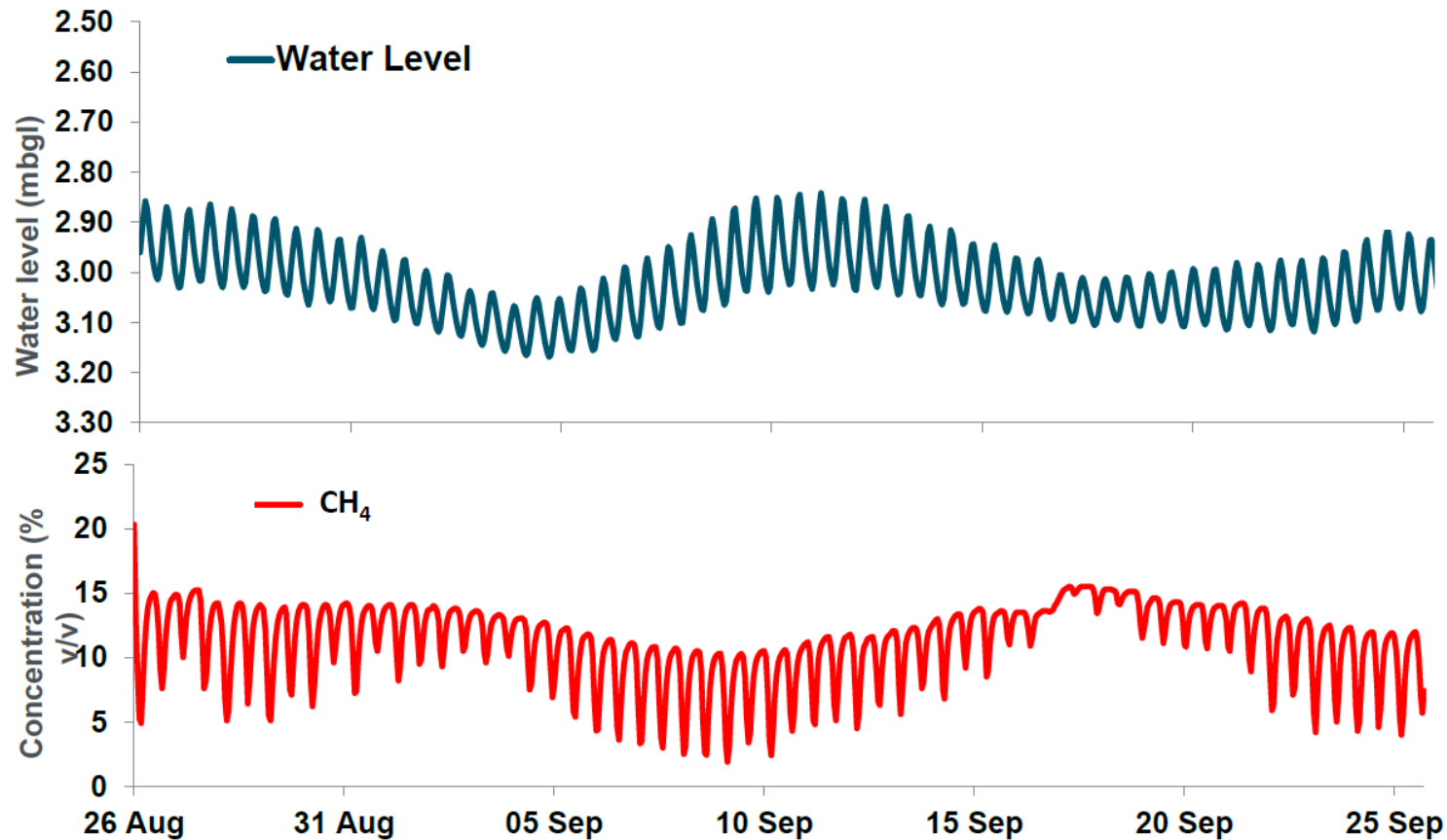
- Typical approach - “aim” to monitor during falling barometric pressure – “aiming” for worst-case conditions.
- Weather doesn’t always work in tandem with consultant working hours.....



