Effective & Sustainable SVE tool to extract PHC vapours

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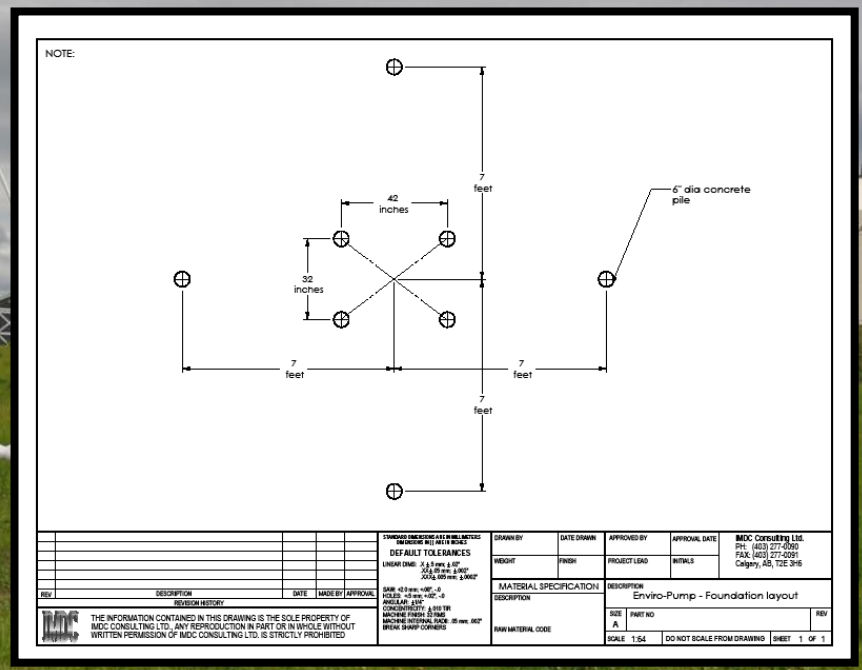
Outline

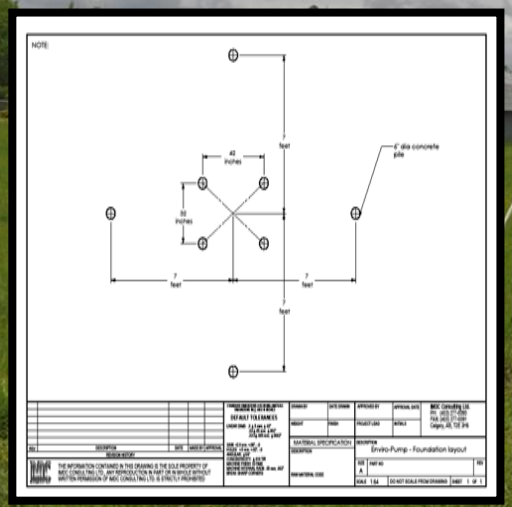
- Goal
- Traditional SVE
- Windmill Design
- Safety
- Pros & Cons
- Performance
- Results
- Costs

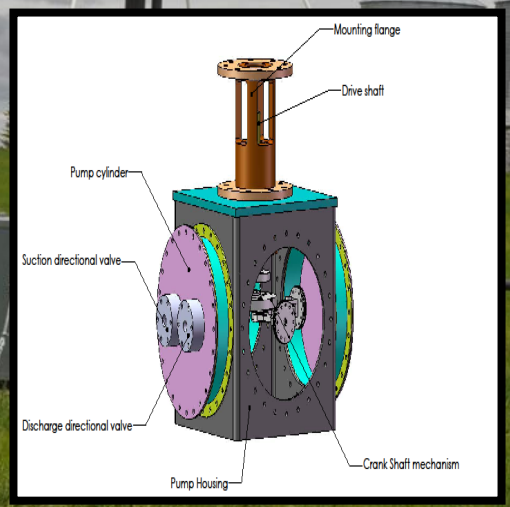


Goal

Providing a remediation tool that is:

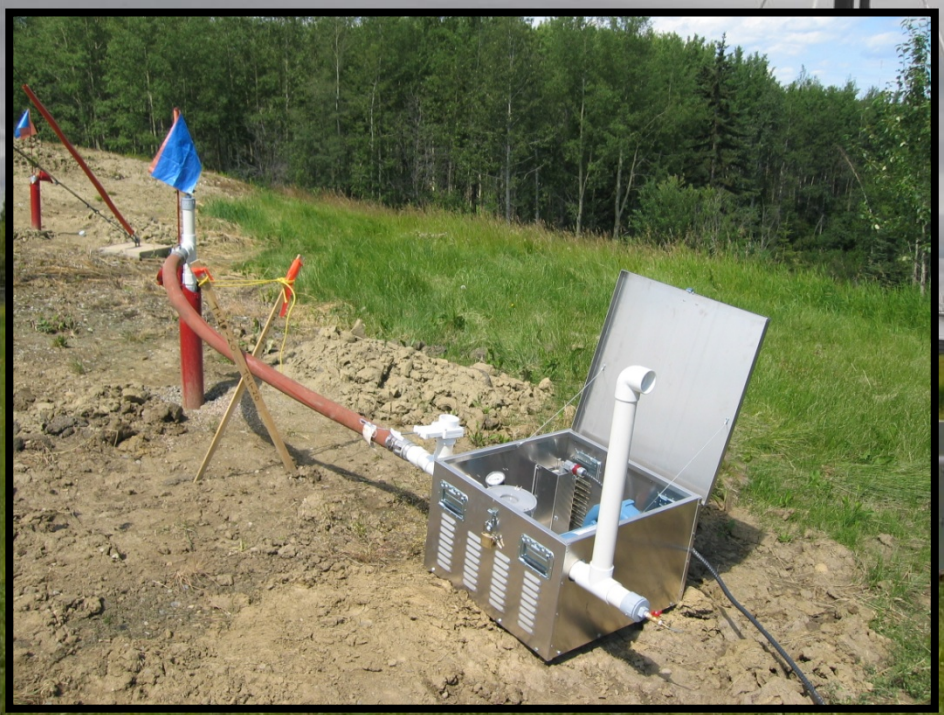
- Reliable, low-cost and long-term
- Low impact and stakeholder accepted
- Sustainable



