Recycling and recovery UK

Whinney Hill Landfill Site

Perimeter Gas Review

March 2021

Report Issue Form

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Contents

1 Introduction 1
1.1 Background 1
1.2 Site Information and Monitoring Data 2
2 Monitoring Network and Compliance History 3
2.1 Current Regulatory Commitments for Gas Management and Control 3
2.2 Ground Gas Compliance Monitoring Network 5
2.3 Review of Site Performance to February 2021 6
3 Review of Conceptual Site Model 1
3.1 Overview 1
3.2 Landfill Gas Source Term 1
3.2.1 Landfill Void and Waste Types 1
3.2.2 Source Term 2
3.3 Landfill Source Term Control 3
3.3.1 Gas Management 3
3.3.2 Leachate Level Management 3
3.3.3 Landfill Engineering 4
3.4 Pathways 5
3.4.1 Geology 5
3.4.2 Hydrogeology 6
3.4.3 Summary of Pathways 6
3.5 Identified Receptors 7
3.6 Summary of Pollutant Linkages at Whinney Hill 7
4 Updated Management Criteria – Perimeter Gas Network 9
4.1 Methane Proposed Action Levels and Compliance Limits 9
4.2 Carbon Dioxide Proposed Action Levels 9
5 Requisite Surveillance 11
5.1 Requisite Surveillance 11
5.2 Contingency Actions –Action Level Exceedance 11
5.3 Contingency Actions – Methane Compliance Limit Exceedance 12
6 Conclusions 13
7 References 14
Figures 15
Appendices 19

Tables

Table 1. Action Limits for Perimeter Gas Boreholes in Phase 1 3
Table 2. Compliance Limits for the Perimeter Gas Points in Phase 2 4
Table 3. Monitoring Frequency and Parameters for Each Set 5
Table 4. Summary of Records of exceedances in Phase 1 - Feb 2005 - Feb 2021 1
Table 5. Breakdown of Records of exceedances in Phase 1 - Feb 2005 - Feb 2021 1
Table 6. Summary of Records and Breaches in Phase 2 - June 2015-Feb 2021 1
Table 7. Summary of Records and Breaches in Phase 2 - Jan 2018-Nov 2020 1

Table 8. Whinney Hill Operational and Capping Dates 2
Table 9. Source Term Control Summary 4
Table 10. Regional Geology..... 5
Table 11. Summary of Potential Pathways 6
Table 12. Receptors at Potential Risk from Subsurface Landfill Gas Migration from Whinney Hill..... 7
Table 13. Summary of Source – Pathway – Receptor Pollutant Linkages at Whinney Hill Phase 2..... 8
Table 14. Carbon Dioxide Action Levels for Boreholes across the Site 10
Table 15. Proposed Contingency Actions –Methane or Carbon Dioxide Action Level Exceedance.... 11
Table 16. Proposed Contingency Actions - Methane Compliance Limit Exceedance..... 12

Figures

Figure 1. Site Layout and Monitoring Point Locations. 15
Figure 2. SLR Conceptual Site Model..... 16
Figure 3. Carbon Dioxide and Methane Plots for Boreholes Within Phase 1 17
Figure 4. Carbon Dioxide and Methane Plots for Boreholes Within Phase 2 18

Appendices

Appendix A. Perimeter Gas Monitoring Data (%v/v)..... 19
Appendix B. Groundwater Review Hydrographs 20
Appendix C. Phase 1 Carbon Dioxide Action Level Calculations 21
Appendix D. Phase 2 Carbon Dioxide Action Level Calculations 22
Appendix E. Comparison of Current and Proposed CO_2 Action Levels 23

1 Introduction

1.1 Background

This report has been prepared by SUEZ Recycling and Recovery UK Ltd ("SUEZ") to support a permit variation for Whinney Hill Landfill Site ("the Site").

This site is comprised of two phases of construction as detailed below:

- Phase 1: a Dilute and Disperse site licensed initially under Waste Disposal Licence 481 and latterly under Waste Management Licence: EAWML54104
- Phase 2: a currently active, engineered site licensed under Permit EPR/BL9500IJ.

This report aims to review the gas concentration data at the Site and provide an updated risk assessment for the nearby receptors.

The review will be used to assess the implementation of Phase 2 carbon dioxide Action Levels and provide recommendations for any monitoring point removals where applicable. In addition to this, assessment and revision of the Phase 1 Action Limits will also be conducted.

Due to the time elapsed since Action Levels were first reviewed in Phase 1 SUEZ considers appropriate to review them and update them with the data collected to date. Additionally, SUEZ proposes a transition from carbon dioxide Compliance Limits to Action Levels for Phase 2 as per current modern permits. This will ensure all limits remain representative of the Site performance.

This report has been completed in line with the following guidance and documentation:

- Published Industry Codes of Practice, including the Industry Code of Practice: Perimeter Soil Gas Emissions Criteria and Associated Management (ICoP, 2011)
- A site-specific Action Plan.
- LFTGN02 and LFTGN03: these set the current guidance and best guidance for landfill monitoring and management of landfill gas.

This document provides:

- Confirmation that SUEZ has taken and continues to take all reasonable practical measures to control gas at the Site.
- An updated review of the landfill gas monitoring results (July 2018 to February 2021) for all perimeter gas monitoring points, including data integrity checks against the current compliance position agreed at the Site.
- A detailed qualitative and quantitative risk assessment of the elevated perimeter gas concentrations along key boundaries of the Site to establish the level of risk at the site boundary and to specific off-site receptors.
- Recommendations, where required, for revised methane and carbon dioxide management levels. These recommendations are based on reviewing the landfill gas data using the techniques included within Industry Code of Practice: Perimeter Soil Gas Emissions Criteria and Associated Management (ICoP, 2011).

- Proposals to implement a revised perimeter gas monitoring schedule supported by contemporary and updated Contingency Actions

The key outcomes of the report are to:

i. Support a permit variation to amend the current compliance limits;

ii. Confirm that there are no adverse trends in ground gas performance other than at selected wells in specific areas the of the Site;

iii. Establish the level of risk associated with the presence of elevated gas concentrations at the site to receptors beyond the site boundary;

1.2 Site Information and Monitoring Data

The following information and data have been used to complete this assessment:

SUEZ, 2016, Whinney Hill Landfil Site Phase 1 Monitoring Management Plan.

SUEZ, 2020, Whinney Hill Landfill Site Phase 2 Monitoring Management Plan.

Environment Agency, 1998, Environment Protection Act 1990 Waste Management Licence Ref: C/00022.

TerraConsult, 2010a, Whinney Hill Landfill Site, Accrington, Validation Report, Gas & Groundwater Monitoring Wells (2009/10 Site Investigation), Report No: 1187/1.

TerraConsult, 2010b, Whinney Hill Landfill Site, Accrington, Validation Report, Gas & Groundwater Monitoring Wells (Sept-Oct 2010 Site Investigation), Report No: 1333/1.

2 Monitoring Network and Compliance History

2.1 Current Regulatory Commitments for Gas Management and Control

A summary of the current limits applied at the Site is shown in below in Table 1 and Table 2, a plan of the monitoring points is provided in Figure 1.

Table 1. Action Limits for Perimeter Gas Boreholes in Phase 1

Borehole Number	Methane (%v/v)	Carbon Dioxide (%v/v)
WH/BH34	1.0	20.3
WH/BH35	1.0	1.9
WH/BH49/1	1.0	13
WH/BH49/2	1.0	6.9
WH/BH49/3	1.0	7.0
WH/BH50/1	1.0	14.9
WH/BH50/2	1.0	15.8
WH/BH51/1	1.0	10.9
WH/BH51/2	1.0	11.2
WH/BH51/3	1.0	8.4
WH/BH52/1	1.0	7.7
WH/BH52/2	1.0	6.7
WH/BH52/3	1.0	12.6
WH/BH53/1	1.0	2.3
WH/BH53/2	1.0	2.3
WH/BH53/3	1.0	2.0
WH/BH53/4	1.0	2.3

Table 2. Compliance Limits for the Perimeter Gas Points in Phase 2

Borehole Number	Methane (%v/v)	Carbon Dioxide (%v/v)
WH/BH65	1.0	6.3
WH/BH66	1.0	4.1
WH/BH67	1.0	7.9
WH/BH68A	1.0	1.5
WH/BH68B	1.0	1.5
WH/BH69	1.0	4.7
WH/BH70	1.0	3.6
WH/BH71	1.0	5.0
WH/BH72	1.0	5.5
WH/BH73	1.0	5.3
WH/BH74	1.0	3.1
WH/BH75	1.0	12.0

As tipping commenced within the Enfield quarry in January 2020 a separate document has been compiled to provide Compliance Limit and Action Level recommendations in conjuction with Improvement Condition 1 of the Permit for Whinney Hill Phase 2 (SUEZ, 2020). Therefore, this document should be read in conjuction with that piece of work.

2.2 Ground Gas Compliance Monitoring Network

For ease of reporting the Gas monitoring points will be grouped as the following:

- Phase 1 points as described in Table 1: Phase 1 Group
- Phase 2 points as described in Table 2: Northern Perimeter Group
- Monitoring Points associated with the Enfield Quarry Extension: Enfield Quarry Group

The gas monitoring network is focussed on those boundaries at the Site that directly face the potential receptors, namely the Northern and Western Boundaries at the perimeter of the Enfield Quarry Extension.

The Phase 1 network of monitoring points was installed as per the conditions of the original Waste Management Licence granted in 1998 (WML/C/00022). As further works progressed within Phase 2, the Northern Perimeter Group were installed in 2009, with further installations occurring in 2010 (TerraConsult, 2010a and 2010b).

The network within the Enfield Quarry area was installed by Lancashire County Council at an unknown date prior to 1996 as indicated by borehole logs in the possession of SUEZ. These points are generally installed as a group of four gas piezometers terminated at increasing depths within a gravel pack.