Output From Continuous Monitoring

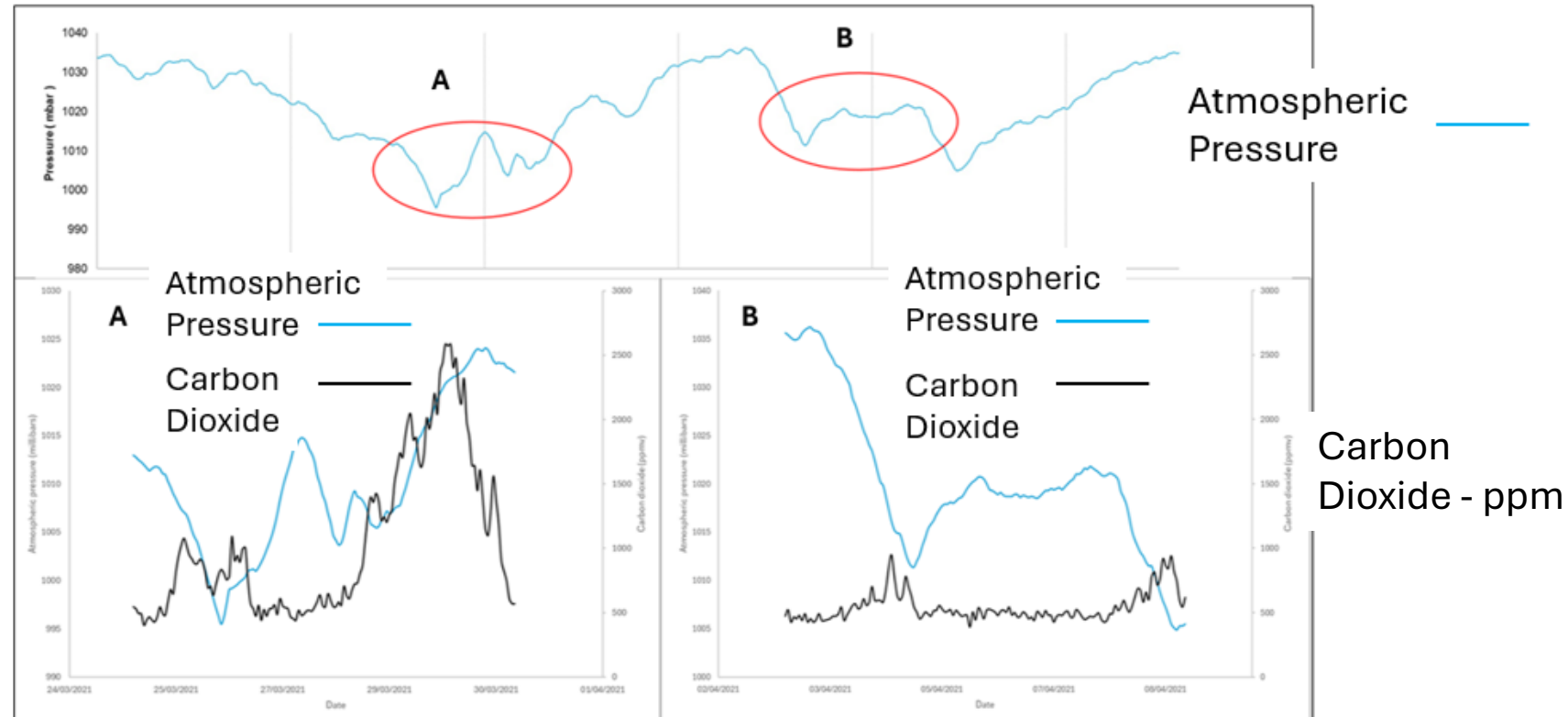


Groundwater Level Fluctuations vs Gas Concentration