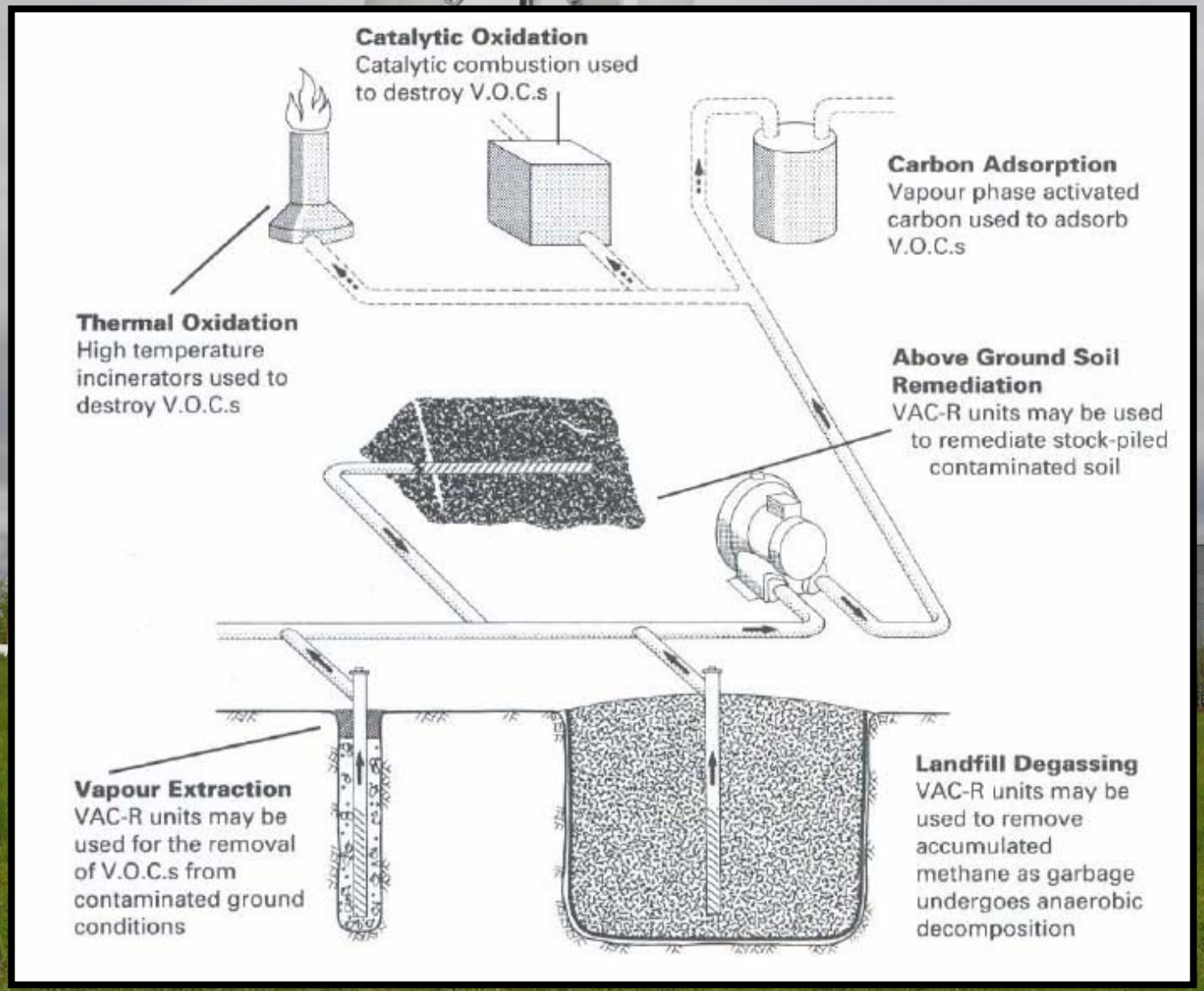


Traditional Soil Vapour Extraction Methods

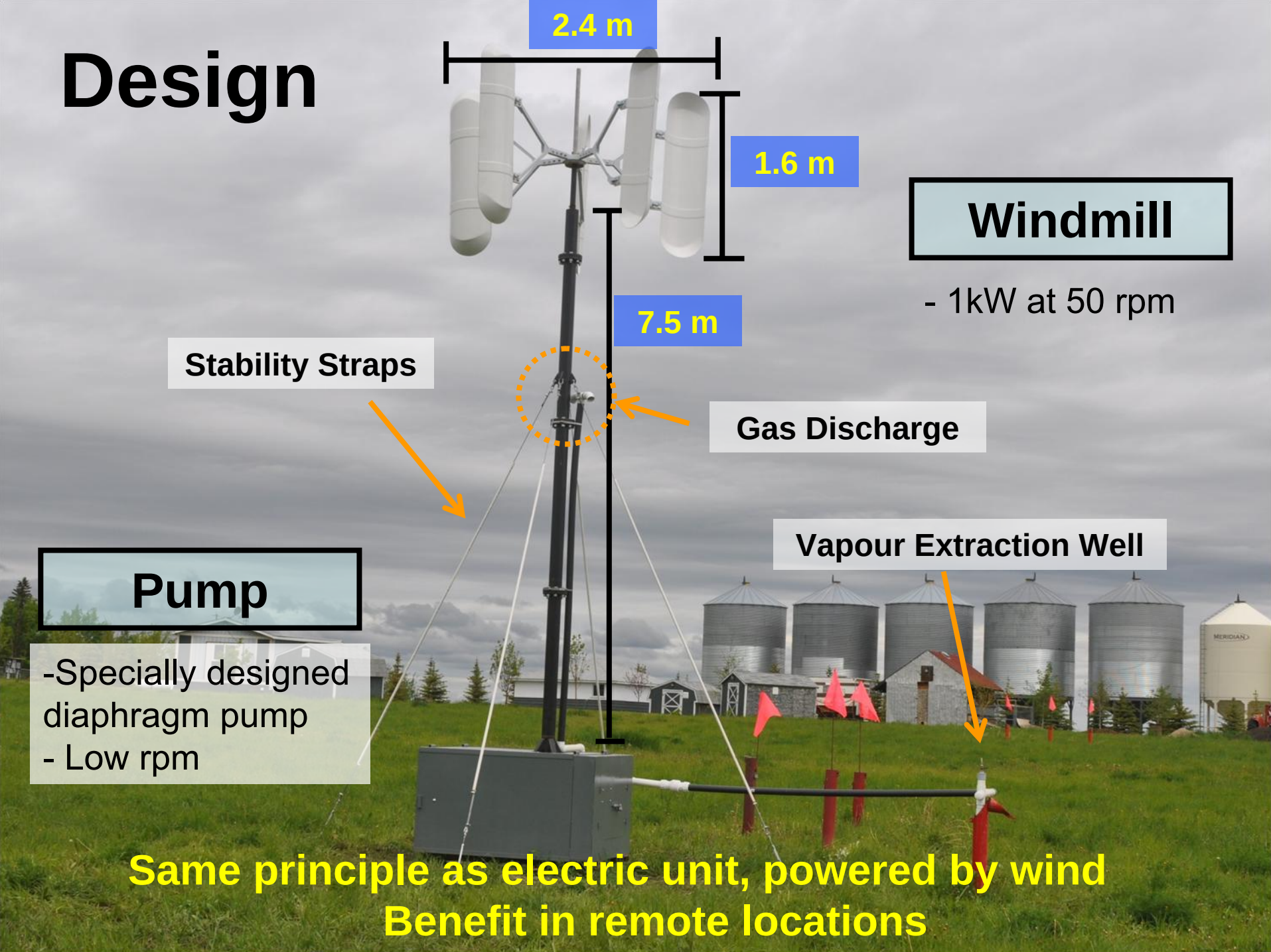
- Electric powered unit (1 or 3 hp)
  - With power supply (generator, city line, etc…)
- High speed (turbine) vacuum pump
- High rpm electric motor