A location plan of all monitoring points is provided in Figure 1.

Monitoring points are in place within the Accrington Mudstone, Dyneley Knoll Flags or Old Lawrence Rock depending on location and depth of the monitoring point.

Ground gas concentrations are monitored within the each group as per the relevant Monitoring Management Plan and summarised in Table 3.

Table 3. Monitoring Frequency and Parameters for Each Set

Borehole Group	Frequency	Parameters
Phase 1	Quarterly	Methane, carbon dioxide, oxygen, atmospheric pressure, meteorological data, flow.
Northern Boundary	Quarterly	Methane, Carbon Dioxide, Oxygen, Atmospheric Pressure, Meterological Data, Ground Conditions (Waterlogged/Frozen/Snow Covered ect.)
Enfield Quarry	Quarterl	Methane, Carbon Dioxide, Oxygen, Atmospheric Pressure, Meterological Data, Ground Conditions (Waterlogged/Frozen/Snow Covered ect.)

2.3 Review of Site Performance to February 2021

A summary of the ground gas concentrations of Methane and Carbon Dioxide up to February 2021 are presented in Appendix A, graphical plots for Phase 1 are provided in Figure 3 and Phase 2 in Figure 4.

The data used in this review for Phase 1 dates back to 2005 as this is the earliest data available within the SUEZ database. Data for Phase 2 is taken since June 2015 when Compliance Limits were amended following an Agency led variation. This allows for greater comparison and identification of short and long term trends. This analysis shows that gas concentrations are largely constant across the site indicating that rates of gas production and extraction is balanced.

Phase 1

The graphical plots for Phase 1 indicate that while there is seasonal variation in the data recorded, concentrations of carbon dioxide and methane remain below the limits outlined in Table 1. The summary presented in Table 5 indicates a limited exceedances of limits across the analysed period in comparison to the number of records. Furthermore, Table 6 indicates a cessation of methane exceedances after 2014, however, there is a slight increase in the percentage of carbon dioxide exceedances, potentially due or a change in source term concentrations as the waste mass has evolved.

Additionally Figure 3 indicates those gas wells that are located further from the waste mass follow a marked decrease in carbon dioxide concentrations between 2014 and 2016. Though there is a large amount of temporal and spatial variation observed in the gas concentrations associated with Phase 1, levels are generally very low, and larger variations are likely attributed to influences from the underlying coal measures.

These observations support the proposal to review and update the carbon dioxide Action Levels for Phase 1 to ensure they remain representative. As methane concentrations have shown no change over the reporting period it is proposed to maintain the compliance levels at the current position, as a negligible risk is presented to the receptors.

Phase 2

The graphical plots of Phase 2 data in Figure 4 indicate that the Site is largely compliant with the current limits on Carbon Dioxide, however, recent breaches have occurred in a number of boreholes (WH/BH70, WH/BH71, WH/BH72 and WH/BH74). A summary of these exceedances is provided in Table 6.

A comparison of recent and earlier results is provided in Table 7 indicating a similar patter to that observed in Phase 1 there is a slight upward trend in the number of exceedances of carbon dioxide, however, these generally occur at the peak of sinusoidal variation as shown in the graphical plots. Potentially due to changes in landfill pathways as waste is deposited, or seasonal variations. This observation supports the change of Compliance Limits to Action Levels as these were set at 1.55 greater than background levels, not accounting for seasonal variation or active landfill processes.

A slight increasing trend of Carbon Dioxide is identified in WH/BH73, this is likely part of a long term variation as observed elsewhere at the site, however, further data is required to monitor this. This can be achieved with an Action Level and monitoring of this borehole is conducted and reported on as part of the Annual Report process at the Site. Additionally, there are no receptors in the immediate vacinity therefore a negligible risk imposed.

Methane concentrations have remained compliant since 2019, and the single exceedance recorded in 2017 is an anomalous result.

Table 4. Summary of Records of exceedances in Phase 1 - Feb 2005 - Feb 2021

Determinand	Number of Records	Number of Exceedances	Percentage Exceeded
CO2	2123	36	1.70
Methane	2200	2	0.09

Table 5. Breakdown of Records of exceedances in Phase 1 - Feb 2005 - Feb 2021

Determinand	February 2005 – December 2014			January 2015 – December 2018			January 2019 – February 2021		
	Number of Records	Number of Exceedances	Percentage Exceeded	Number of Records	Number of Exceedances	Percentage Exceeded	Number of Records	Number of Exceedances	Percentage Exceeded
CO2	1723	20	1.16	315	12	3.81	153	7	4.58
Methane	1800	2	0.11	247	0	0	153	0	0

Table 6. Summary of Records and Breaches in Phase 2 - June 2015-Feb 2021

Determinand	Number of Records	Number of Exceedances	Percentage Exceeded
CO2	312	33	10.58
Methane	312	1	0.32

Table 7. Summary of Records and Breaches in Phase 2 - Jan 2018-Feb 2021

Determinand	June 2015 – December 2018			January 2019 – February 2021		
	Number of Records	Number of Exceedances	Percentage Exceeded	Number of Records	Number of Exceedances	Percentage Exceeded
CO2	194	20	10.31	118	13	11.02
Methane	194	1	0.52	118	0	0

Closer analysis of the exceedances in Phase 1 indicates that the majority of them occur within the 4 co-located points within WH/BH53 which currently all have very low action levels (WH/BH53/1, WH/BH53/2 and WH/BH53/4 of 2.3%v/v and WH/BH53/3 of 2.0%v/v). This results in a greater likelihood of exceedance due to both seasonal variations and influence from external sources such as the underlying coal measures units.

Similarly, the majority of the exceedances of carbon dioxide in Phase 2 are recorded in WH/BH72 and WH/BH74, which although being close to the currently active areas have low compliance limits assigned (5.5 and 3.1 %v/v respectively).

This influence of low Action Levels and Compliance Limits on the exceedances recorded supports the need to review the limits in place at the Site.

3 Review of Conceptual Site Model

3.1 Overview

A review of the Conceptual Site Model (CSM) has been conducted as part of the ongoing work by SLR Consulting to reivew the Hydraulic Risk Assessment for the Site (SLR, 2021), a copy of this is provided in Figure 2. Data from this new review has been used, along with information within the Site ESID (SITA, 2004), data from the British Geological Survey Geoindex (BGS, 2020) and onsite monitoring data to review and update the CSM with respect to gas migration.

3.2 Landfill Gas Source Term

With regards to the landfill source, it is considered that the three areas that require review relate to site design and construction, gas and leachate management and external sources, as detailed below.

3.2.1 Landfill Void and Waste Types

The Site is a mixture of closed and active landfill operations. The area within Phase 1 is wholly closed, capped and restored, whilst Phase 2 contains a mixture of temporarily capped and active cells.

Waste accepted into both Phase 1 and Phase 2 consist of a range of hazardous and non-hazardous household, commercial and industrial wastes, as licenced under the individual permits. Enfield Quarry accepts inert wastes only.

Table 8. Whinney Hill Operational and Capping Dates

Phase	Cell	Operational Dates	Final Capping Date**
Phase 1+ –Dilute and Disperse Construction	1	1993-2011	2011
	2	1993-2007	2007
	3	1993-2006	2006
Phase 2 – Engineered construction	4	1999- Present	2023/24
	5	1999- Present	2023/24
	6a	2020-Present	2035
	6b*	2023	2035
	7-1 and 7-2	2011-Present	2023/24
	7-3	2012- Present	2022
	8/1	2015- Present	2023/24
	8/2	2017- Present	2022

+Tipping of Putrescible Waste ceased in 2006, inert waste was then accepted until closure

*As yet undeveloped, construction due when void in other engineered cells is exhausted, current estimate provided

** Includes future provisional dates for capping of active cells, these dates are subject to change

3.2.2 Source Term

For the purpose of this assessment, the Source is the activity representing the potential hazard. Within Whinney Hill Landfill Site this is considered to be landfill gas generated by the biological and chemical degradation of the waste mass within the licenced area of the Site

The Source can be variable both temporally and spatially across the Site and between the Phases depending on the availability of water and the maturity of the waste mass itself. Due to on going gas extraction within the site, no on going in waste gas monitoring is required under the Permit. However, annual monitoring of raw gas at the engine stack indicates a concentration of 39.9%v/v Methane.

The gas source term within Phase 1 is likely to contain lower concentrations of methane due to the age of the waste mass and the peak production stage being passed since the site ceased accepting waste.

However, concencetrations within Phase 2 are not likely to exceed the stated values above due to this value representing a homogenisation of the source term due to the gas being collected from every cell and mixed prior to entry into the gas engines. this value therefore provides a broad overview of the Source term at the Site.

3.3 Landfill Source Term Control

3.3.1 Gas Management

As Phase 1 of the Site has been placed into definitive closure there is currently no Gas Management Plan in effect, however, active gas extraction is conducted

Gas management within Phase 2 of the Site is carried out following the 2012 Gas Management Plan (SITA, 2013).

Gas control in Phase 2 is provided through active extraction of landfill gas through a series of valved header pipes (carrier mains), each with a valved connection to the individual gas wells. This is then fed to six 1.06MW Jenbacher Engines for electricity production.

To ensure continued management of gas in the event of engine downtime a 4000m^3/hr flare is also present on site.

Proceedures are in place for prompt action should any abnormal conditions arise with the engines or flare that lead to a release of landfill gas and an impact on the environment. These proceedures are laid out in the Odour Management Plan (SUEZ, 2018).

3.3.2 Leachate Level Management

Leachate management is controlled and conducted under the Leachate Management Plan (SITA, 2015) for the Site and is only conducted within the engineered Phase 2. This plan is being updated by SLR in 2021.