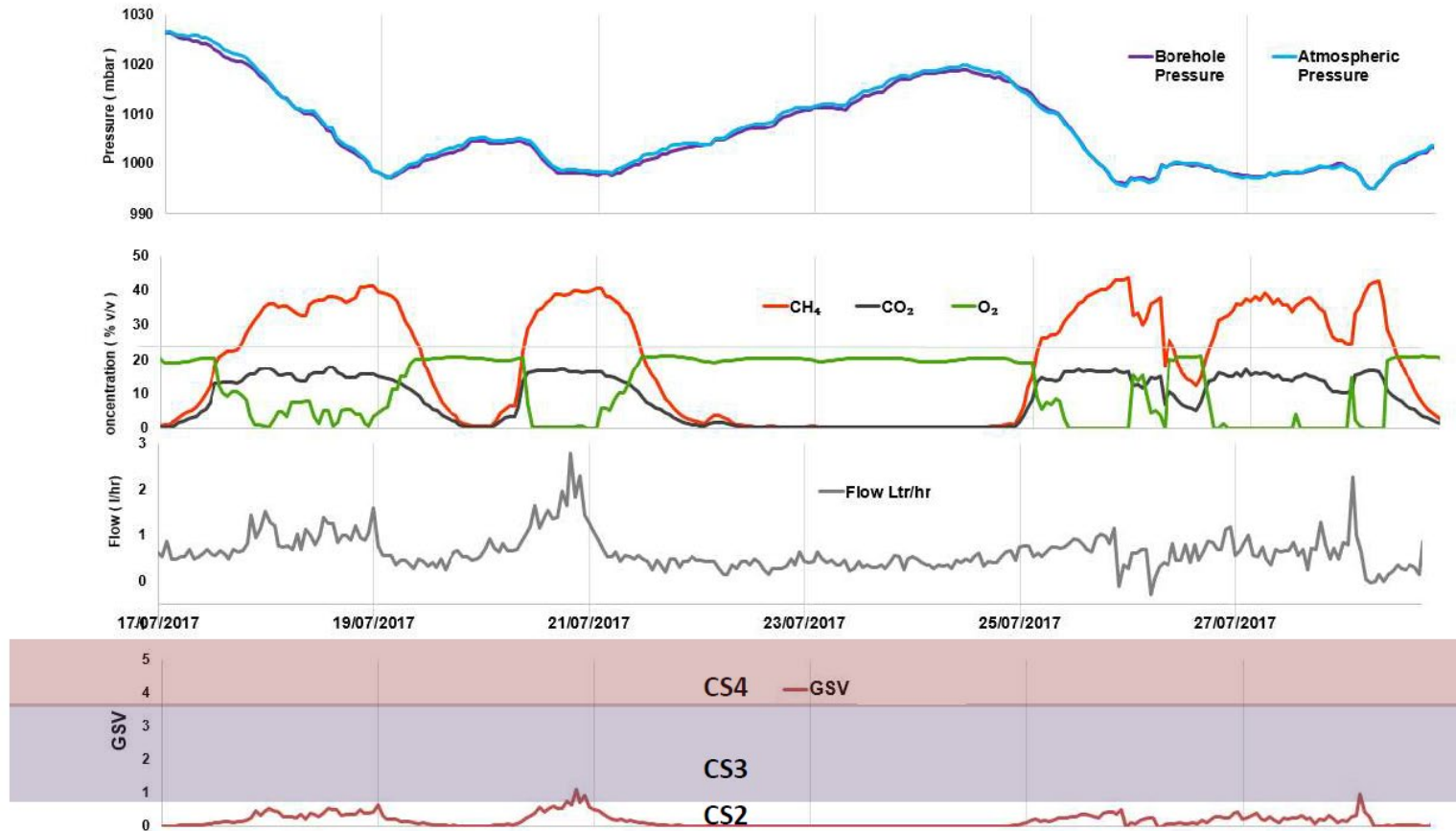


Hysteresis (lagged response)

- Hysteresis occurs for a variety of reasons – geology, seasonal issues, LFG supply/volume.