Traditional Soil Vapour Extraction Methods



Design



Windmill

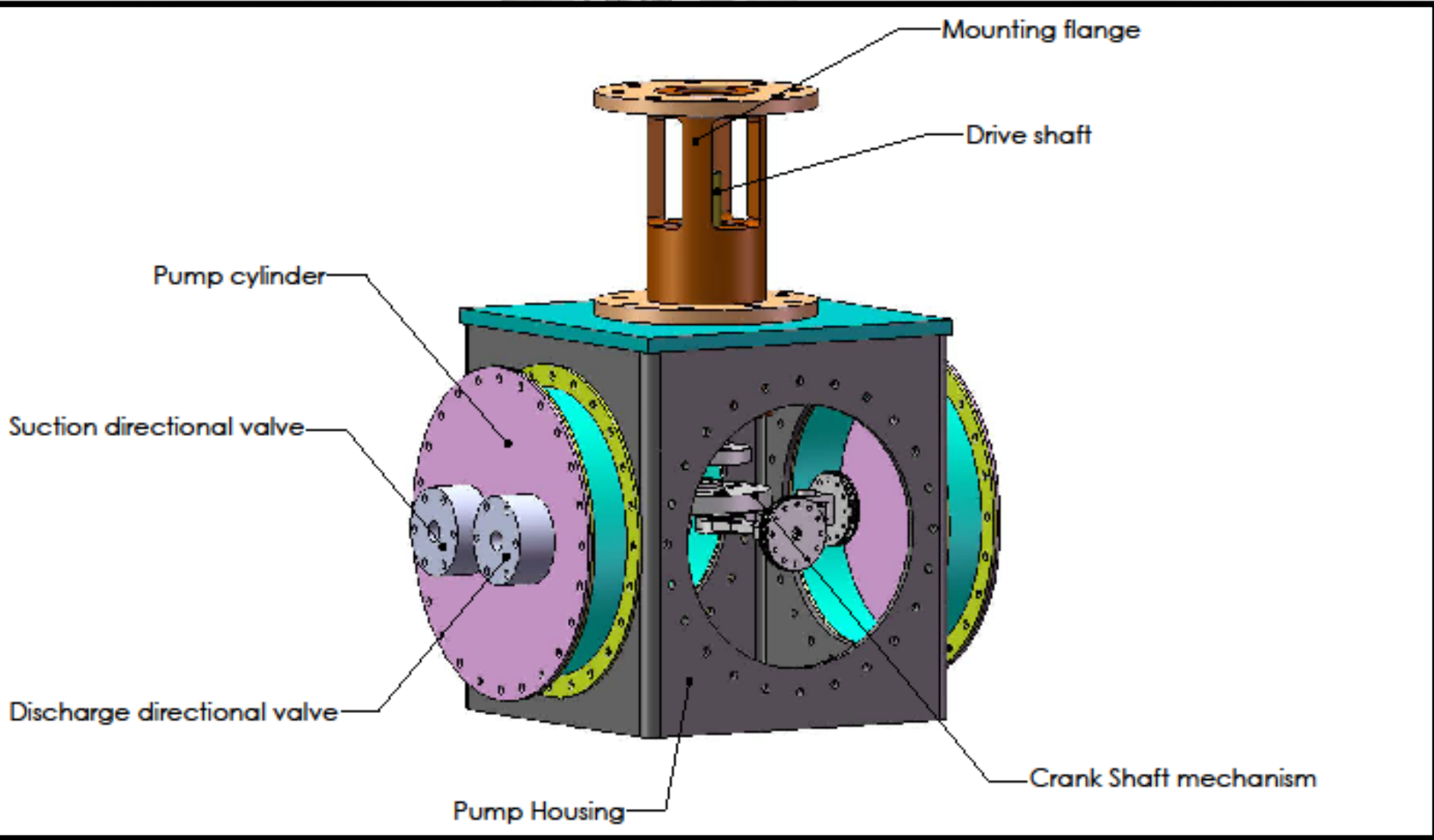
- 1kW at 50 rpm

Pump

-Specially designed diaphragm pump
- Low rpm

Same principle as electric unit, powered by wind
Benefit in remote locations

Diaphragm Pump



Safety - HSE

- Windmill height at ~7.5m and out of reach
- Guard wires for stability
- Vertical design - no low point
- Low rpm (max 50 rpm)
- No electricity
- CSA approval in progress
- No lubricants
- No worker exposure – 2 chamber design

Traditional SVE

Pros

- Low initial costs
- Easy installation
- Light weight
- Mobile
- Easily accessible (many suppliers)

Cons

- Cost of electricity
- High maintenance cost
  - typically equivalent to cost of new unit
- Short life span (2-3 years)
- Over heating due to vacuum
- Noise
- Explosive proof components
  - motor and pump
- Understanding of soil permeability
- Electric power supply
- Pump uptime
  - Difficult to determine volume extracted
- Difficulty to control flow and vacuum
  - Adjusting bleeding valve

Windmill SVE

Pros

- Low O&M costs
  - In-frequent site visits
  - low cost of parts – simple design
- Long life span
  - Low maintenance design
- Pump durability
  - No over heating due to over vacuum
- Quiet system
- Revolution counter
  - to calculate volume extracted
- No electricity, no sparks
  - Explosive proof
  - Ideal for remote locations
  - Green energy

Cons

- Installation effort
  - Requires site preparation, i.e. foundation
- Heavy weight
- Fixed on site (limited mobility)