Leachate management in Phase 1 is conducted through retrofitted wells installed with pneumatic pumps.

Extracted leachate from both Phases is then treated within the leachate lagoons on site before disposal.

3.3.3 Landfill Engineering

A summary of the engineering methods in place at Phase 1 and 2 is provided in Table 9. The Enfield Quarry area is included within Phase 2 for this summary as engineering methods are the same.

Table 9. Source Term Control Summary

Element	Phase 1	Phase 2
Capping	0.001m thick welded LLDPE panels with 1m cover of protection and restoration soils	Temporary, welded LLDPE panels
Sidewall Liner	None	0.5m engineered clay (<$1x10^{-9}$m/s), FML and protective cover up to 4m above base of cell (Cells 4/1 and 4/2 have additional 1m thick clay above 4m level on southern edge)
Basal Liner	None	0.5m engineered clay (<$1x10^{-9}$m/s), FML and protective cover
Active Gas Control	Yes	Yes
Sub-surface Emissions Potential* (Gas systems operative)	Low/Medium	Low

*: based on recognised UK industry performance standards for landfill gas control.

3.4 Pathways

3.4.1 Geology

A summary of the regional geology is presented in Table 10, based on data from the British Geological Society (BGS) GEOINDEX (BGS, 2020) as well as previous summaries conducted for other works (SITA, 2015).

Table 10. Regional Geology

Group	Formation	Description	Expected Thickness
Superficial Deposits	Glacial Till (Diamicton)	Gravelly CLAY	Variable (Fully removed onsite)
Peninne Lower Coal Measures (LCM)	Old Lawence Rock (OLR)	Fine to medium grained SANDSTONE	10-20 m *(Before Quarrying)*
	Upper Accrington Mudstone (UAM)	Grey silty MUDSTONES and SILTSTONES with closely spaced horizontal and sub-hortizontal discontinuities	34-39 m *(Before Quarrying)*
	Lower Accrington Mudstone (LAM)	Black carbonaceous MUDSTONE withi high organic content and loosely spaced horizontal and sub-horizontal discontinuities	4-6 m
	Dyneley Knoll Flags (DKF)	Fine to medium grained SANDSTONE and interbedded SILTSTONES with loosely spaced horizontal and sub-horizontal discontinuities	Up to 16 m
	Unnamed Mudstones	MUDSTONE	Unknown

The Site is situated within the Mudstone and Siltstone and Sandstone members of the Pennine Lower Coal Measures (LCM). A boundary between the Accrington Mudstones and the OLR is present in the north of the Site beneath the cells in the north-east. A further boundary between the AM and DKF is located to the south of the Site, however this is outside of the site boundary.

Additionally, due to quarrying works no superficial material is recorded as present immediately above the Site, however, superficial cover of diamicton till is present regionally and adjacent to the Site.

Two coal seams are noted to be present at depth beneath the Whinney Hill Site as a whole: the Upper and Lower Mountain Mine seams, which occur below the interface of the LAM and DKF.

3.4.2 Hydrogeology

The adjacent superficial cover is designated as unproductive due to low permeability, therefore, these have been classified with negligible importance for water supply, and are neither considered as a receptor or pathway.

Both sandstone units in the area are classified as Secondary A aquifers; capable of providing abstractable water on a strategic scale, and potentially providing base flow into local rivers.

The Accrington Mudstones (AM) and the Unnamed Mudstone are classified as Secondary B aquifers; identified as being of low permeability whilst retaining groundwater in limited amounts within fissures and discontinuities.

Groundwater in the area is found in two locations, perched within the AM as a local body and a regional scale body within the DKF, there may be a degree of hydraulic conductivity between these two units close to the boundary (SLR,2021). Though removed at the site by quarrying activity, a third groundwater body may be present within the OLR.

Groundwater contours for each of the underlying lithologies have been plotted by SLR (2021) as part of an ongoing HRA review, and are presented within the CSM in Figure 2. These plots indicate that there is a small unsaturated zone beneath the base of the landfill of variable thickness across the site.

The principle aquifer receptor beneath the site is interpreted to be the DKF due to the discontinuous nature of the higher aquifer within the AM.

3.4.3 Summary of Pathways

SUEZ has identified the following pathways for lateral gas migration from the Site into the subsurface environment. These have been summarised in Table 11 below.

Table 11. Summary of Potential Pathways

Pathway	Description	Lateral Flow Potential*
Service Conduits	Near surface service ducts for power telecoms, gas etc.	Where present - high
Unsaturated Zone	Area of subsurface without saturating groundwater.	Low-High dependent on material and level of saturation
Old Lawrence Rocks	Fine to medium grained sandstone, high permeability largely unsaturated leading to intergranular flow	Medium-high
Accrington Mudstone	Fine grained, low permeability unit dominated by fracture flow along loosely spaced discontinuities	Low-medium
Dyneley Knoll Flags	Fine to medium grained sandstone interbedded with fine grained siltstones: combination of high and low permeabilty leads to slower flow. Combination of intergranular and fracture flow though horizontal discontinuities in siltstone	Medium

*: for a sustained pressure head to drive gas migration along the pathway.

It is noted, that for a pathway to be capable of transmitting significant quantities of gas that could present an adverse risk to a receptor, the pathway must be assessed first. The pathway is likely to be influenced principally by the presence (or absence) of groundwater, the in-situ mineralogy and the potential transmissivity of the strata.

A review of the groundwater levels is summarised by the hydrographs provided in Appendix B and interpreted within the SLR conceptual model in Figure 2

3.5 Identified Receptors

The Site sit within a heacy developed area with a number of receptors within 500m of the north, west and south site boundaries. A summary of the closest receptors to the Site are provided in Table 12.

Table 12. Receptors at Potential Risk from Subsurface Landfill Gas Migration from Whinney Hill

Receptor	Distance and Direction
Printworks	65 m / SW
Residential Buildings (William Street)	105 m / SW
Residential Buildings (Well Field)	160 m / NW
Brickworks	200 m / E

Note: Locations are as measured from the edge of the waste mass.

3.6 Summary of Pollutant Linkages at Whinney Hill

Those receptors identified in Table 12 are all located at a higher elevation than the assumed base of the landfill, therefore a potential pathway exists for any landfill gas.

A summary of the potential Source- Pathway-Receptor (SPR) linkages for Phase 2 is provided in Table 13.

Additionally though receptors are present to the south of Phase 1, the basal elevation of the waste mass is thought to be higher than that of the residential properties forming these receptors. It is therefore interpreted that no pathway is present between the site and the receptor and that a risk is not presented.

Any further impact from Phase 1 to the north and south is accounted for under the SPR summary in Table 13.

Table 13. Summary of Source – Pathway – Receptor Pollutant Linkages at Whinney Hill Phase 2

Source	Pathway	Pathway Thickness (m) and elevation	Engineered Barrier	Receptor	SPR Linkage
Landfill Gas	Accrington Mudstone	38-45m	Yes	Printworks	Unlikely – base of the structures is above the height of the base of the cells however, the closest cell (Enfield Quarry) is for disposal of inert waste therefore gas production will be minimal, additionally, structure is reportedly built on raft foundation so reduction in transmission into the building. Permeability of AM is low and transmission reliant on fractures Pathway additionally disrupted by low permeability superficial deposits
		38-45m		William Street residences	Unlikley – Though foundations are likely simpler than printworks, receptor remains closest to Enfield Quarry where gas production is likely to be low Permeability of AM is low and transmission reliant on fractures Pathway additionally disrupted by low permeability superficial deposits
	Old Lawrence Rock	10-20m		Well Field Residences	Unlikely – Large distance of high permeability material increases chance of transmission to air, though unlikely to be built on raft foundations Pathway additionally disrupted by low permeability superficial deposits

4 Updated Management Criteria – Perimeter Gas Network

With the existing performance criteria for gas concentrations in the perimeter network at the Site, a simplified and contemporary approach for the future management criteria at the Site is proposed. This will adopt contemporary carbon dioxide action levels derived from an ICoP approach.

4.1 Methane Proposed Action Levels and Compliance Limits

As no exceedances for Methane have been observed, and the data analysed shows no adverse trends within the recorded concentrations, no changes to the methane Action Levels or Compliance Limits are proposed.

4.2 Carbon Dioxide Proposed Action Levels

A review of the perimeter gas records between January 2015 and February 2021 has been conducted.

This review proposes contemporary carbon dioxide action levels as opposed to the continued application of compliance limits. The approach used to calculate carbon dioxide action levels is that presented in the ICoP for Perimeter Gas (2011).

In undertaking this task, SUEZ has reviewed the perimeter gas data at the Site for the period July 2018 to February 2021. Any carbon dioxide data associated with methane concentrations from the same monitoring event which are above 0.1%v/v have been excluded from the data set used for subsequent calculation of the T_{max} concentration at the monitoring location.

A workbook containing the screened monitoring data and resultant T_{max} calculations to calculate carbon dioxide action levels is included as Appendix C and Appendix D with the outputs of the assessment summarised below in Table 14.

The period of time used for these calculations is between 1 January 2015 and 12 February 2021. A period of time greater than the two years advised in Agency guidance is used to provide a data set of sufficient size to allow for calculations. In addition to this, assessment of this data shows that concentrations are generally constant, therefore, there is little affect to the calculated levels.

After standardisation the data sets for both Phase 1 and Phase 2 fall short of having the recommended 24 data points in each well. However, including a greater time period to collect additional points introduces the potential of including data that is no longer representative of the current state of the Site. Where Action Levels have been calculated by data sets of less than 24 data point review will be conducted within the Annual Review process.

Action Levels within Phase 1 have been calculated on those boreholes that currently have action limits assigned, as presented in Table 1.