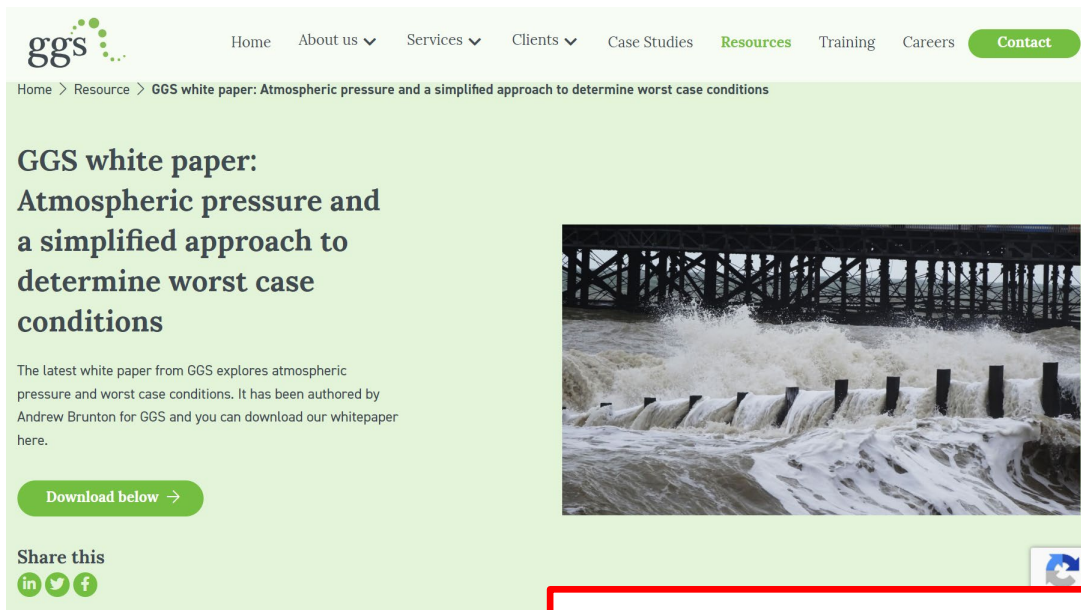


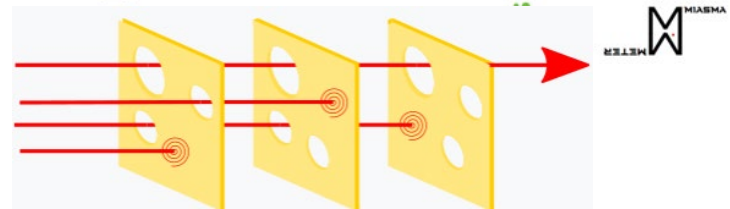
Output From Continuous Monitoring



What Constitutes Worst Case Pressure Conditions (in the UK)?

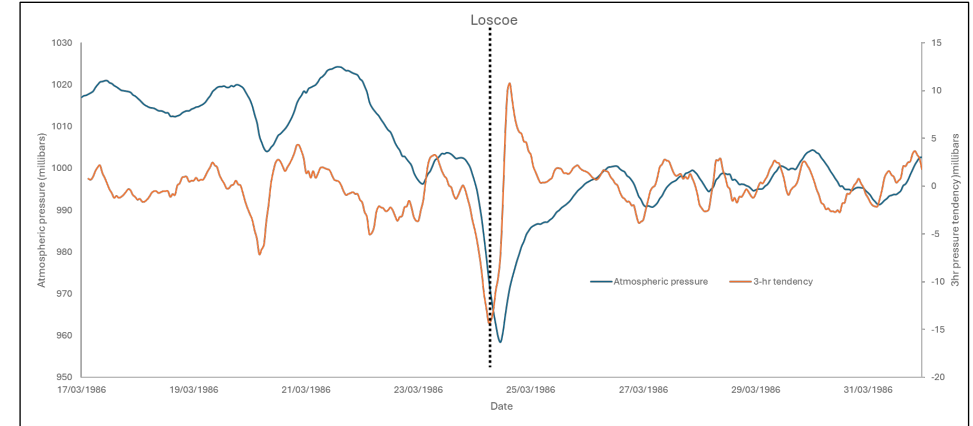
- Worst-case thresholds that influence ground gas behaviour and migration.
 - $>0.99 - 1.11$ millibar fall per hour.
 - Averaged over 8 hours.