Performance Comparison

Traditional SVE

- 3,000 kg PHC / 2,000,000 m^3

  = 1.5 g/m^3 PHC removed

Windmill SVE

- 850 kg PHC / 15,000 m^3

  = 57 g/m^3 PHC removed

Windmill SVE performance 38 times greater

Data was collected from the same site over a period of 7 months

Performance Comparison

Traditional SVE

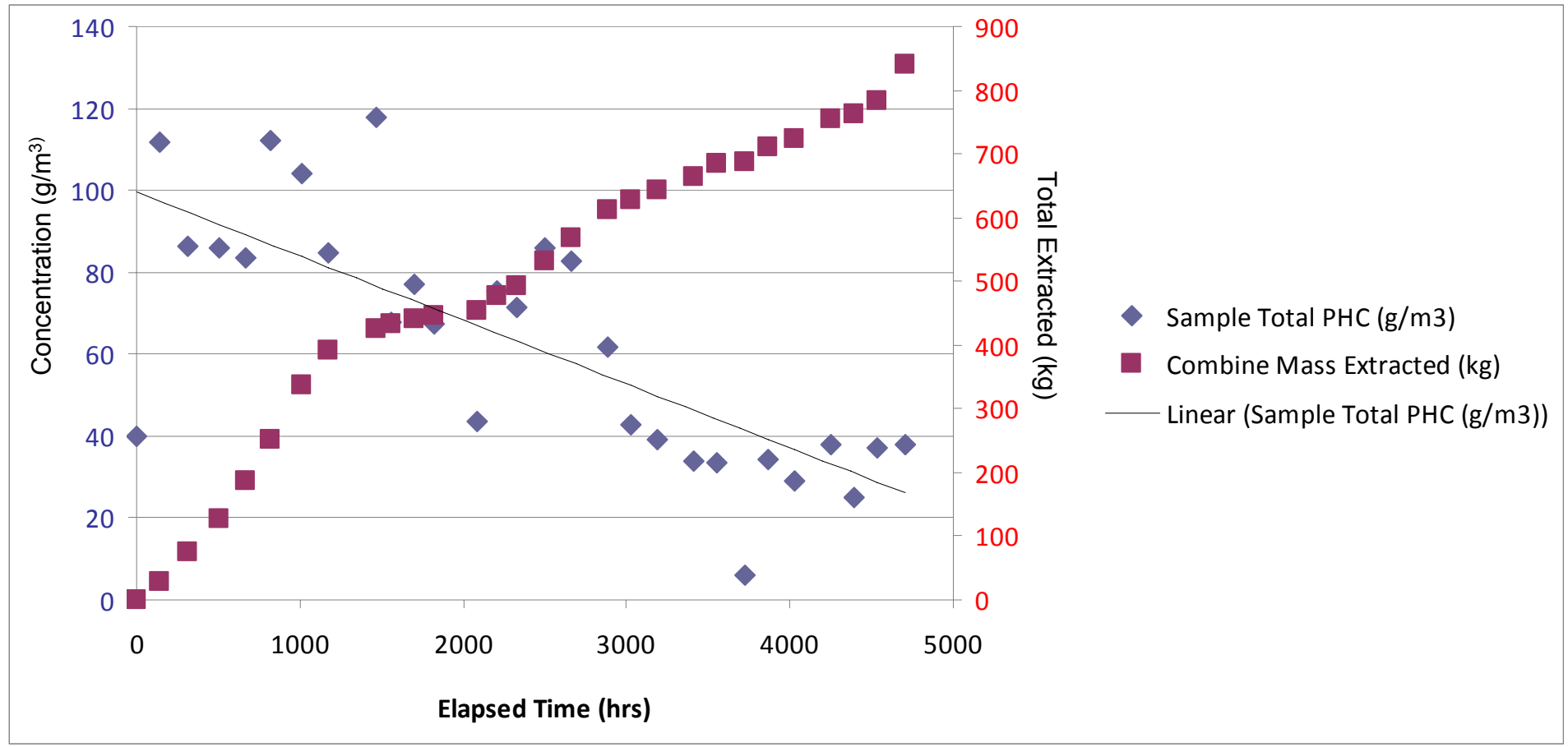
- 1 kW power = 1.31 lbs of CO_2 emissions
- Running traditional method for 1 year:
  - 8760 h = 11,388 lbs
  - For 7 months = 6643 lbs = 3016 kg of CO_2

3000 kg of PHC was removed at the cost of emitting 3000 kg of CO_2.

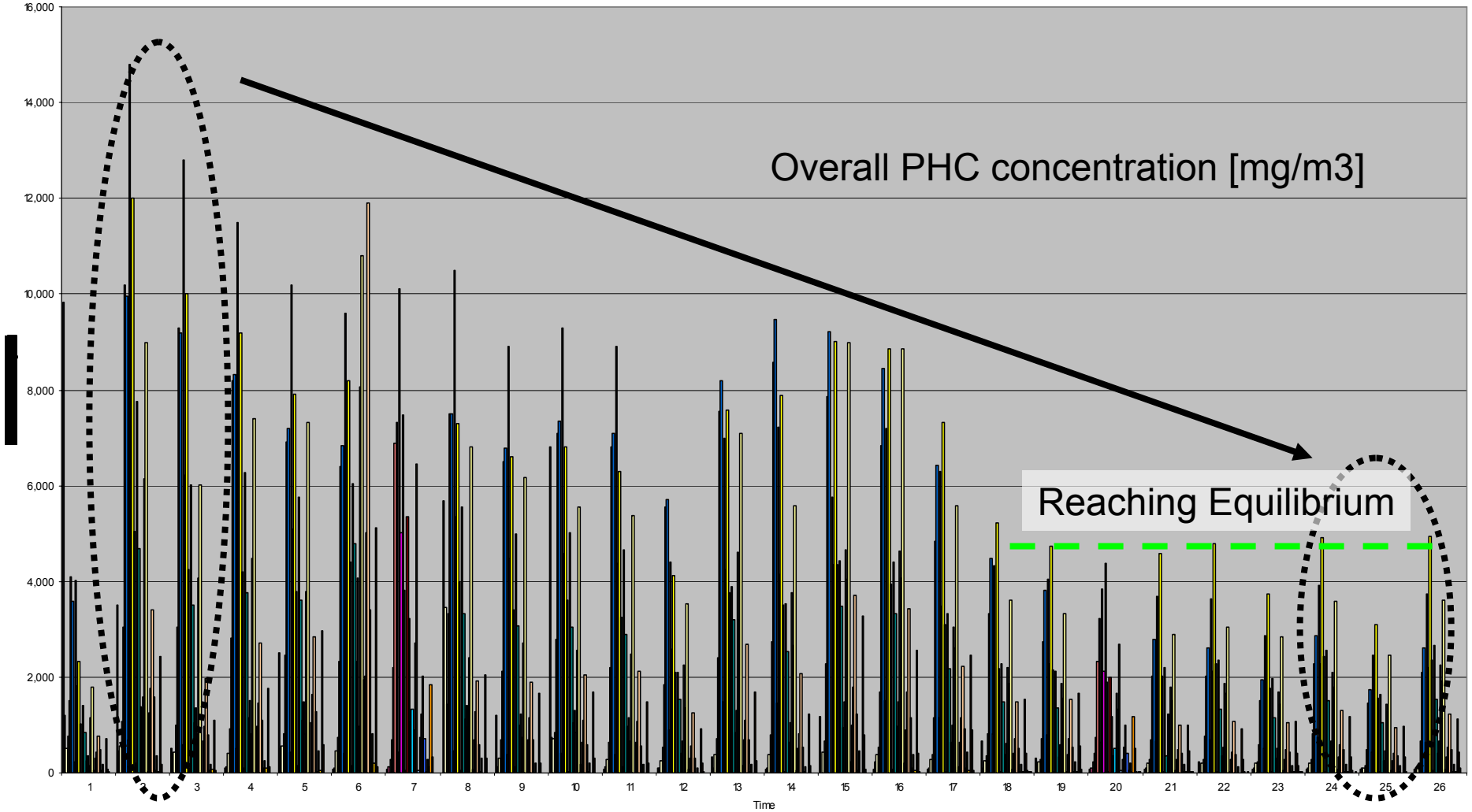
Windmill does not generate CO_2 emissions