Table 14. Carbon Dioxide Action Levels for Boreholes across the Site

Phase Number	Monitoring Point	Action Level (%v/v)
Phase 1	WH/BH34	21.2
	WH/BH35	1.3
	WH/BH49/1	5.4
	WH/BH49/2	8.3
	WH/BH49/3	5.0
	WH/BH51/1	7.7
	WH/BH51/2	7.7
	WH/BH51/3	7.1
	WH/BH52/1	1.2
	WH/BH52/2	8.8
	WH/BH52/3	1.2
	WH/BH53/1	5.5
	WH/BH53/2	5.0
	WH/BH53/3	5.3
	WH/BH53/4	2.2
Phase 2	WH/BH65	5.6
	WH/BH66	1.7
	WH/BH67	8.0
	WH/BH68A	2.1
	WH/BH68B	2.1
	WH/BH69	7.1
	WH/BH70	3.9
	WH/BH71	7.1
	WH/BH72	9.8
	WH/BH73	7.0
	WH/BH74	5.3
	WH/BH75	11.5

An associated risk based contingency plan is detailed below.

5 Requisite Surveillance

This review process provides the opportunity to review current monitoring locations, frequencies and Contingency Actions.

5.1 Requisite Surveillance

As the Site is largely active, the monitoring locations, parameters and frequency are proposed to remain the same, as laid out in the Permit and summarised in Table 3.

5.2 Contingency Actions –Action Level Exceedance

Where methane or carbon dioxide Action Levels are exceeded, the following Contingency Actions will be completed:

Table 15. Proposed Contingency Actions –Methane or Carbon Dioxide Action Level Exceedance

Scenario	Contingency Action		Response Time
Initial Result Exceeds Control Level	Hazard Potential ≤Low	Inform the Site Manager. Record internally. End of Actions.	24 Hours
	Hazard Potential ≥*Moderate*	Inform Site Manager and Technical Support Manager to initiate measures to control migration. Record internally.	48 Hours
		Confirm calibration and QA procedures for equipment used	48 Hours
		Review actions and data trends during monthly compliance meeting	1 Month
In the event of persistent Action Level breaches or rising trends: Produce a Gas Action Plan and submit to the EA			To be agreed with the EA.

In all cases, contingency actions will cease once concentrations decrease in line with action levels.

5.3 Contingency Actions – Methane Compliance Limit Exceedance

SUEZ proposes when a methane compliance limit is exceeded, the following Contingency Actions

Table 16. Proposed Contingency Actions - Methane Compliance Limit Exceedance

Scenario	Contingency Action		Response Time
Initial Result	Internally Record and inform Site Manager		Up to 24 Hours
	Hazard Potential (calculated as) ≤*Low*	Record internally End of Actions	24 Hours
	Hazard Potential (calculated as) ≥*Moderate*	Inform the Environment Agency	24 Hours
		Confirm calibration and QA procedures for equipment used.	48 Hours
		Inform Site Manager to initiate measures to control migration in accordance with the Gas Management Plan.	48 Hours
		Complete repeat monitoring visit	1 Month
Re-Sample (Compliant)	End of Actions		
Re-Sample (Non-Compliant)	Hazard Potential (calculated as) ≤*Low*	Inform the Site Manager and record internally End of Actions	24 Hours post re-sample
	Hazard Potential (calculated as) ≥*Moderate*	Maintain monthly monitoring frequency until concentration declines below the Compliance Limit or if concentration does not decline for a period of 3 months maintain monitoring until the concentration is shown to be stable.	1 Month
		Review gas infrastructure (if applicable) and notify the Environment Agency.	Up to 3 Months
An increasing trend (above compliance limits) is identified	Produce a Gas Action Plan (if necessary) and submit to the EA.		To be agreed with the EA.

In all cases, contingency actions will cease once methane concentrations decrease below the compliance limit.

6 Conclusions

SUEZ has conducted a review of the perimeter gas data collected across the Whinney Hill Landfill site to assess the current applicability of the set gas Action Levels and Compliance Limits.

As displayed in Appendix E, Action Levels in Phase 1 are generally lowered by this review, as would be expected with the maturation of the waste mass. The increase of action levels within Phase 2 is also expected as waste tipping operations continue and chemical and biological decomposition of waste commences.

The review confirms that the Site remains compliant with regards to Methane concentrations in both phases, indicating that the active gas management system continues to function as intended. This also confirms that the Site poses a negligible risk to the nearby receptors.

As the Site is predicted to be active within the Phase 2 and Enfield Quarry areas up to 2035, it is recommended that periodic review of the permiter gas monitoring network and results be conducted. This will ensure that compliance is maintained and risk continually mitigated.

7 References

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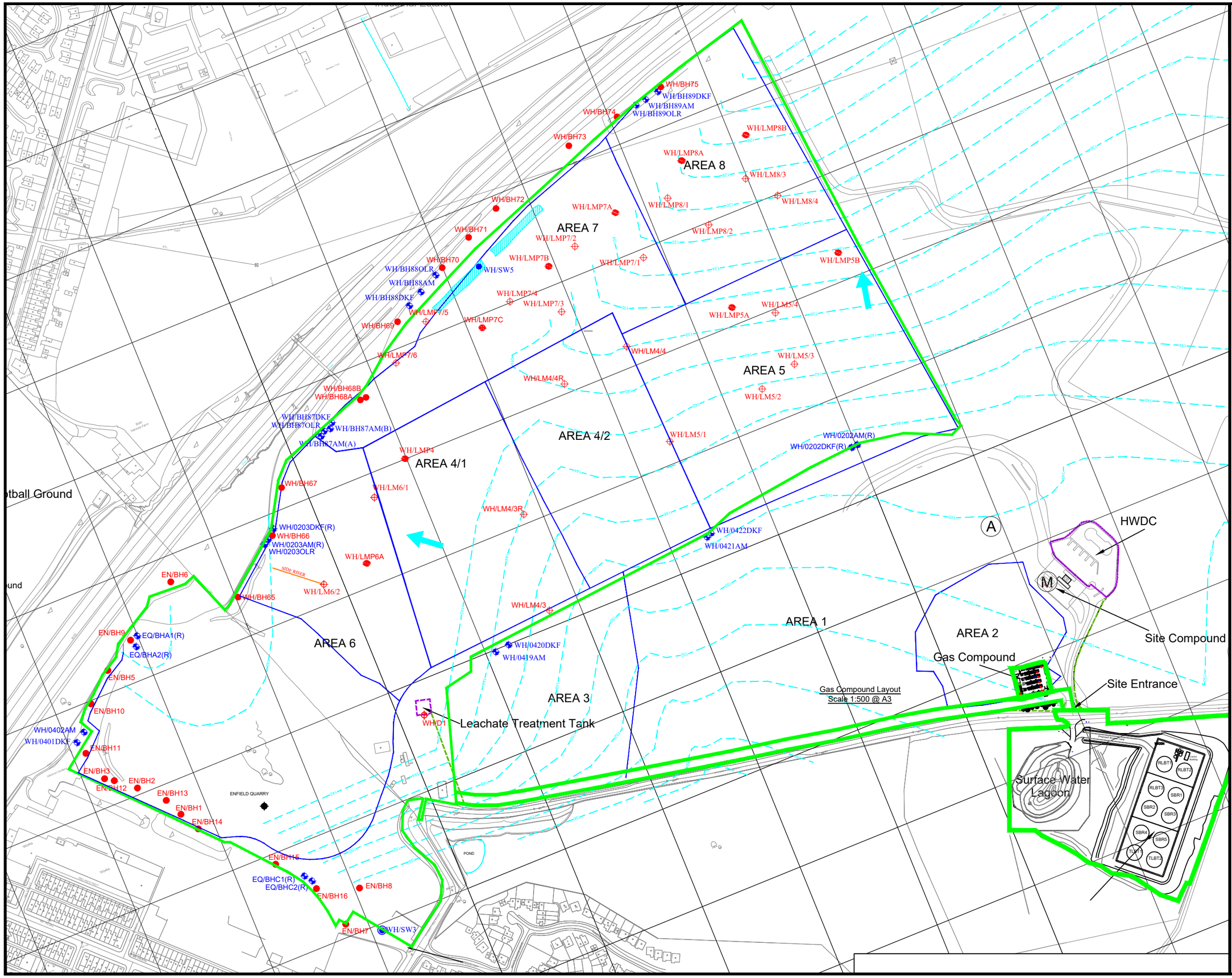
Figures

Figure 1. Site Layout and Monitoring Point Locations.



Notes

1. Reproduced from the Ordnance Survey Map with the permission of the Controller of Her Majesty's Stationary Office, Crown Copyright, Licence Number 100004910.