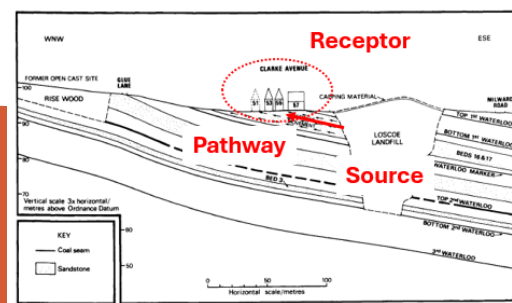
Re-Visiting Loscoe Incident

- Extreme event.
- Damaged property 60 m from fill site.
- Domestic waste landfilled (fresh) and fill site recently capped.
- Gas issues noted on neighbouring properties before the incident.
- Pressure flow (through permeable bedrock) and accumulation in void adjacent to the site.
- Barometric pressure-driven LFG migration.



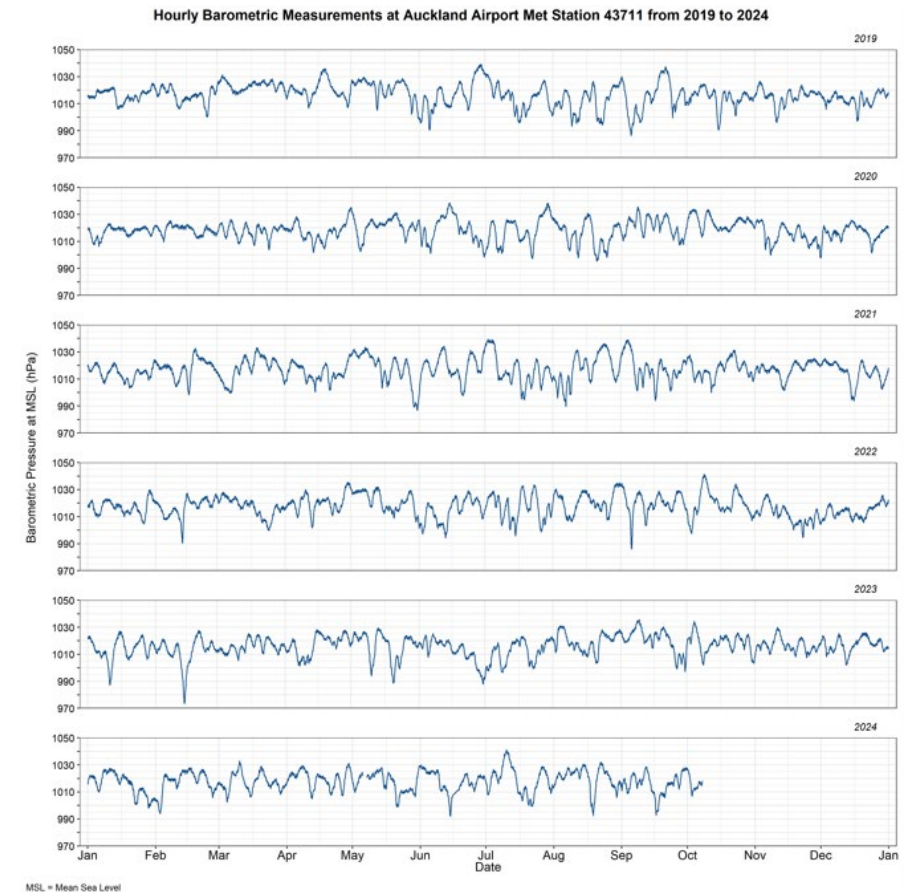
Brunton, A. 2024. Atmospheric Pressure and a Simplified Approach to Determine Worst Case Conditions for Ground Gas Monitoring in the UK. Ground Gas Solutions – White Paper.