Data was collected from the same site over a period of 7 months

Windmill Extraction Results

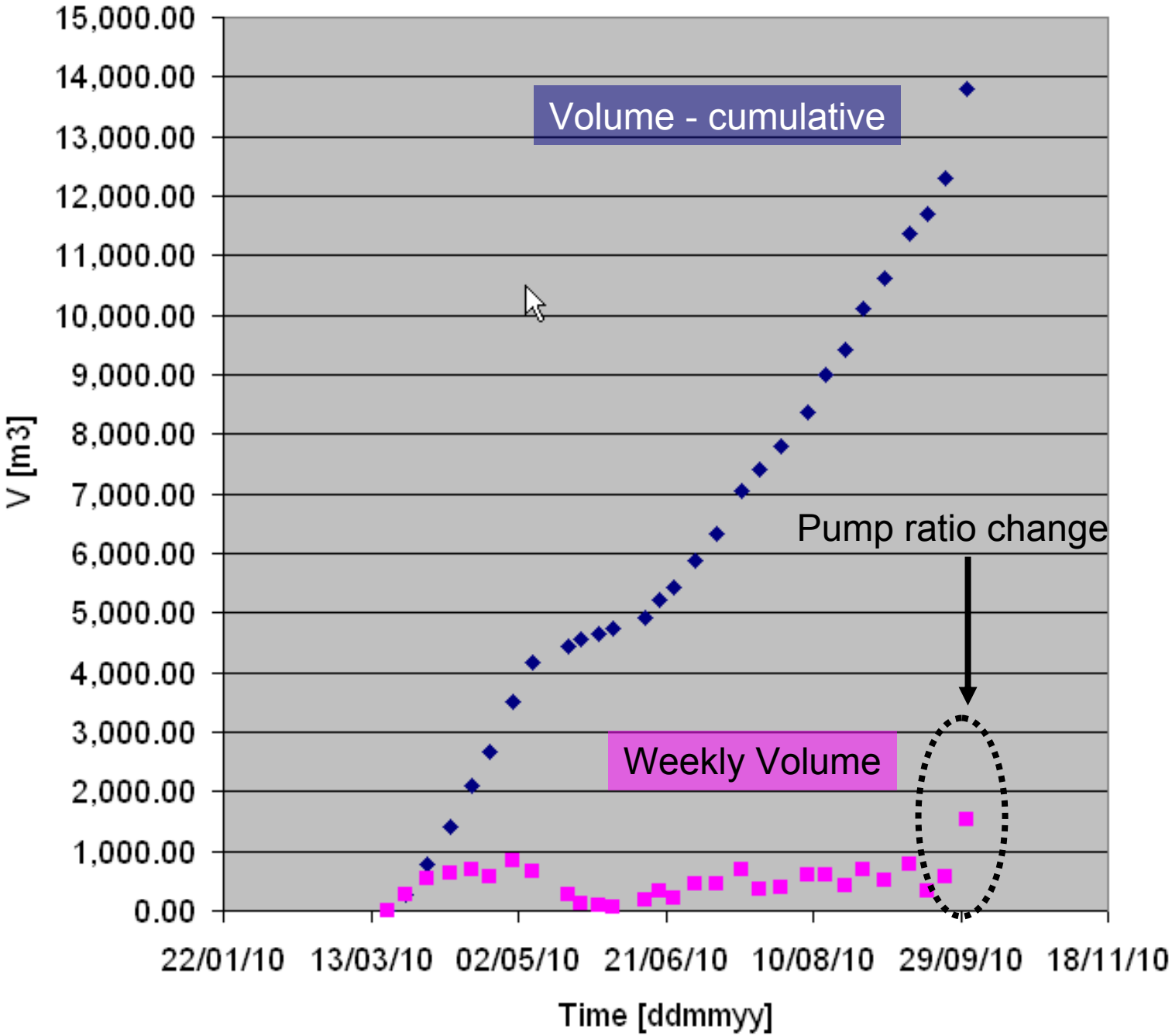


PHC

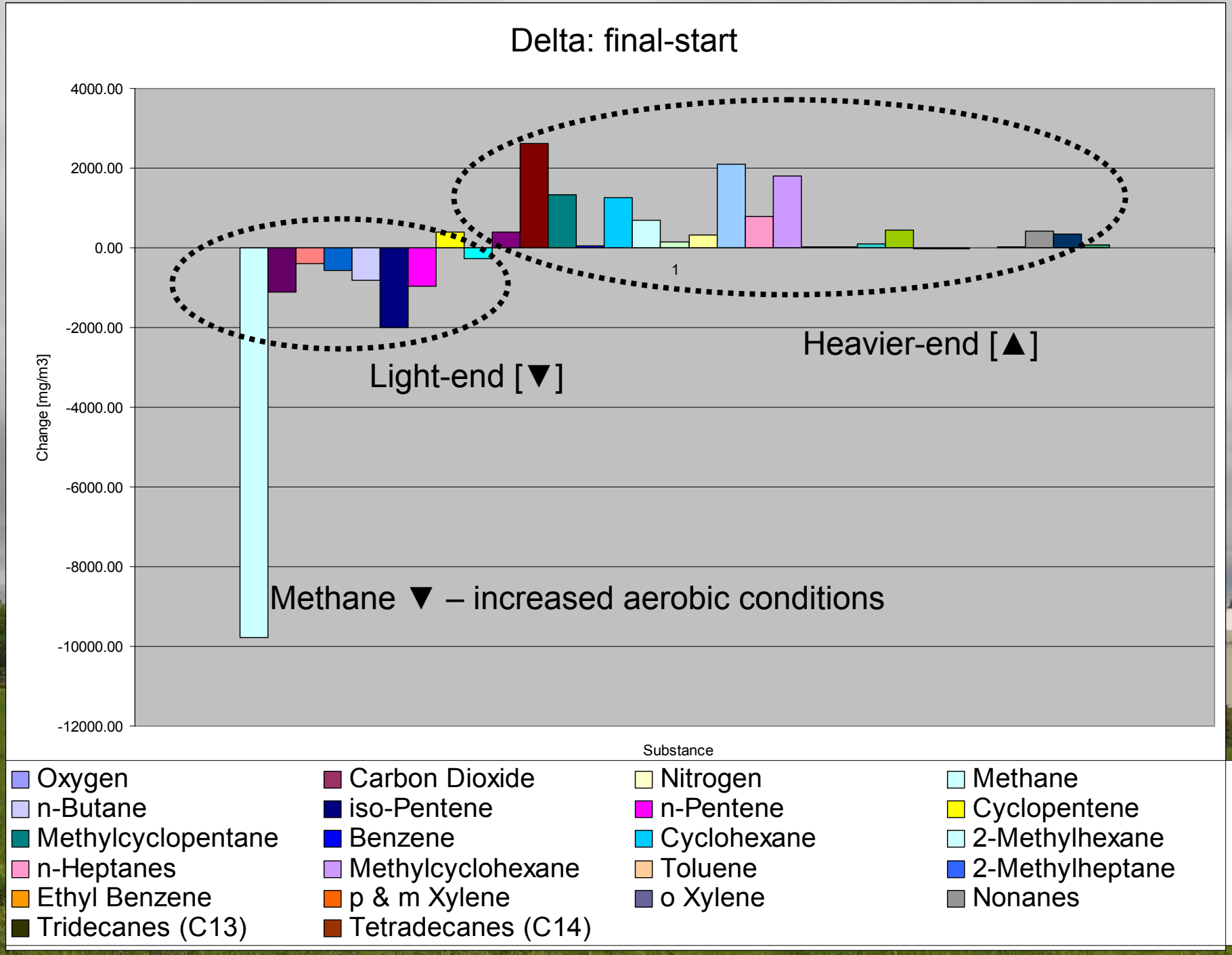


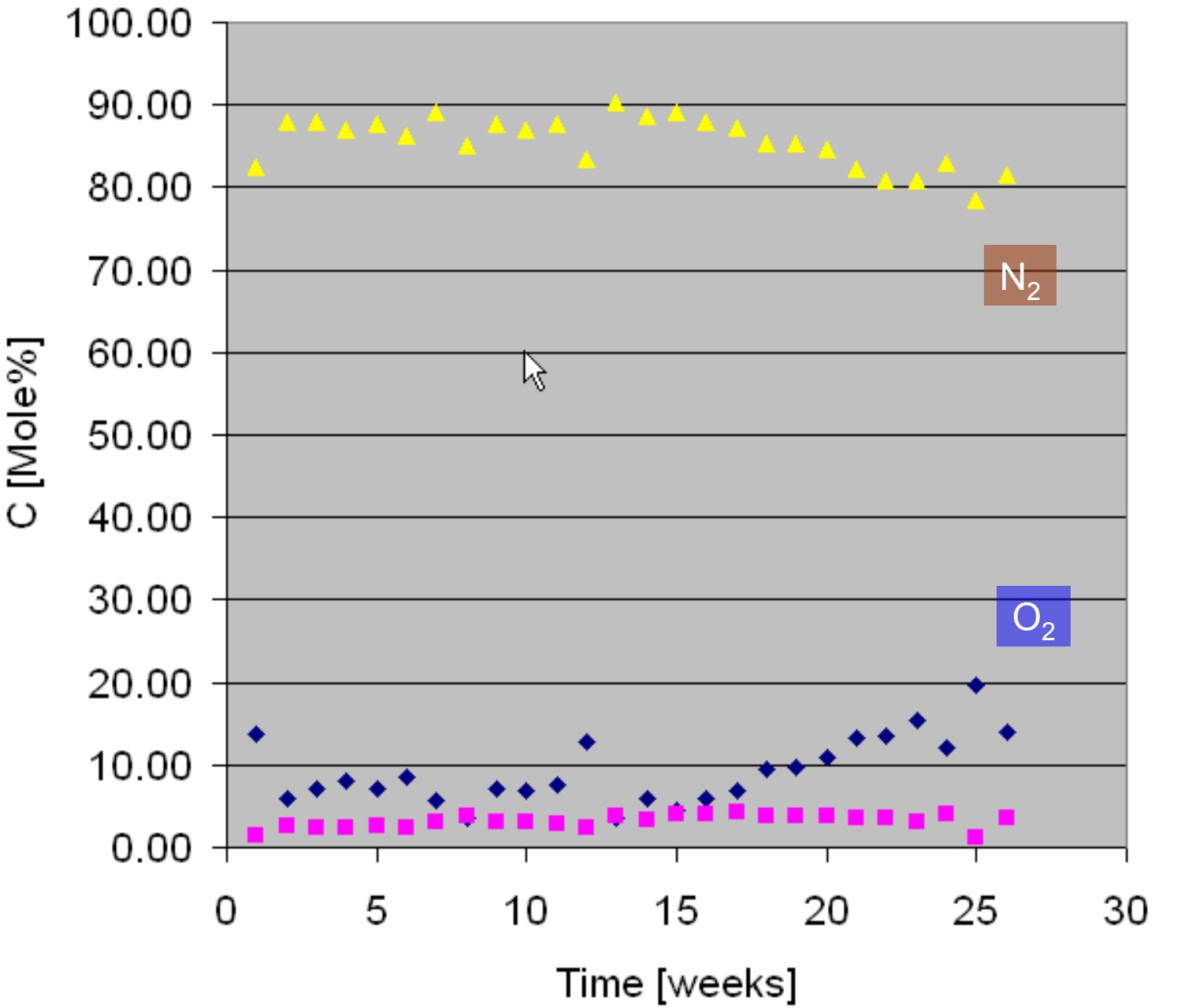
---------- Weeks (1-26) ----------

Methane (mg/m3) | Ethane (mg/m3) | Propane (mg/m3) | iso-Butane (mg/m3) | n-Butane (mg/m3) | iso-Pentene (mg/m3)
n-Pentene (mg/m3) | Cyclopentene (mg/m3) | 2-Methylpentene (mg/m3) | 3-Methylpentene (mg/m3) | n-Hexane (mg/m3) | Methylcyclopentane (mg/m3)
Benzene (mg/m3) | Cyclohexane (mg/m3) | 2-Methylhexane (mg/m3) | 3-Methylhexane (mg/m3) | 2,2,4 Trimethylpentene (mg/m3) | other Heptanes (mg/m3)
n-Heptanes (mg/m3) | Methylcyclohexane (mg/m3) | Toluene (mg/m3) | 2-Methylheptane (mg/m3) | 3-Methylheptane (mg/m3) | other Octanes (mg/m3)
n-Octane (mg/m3) | Ethyl Benzene (mg/m3) | p & m Xylene (mg/m3) | o Xylene (mg/m3) | Nonanes (mg/m3) | Decanes (C10) (mg/m3)