- Permit Boundary
- Groundwater Monitoring Point
- Groundwater and Gas Monitoring Point (depth varies)
- Leachate and Gas Monitoring Point
- Gas Monitoring Point
- Leachate Monitoring Point
- Proposed Leachate Monitoring Point
- Leachate Extraction Point
- Proposed Leachate Extraction Point
- Surface Water Monitoring Point
- Proposed Surface Water Monitoring Point
- M Meterological Monitoring Point
- A Anemometer
- 48 Inferred Groundwater Contour (mAOD)
- Inferred Groundwater Flow Direction

Rev	subject	date
F	Cell 6A As built Mon Points Added	April 2020
E	Cell 8/2 As built Mon Points Added	Aug 2017
D	LM4/4R Added & Drawing Border Updated	April 2016
C	PPC Boundary Amended, Cell 8/1 As built Mon Points Added & Cell 7/3 Sideisers Added	April 2015
B	WH/LM4/3R Added	Dec 2013
A	Gas Compound Sampling Points Added	Jan 2013

Darwen Resource Recovey Park, Lower Eccleshill Road, Darwen, BB3 0RP
Tel:(01254)819700, Fax:(01254)819749, Email: richard.bisset@siita.co.uk

Site: Whinney Hill Landfill Site

Title: Environmental Monitoring Locations

Scale: Not To Scale on A3

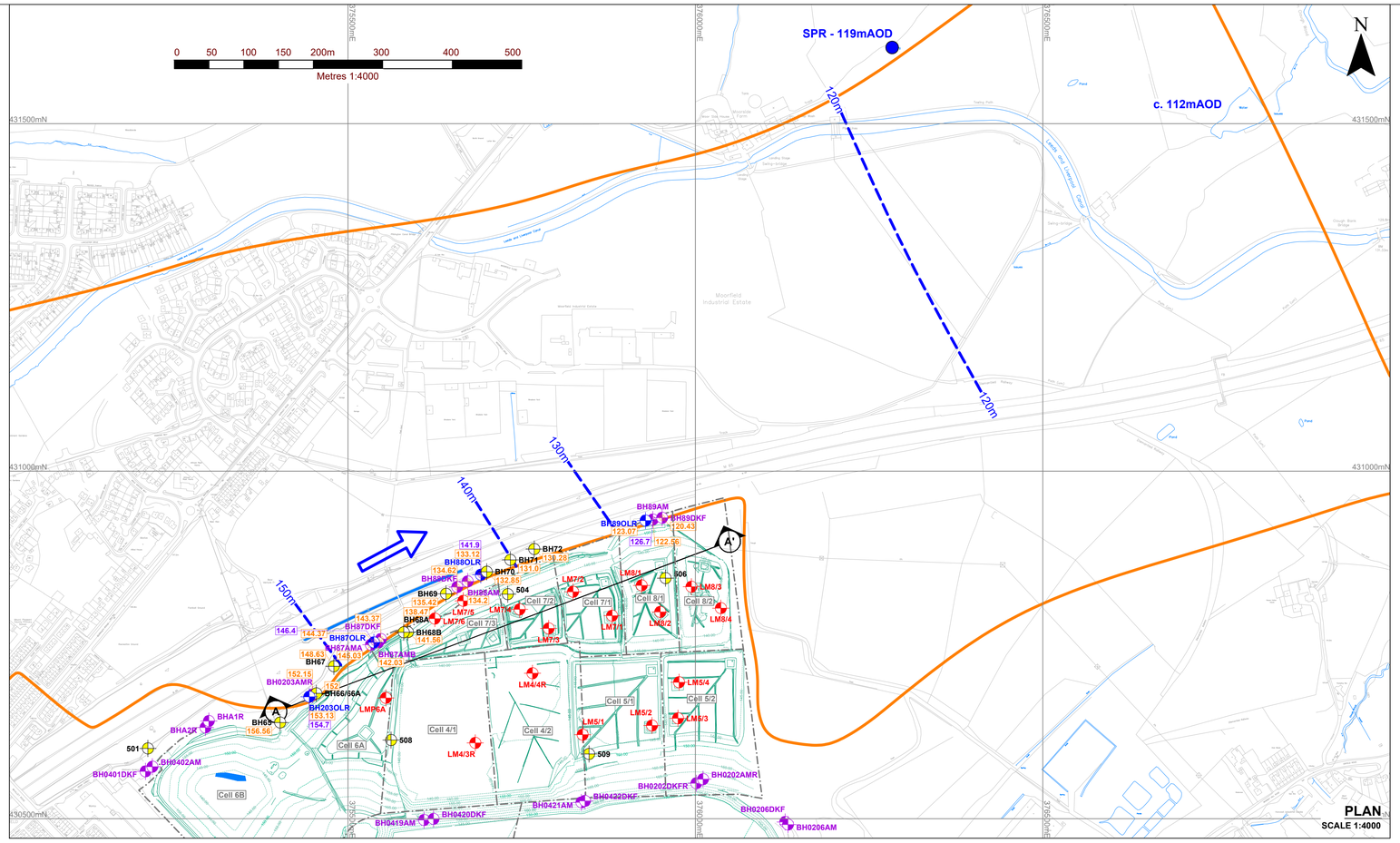
Date: August 2017

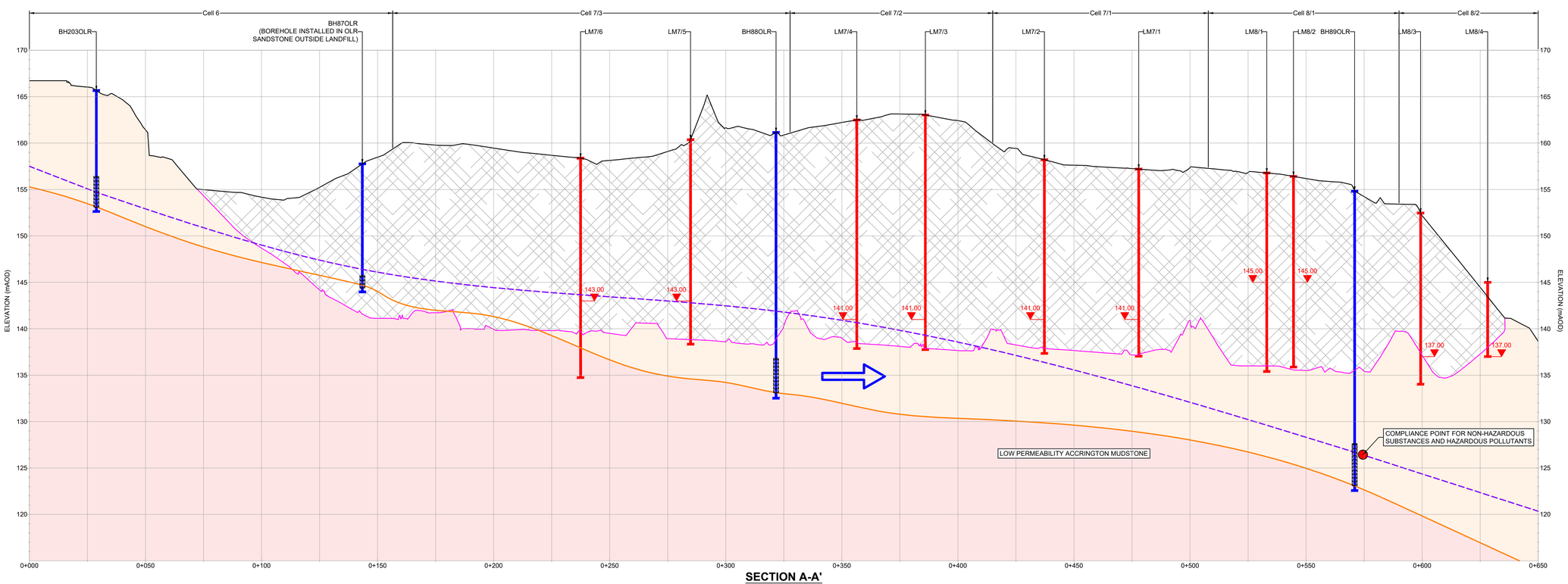
Drawing Ref: WNH-P2-ESID-1112-07f

Drawn by: RB

Checked by: SW

Figure 2. SLR Conceptual Site Model





SECTION A-A'

HORIZONTAL SCALE 1:1000

VERTICAL SCALE 1:250

LEGEND - PLAN

- 88OLR — OLR MONITORING BOREHOLE LOCATION & REFERENCE
- 88ODKF — AM / DKF MONITORING BOREHOLE LOCATION & REFERENCE
- 501 — SITE INVESTIGATION BOREHOLE LOCATION & REFERENCE
- LM7/1 — LEACHATE MONITORING BOREHOLE LOCATION & REFERENCE
- 141.9 — MEAN GROUNDWATER LEVEL (mAOD) - 2015-20
- INFERRED GROUNDWATER LEVEL CONTOURS
- 152.1 — BASE OF OLR SANDSTONE LEVEL (mAOD)
- OUTCROP OF OLR SANDSTONE
- INFERRED GROUNDWATER FLOW DIRECTION
- BH0422 — ENGINEERED BASAL LINER
- CELL BOUNDARY
- OS SURVEY DATA
- SURFACE WATER BODY

LEGEND - SECTION

- OCTOBER 2020 TOPOGRAPHIC SURVEY LEVEL PROFILE
- AS-BUILT BASAL LINER LEVEL PROFILE
- MEAN GROUNDWATER LEVEL PROFILE (2015-20)
- BASE OF OLR SANDSTONE LEVEL PROFILE
- GROUNDWATER MONITORING BOREHOLE
- SLOTTED SECTION OF BOREHOLE
- LEACHATE MONITORING BOREHOLE
- 144.00 — PROPOSED COMPLIANCE LIMIT
- INFERRED GROUNDWATER FLOW DIRECTION
- WASTE
- OLR SANDSTONE
- ACCRINGTON MUDSTONE