		1 hr change	3-hr tendency	8-hr ave fall	
24/03/1986 0:00	996.7	-1.8	-4.5	-0.7	rapid fall
24/03/1986 1:00	994.5	-2.2	-5.7	-0.9875	rapid fall
24/03/1986 2:00	991.3	-3.2	-7.2	-1.4	very rapid fall
24/03/1986 3:00	987.7	-3.6	-9	-1.8375	very rapid fall
24/03/1986 4:00	983.2	-4.5	-11.3	-2.35	very rapid fall
24/03/1986 5:00	978.5	-4.7	-12.8	-2.8375	very rapid fall
24/03/1986 6:00	973.4	-5.1	-14.3	-3.35	very rapid when house exploded
24/03/1986 7:00	969.2	-4.2	-14	-3.6625	very rapid fall
24/03/1986 8:00	965.6	-3.6	-12.9	-3.8875	very rapid fall
24/03/1986 9:00	962.5	-3.1	-10.9	-4.00	very rapid fall
24/03/1986 10:00	959.6	-2.9	-9.6	-3.9625	very rapid fall
24/03/1986 11:00	958.4	-1.2	-7.2	-3.6625	very rapid fall
24/03/1986 12:00	960.7	2.3	-1.8	-2.8125	fall
24/03/1986 13:00	964.7	4	5.1	-1.725	rising



Applying the GGS UK Thinking to Auckland

- UK recorded approx. 350-400 worst-case events over 6 years – 1 every 1.1 weeks.
- Auckland recorded 115 worst-case events over 6 years – 1 every 2.7 weeks.
- The depth of lows/depressions is not as great in Auckland vs. the UK.
- NSW EPA recommended 95th percentile of 3-hour pressure decrease.
- Suggest that Auckland perhaps fall >5 millibars over 8 hours (compared to the UK, which has 8 millibars).



Miasma Meter

- Developed in Australia.
- Release date very imminent.
- Measures flow and concentration – CH_4 , CO_2 , & O_2 .
- Extended battery life because of the way it measures concentration.
- Easy to install and telemetry linked.
- “Easier, simpler, and cheaper”



Thoughts On Continuous Gas Monitoring

- A C3 site could reduce monitoring time from 3 months to 3 weeks.
- A C5 site could reduce monitoring time from 12 months to 3 months.
- Miasma Meter – pitched at a rental price of NZ\$1,600/month.
- Other continuous monitoring meters – rental price Aus approx. \$3,300/month.
- Continuous monitors fit a 50 mm dia. well.
 - Potential modifications to existing wellhead works need to be considered.
- Likely to want to move the monitors between wells.
- Metal headworks may affect the performance of the telemetry link.
- Continuous monitoring enables the “significance” of worst-case conditions to be established – which may suggest that it is unreasonable to apply worst-case conditions.

References

- ASTM E2993-16. Standard Guide for Evaluating Potential Hazard as a Result of Methane in the Vadose Zone. March 2016.
- Brunton. A. Atmospheric Pressure and a Simplified Approach to Determine Worst Case Conditions for Ground Gas Monitoring in the UK. Ground Gas Solutions – White Paper. 2024.
- CIRIA 665. Assessing Risks Posed by Hazardous Ground Gases to Buildings. 2007.
- Ettinger and Kerfoot. Evaluating the Vapor Intrusion Pathway for Methane. AEHS 22nd Annual Conference, San Diego, California. March 2012.
- Massmann and Farrier. Effects of Barometric Pressure on Gas Transport in the Vadose Zone. Water Resources Research, Vol. 28, No. 3. 777-791. 1992.
- NSW EPA. Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases. 2012.
- NHBC Foundation. Hazardous ground gas - an essential guide for housebuilders. April 2023.
- Williams and Aitkenhead. Lessons from Loscoe: the uncontrolled migration of landfill gas. Quarterly Journal Engineering Geology. 1991.