15,000.00
14,000.00
13,000.00
12,000.00
11,000.00
10,000.00
9,000.00
8,000.00
7,000.00
6,000.00
5,000.00
4,000.00
3,000.00
2,000.00
1,000.00
0.00
V [m3]
Volume - cumulative
Pump ratio change
Weekly Volume
22/01/10
13/03/10
02/05/10
21/06/10
10/08/10
29/09/10
18/11/10
Time [ddmmyy]

VOLUME [m3]


Delta: final-start
4000.00
2000.00
0.00
-2000.00
-4000.00
-6000.00
-8000.00
-10000.00
-12000.00
Change [mg/m3]
1
Light-end [▼]
Heavier-end [▲]
Methane ▼ – increased aerobic conditions
Substance
Oxygen
Carbon Dioxide
Nitrogen
Methane
n-Butane
iso-Pentene
n-Pentene
Cyclopentene
Methylcyclopentane
Benzene
Cyclohexane
2-Methylhexane
n-Heptanes
Methylcyclohexane
Toluene
2-Methylheptane
Ethyl Benzene
p & m Xylene
o Xylene
Nonanes
Tridecanes (C13)
Tetradecanes (C14)


100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
C [Mole%]
0
5
10
15
20
25
30
Time [weeks]
N2
O2
Oxygen (Mole %)
Carbon Dioxide (Mole %)
Nitrogen (Mole %)