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WHINNEY HILL LANDFILL

HYDROGEOLOGICAL RISK ASSESSMENT REVIEW

OLD LAWRENCE ROCK SANDSTONE GROUNDWATER CONTOURS

HRA1

Scale	Date
AS SHOWN @ A1	DECEMBER 2020

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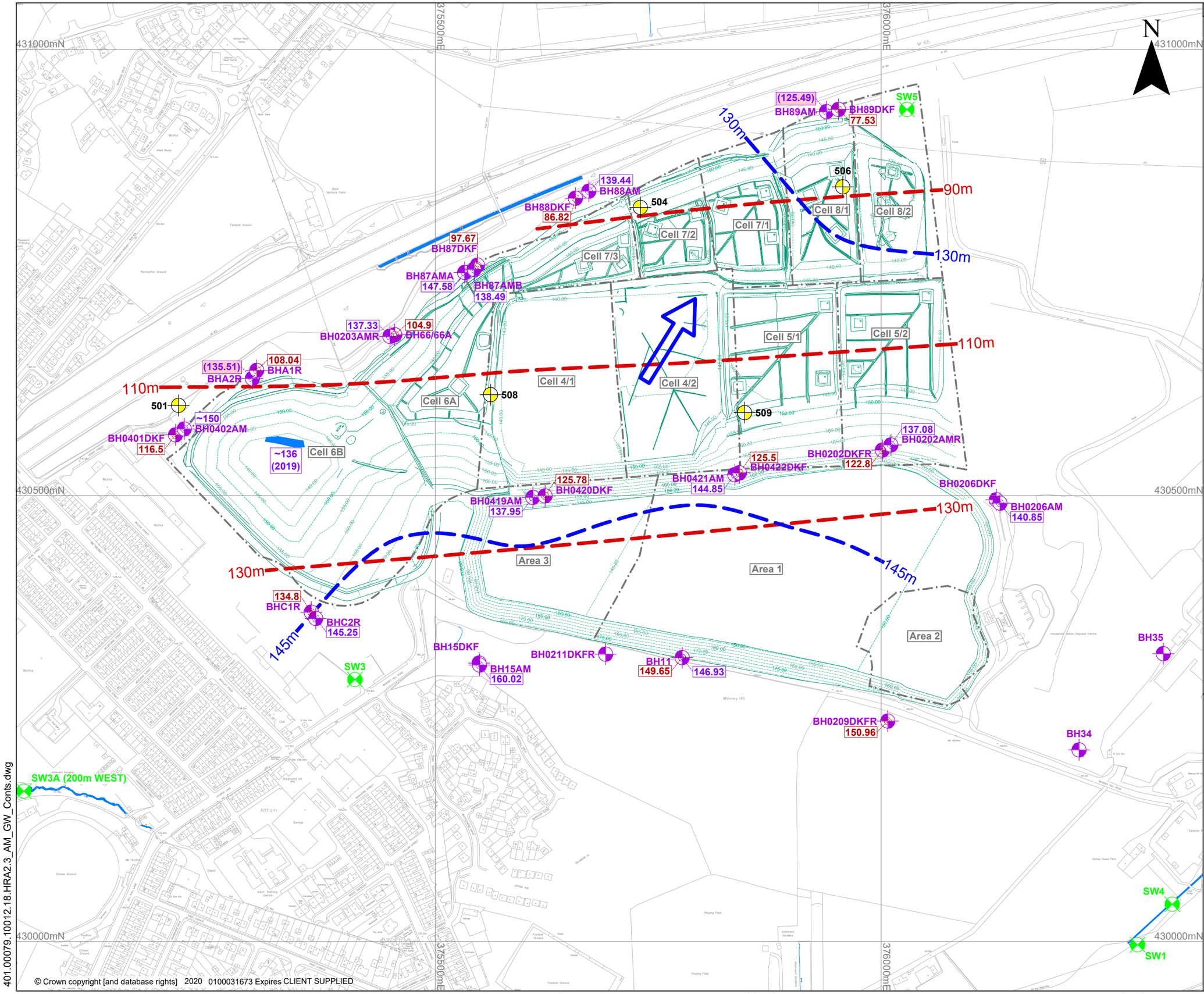

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401.00079.10012.18.HRA2.3_AM_GW_Conts.dwg

LEGEND

- BH89AM — AM / DKF MONITORING BOREHOLE LOCATION & REFERENCE
- 501 — SITE INVESTIGATION BOREHOLE LOCATION & REFERENCE
- SW3 — SURFACE WATER MONITORING LOCATION & REFERENCE
- INFERRED BASE OF ACCRINGTON MUDSTONE LEVEL CONTOURS (mAOD)
- 116.5 — BASE OF ACCRINGTON MUDSTONE LEVEL (mAOD)
- INFERRED GROUNDWATER LEVEL CONTOURS IN ACCRINGTON MUDSTONE (mAOD) - AUGUST 2020
- 137.33 — GROUNDWATER LEVEL IN ACCRINGTON MUDSTONE (mAOD) - AUGUST 2020
- (125.49) — GROUNDWATER LEVEL IN LOWER ACCRINGTON MUDSTONE (mAOD) - AUGUST 2020
- INFERRED GROUNDWATER FLOW DIRECTION IN ACCRINGTON MUDSTONE
- ENGINEERED BASAL LINER
- CELL BOUNDARY
- OS SURVEY DATA
- SURFACE WATER BODY

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WHINNEY HILL LANDFILL

HYDROGEOLOGICAL RISK ASSESSMENT REVIEW

ACCRINGTON MUDSTONE GROUNDWATER CONTOURS

HRA2

Scale	Date
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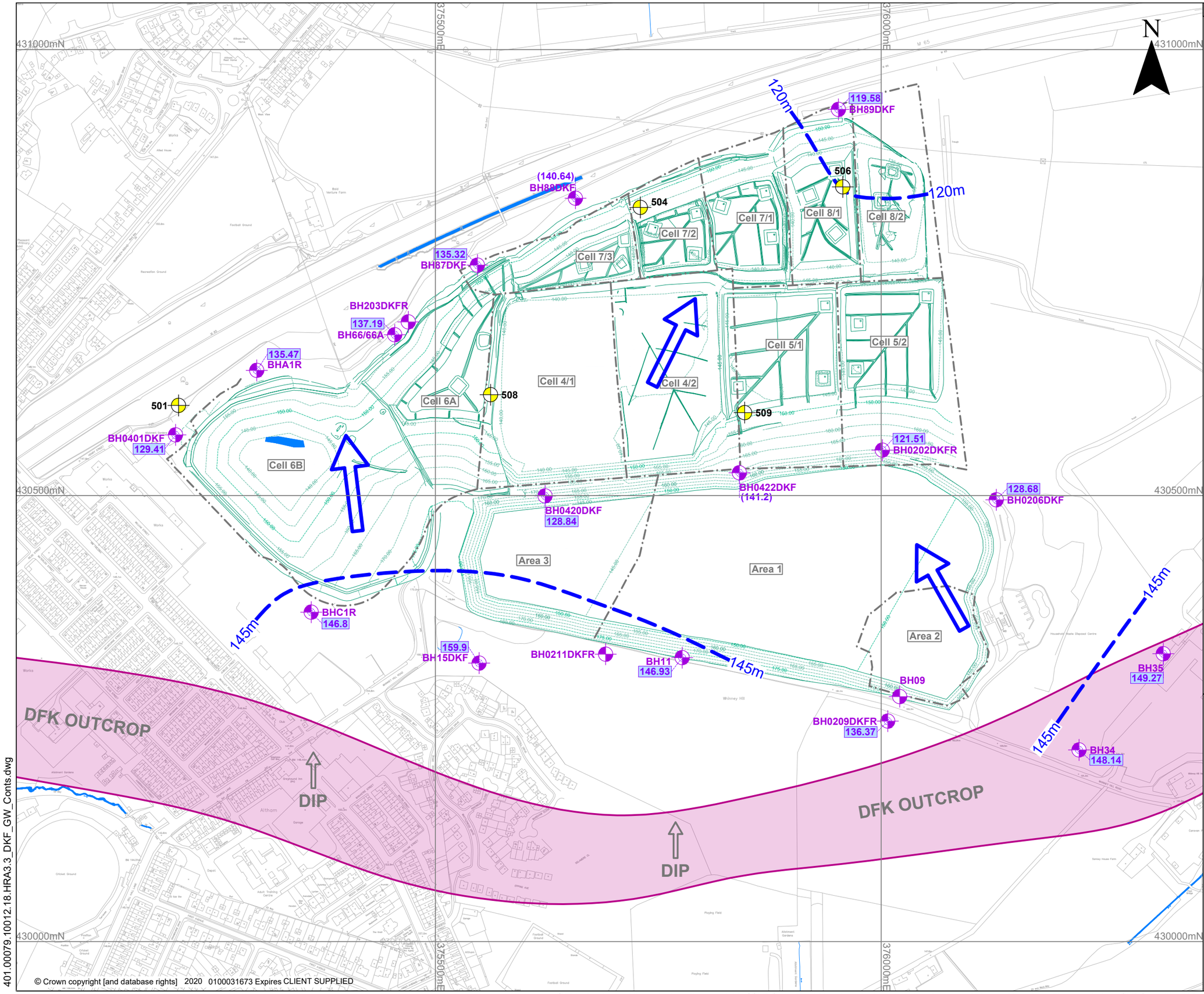

LEGEND

- BH87DKF — DKF MONITORING BOREHOLE LOCATION & REFERENCE
- 501 — SITE INVESTIGATION BOREHOLE LOCATION & REFERENCE
- INFERRED GROUNDWATER LEVEL CONTOURS IN DKF SANDSTONE (mAOD) - AUGUST 2020
- 121.51 — GROUNDWATER LEVEL IN DKF SANDSTONE (mAOD) - AUGUST 2020
- (140.64) — GROUNDWATER LEVEL IN DKF SANDSTONE (mAOD) - AUGUST 2020 (POTENTIALLY INFLUENCED BY ACCRINGTON MUDSTONE)
- INFERRED GROUNDWATER FLOW DIRECTION IN DKF SANDSTONE
- OUTCROP OF DKF SANDSTONE
- ENGINEERED BASAL LINER
- CELL BOUNDARY
- OS SURVEY DATA
- SURFACE WATER BODY

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HYDROGEOLOGICAL RISK ASSESSMENT REVIEW

DKF SANDSTONE GROUNDWATER CONTOURS

HRA3

Scale	Date
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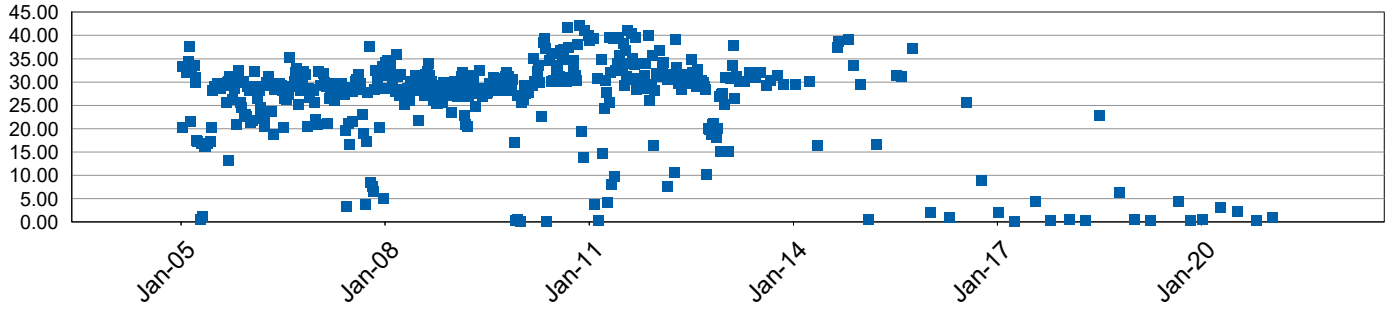
401.00079.10012.18.HRA3.3_DKF_GW_Conts.dwg

Figure 3. Carbon Dioxide and Methane Plots for Boreholes Within Phase 1

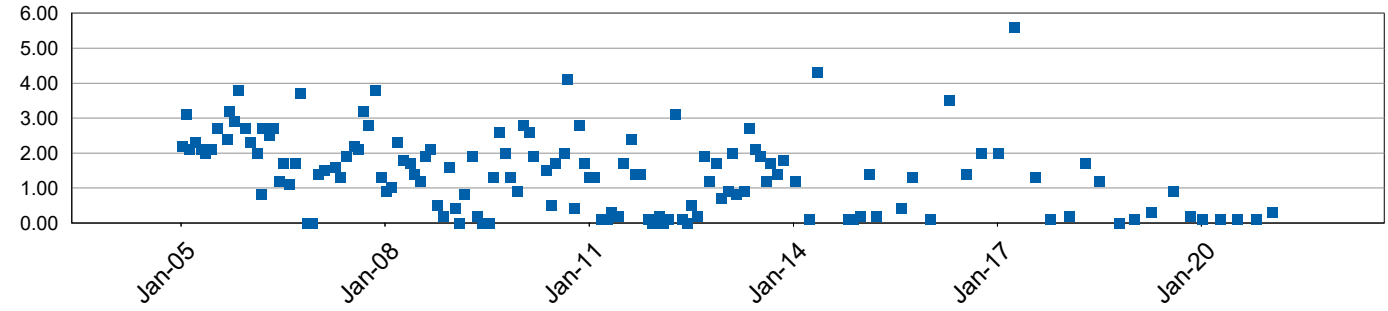
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

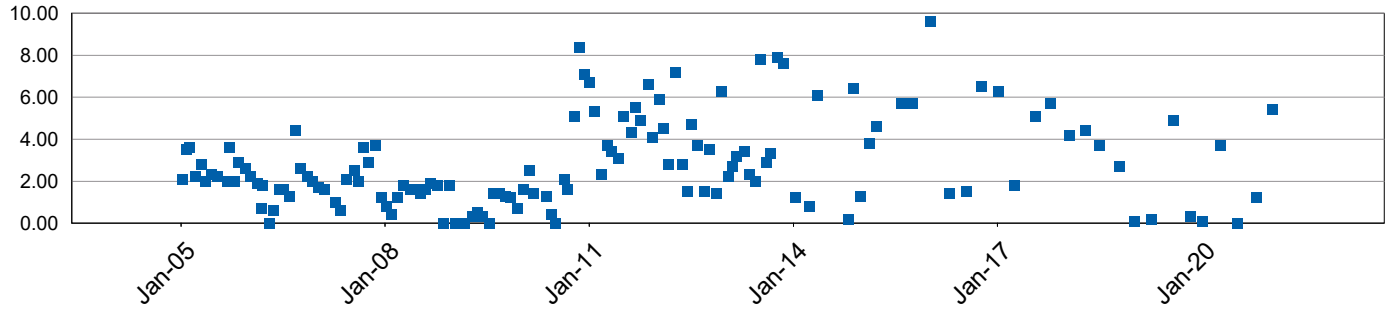
Carbon Dioxide (% v/v)
WH/BH13A



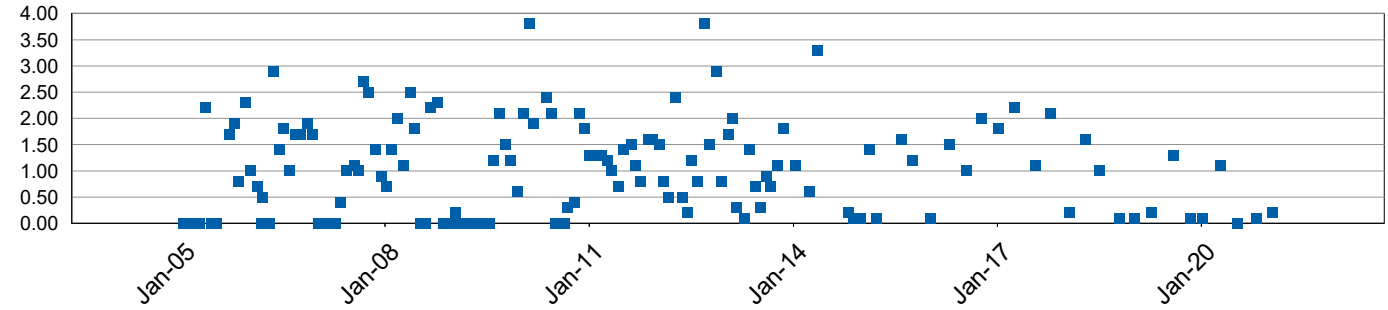
Carbon Dioxide (% v/v)
WH/BH2/1



Carbon Dioxide (% v/v)
WH/BH2/2



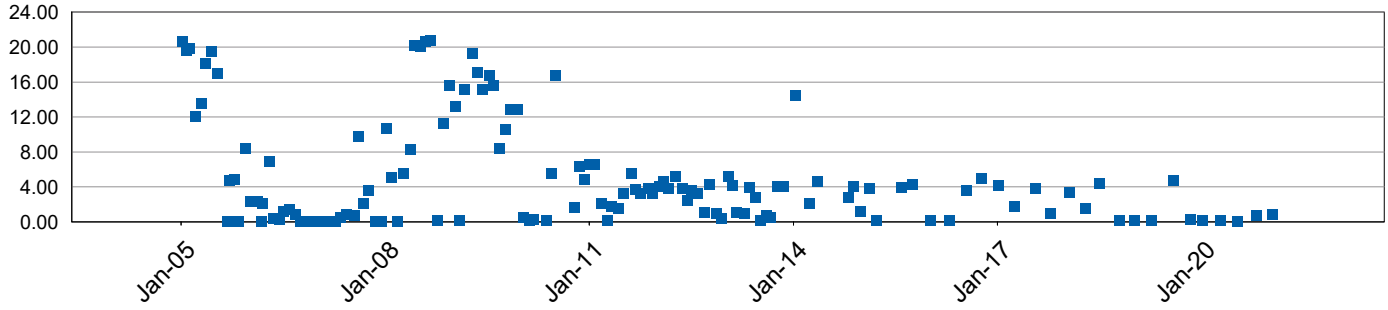
Carbon Dioxide (% v/v)
WH/BH2/3



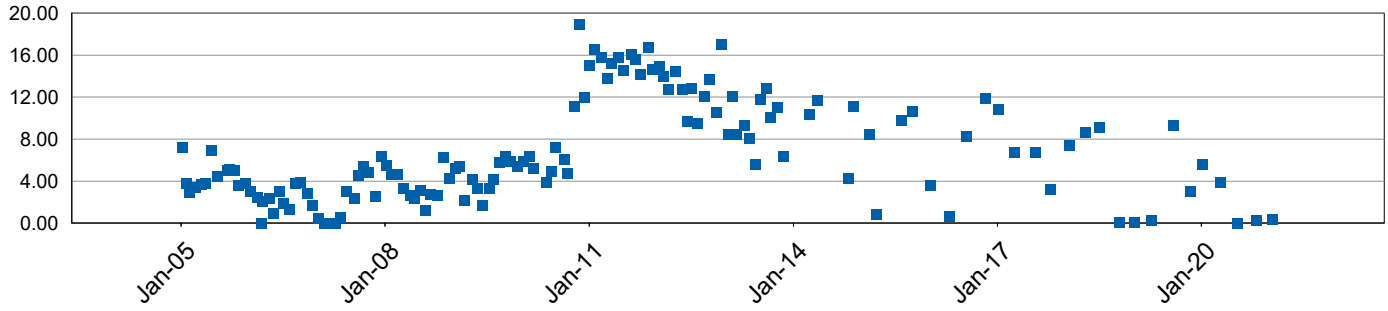
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