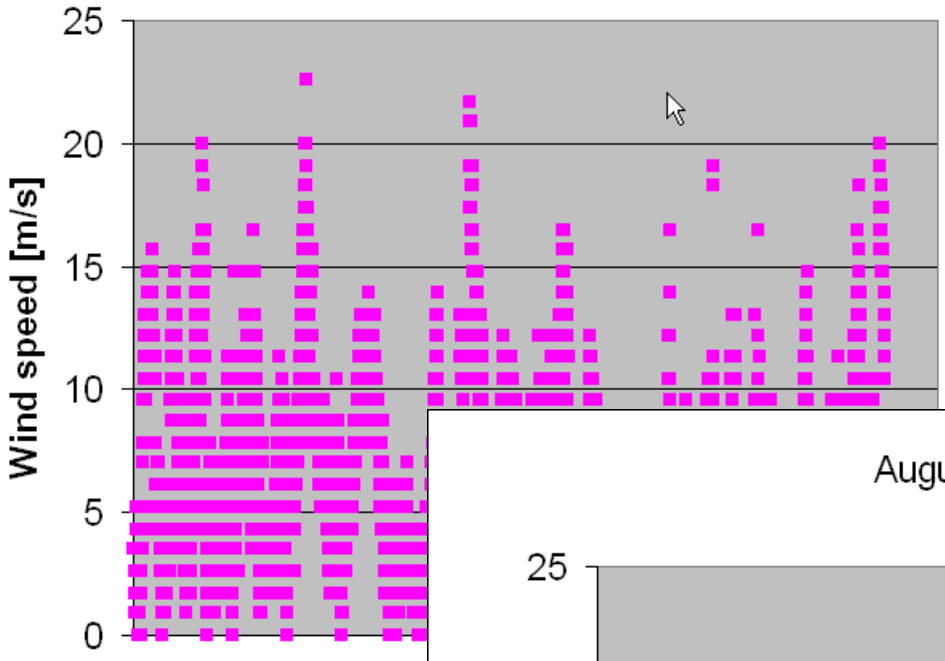
N_2

O_2

CO_2

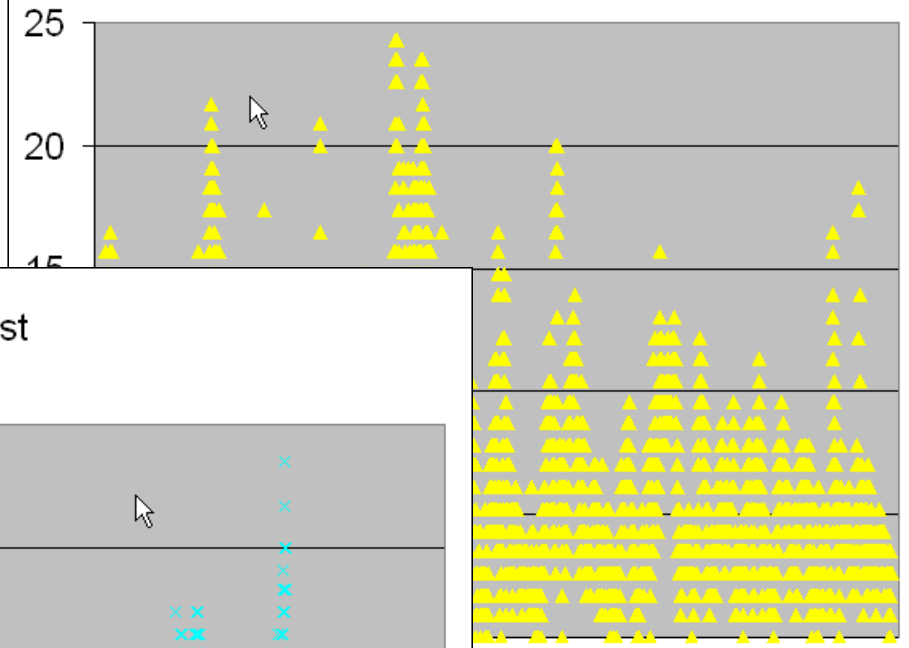
June

Uptime: 94%

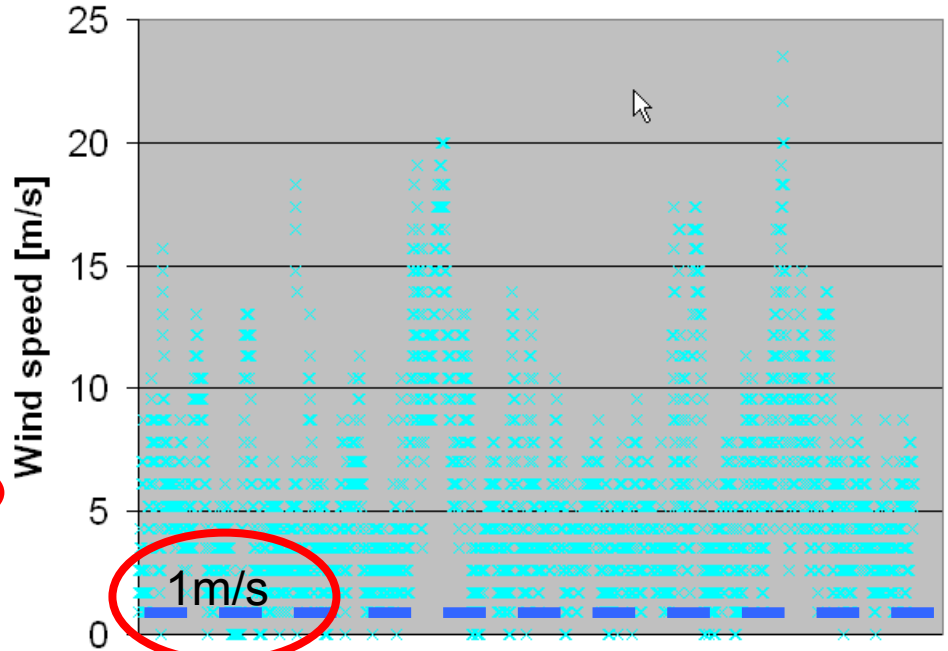


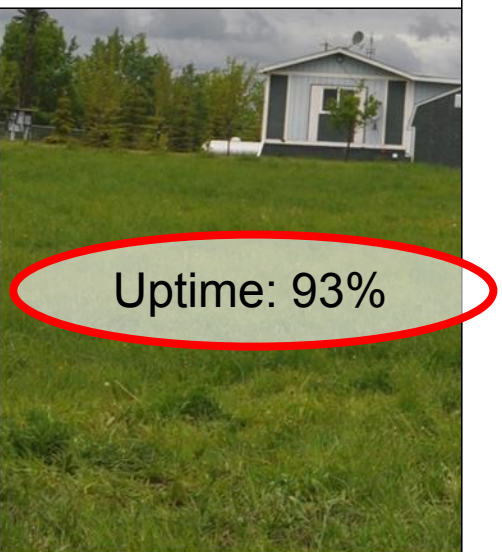
Uptime: 94%

July



August



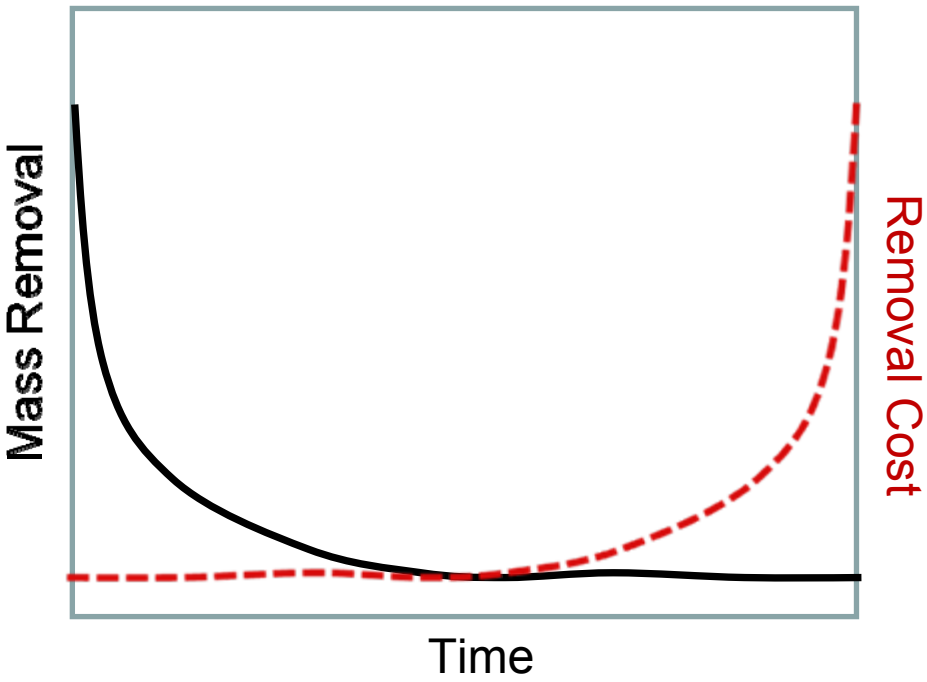


Uptime: 93%

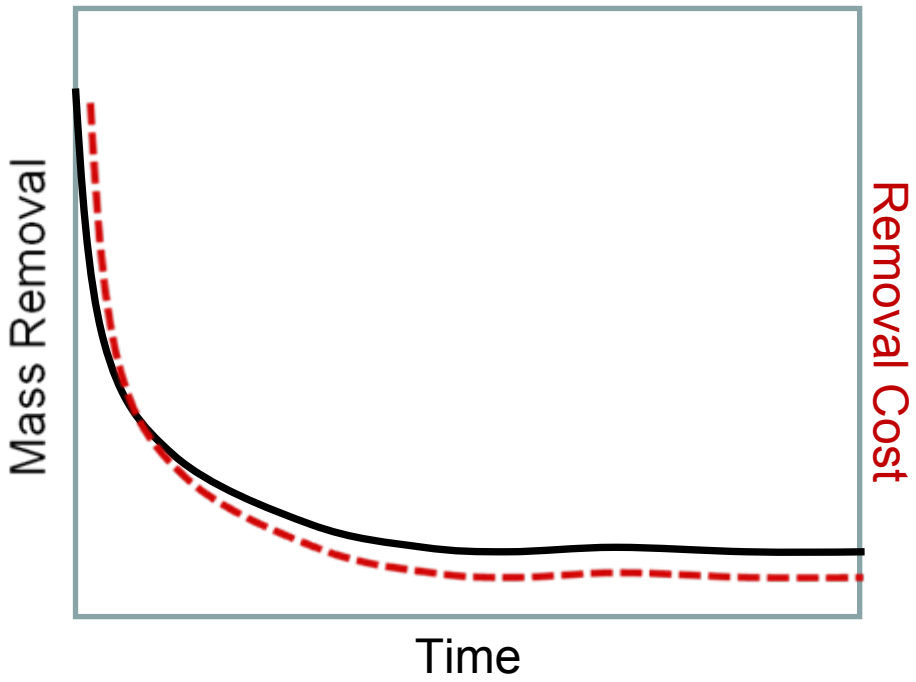
1m/s = 3.6km/h

Mass Removal vs Cost

Traditional method



Wind Powered method



Conclusions

- Windmill SVE is reliable, has a long life span, and has safety benefits.
- Wind power allows application in remote locations.
- More effective than traditional SVE method and has no CO_2 emissions.

Acknowledgments

Dan Gilbert • Project Meteorologist • Weather Modification, Inc.