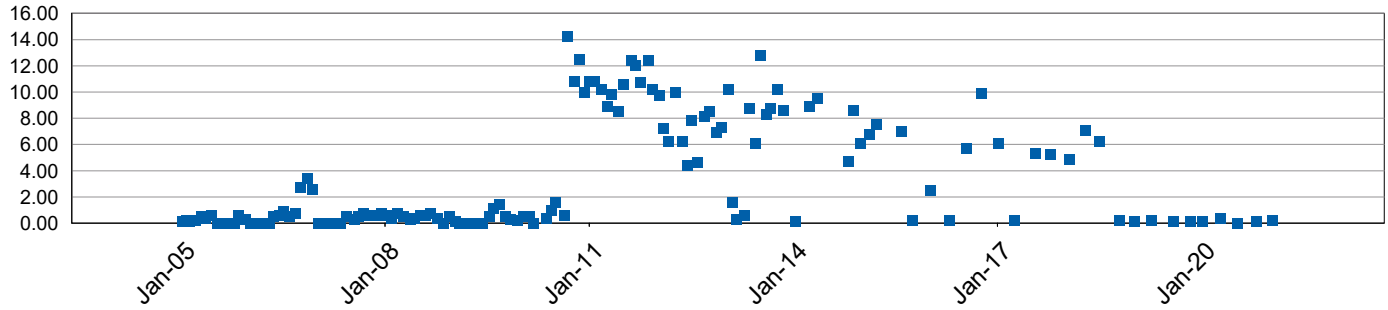
Carbon Dioxide (% v/v)
WH/BH2/4



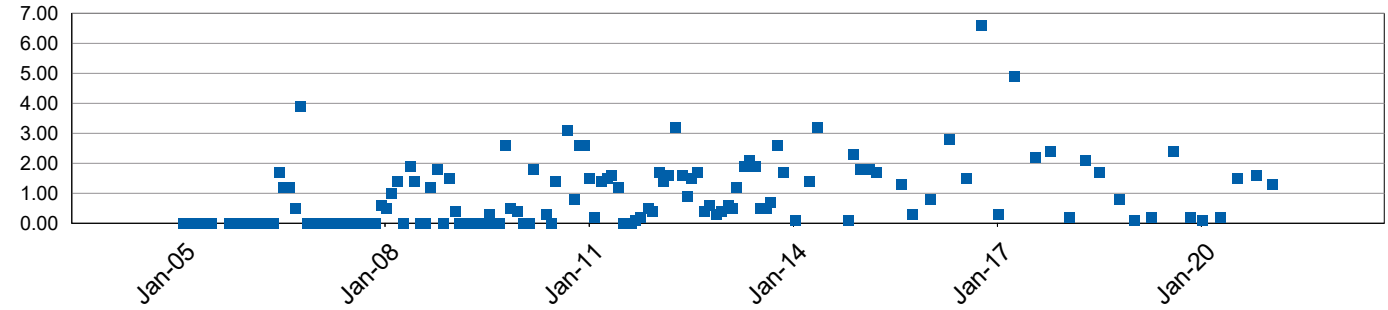
Carbon Dioxide (% v/v)
WH/BH2/5



Carbon Dioxide (% v/v)
WH/BH3/1



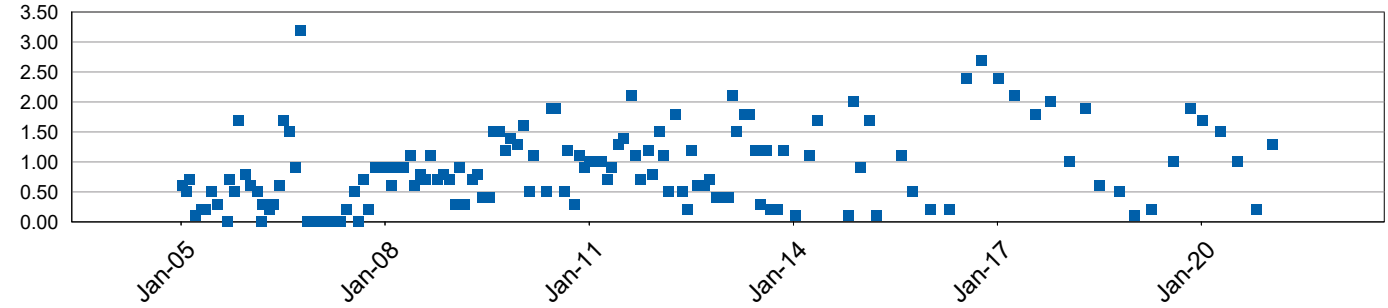
Carbon Dioxide (% v/v)
WH/BH3/2



Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

Carbon Dioxide (% v/v)
WH/BH3/3



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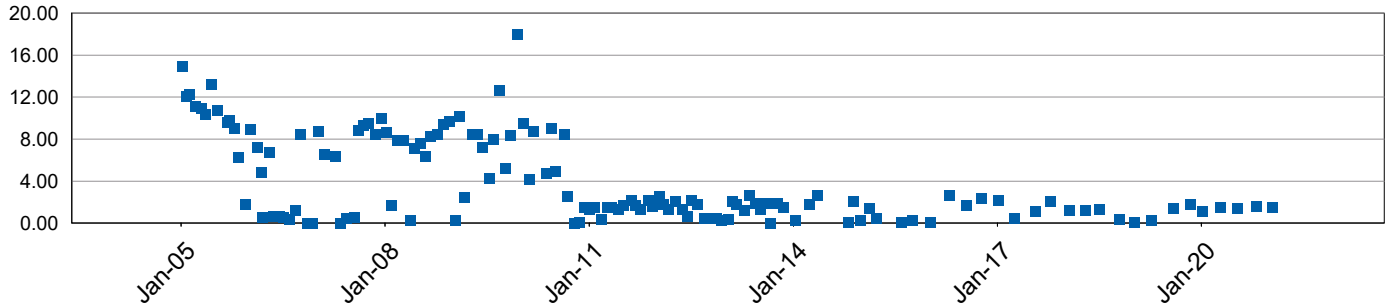
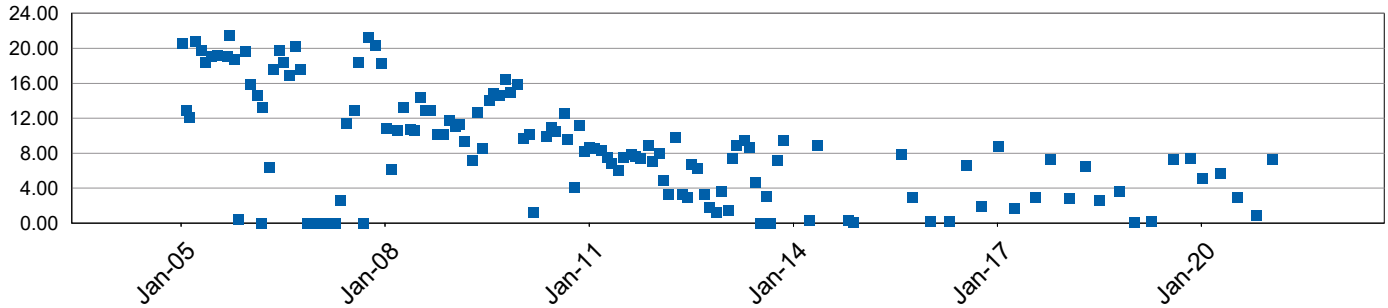
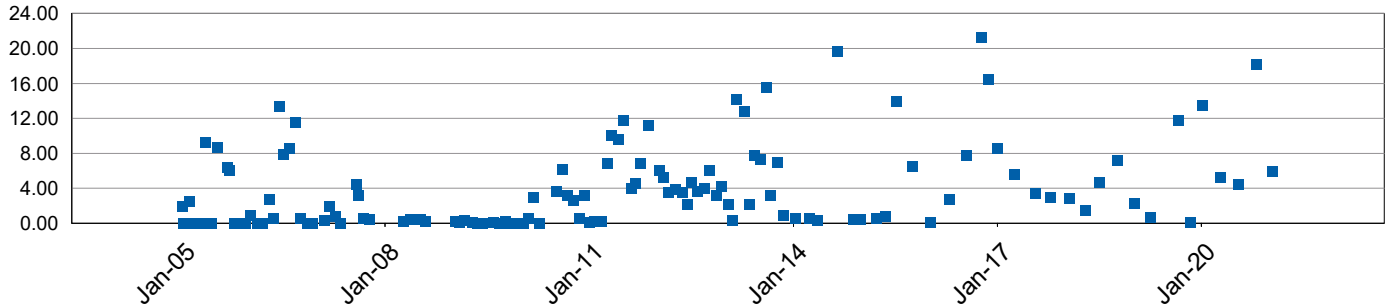


Carbon Dioxide (% v/v)
WH/BH3/5



Carbon Dioxide (% v/v)
WH/BH34



Carbon Dioxide (% v/v)
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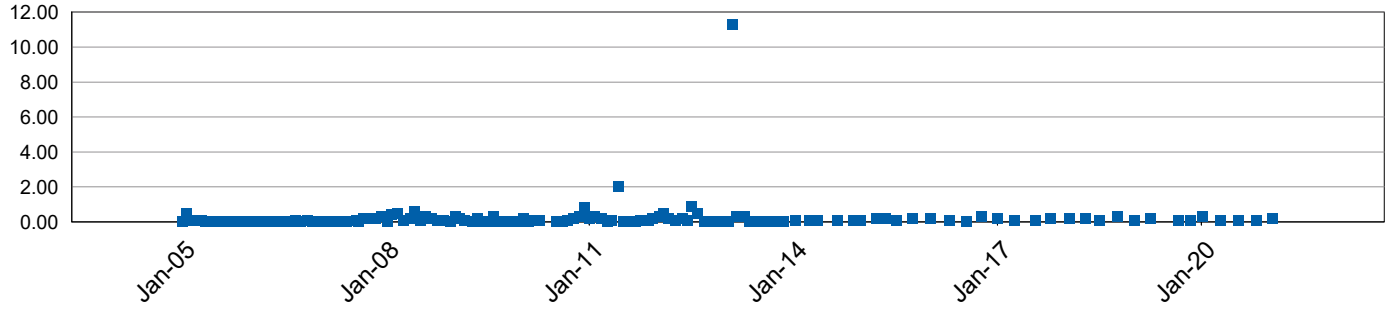
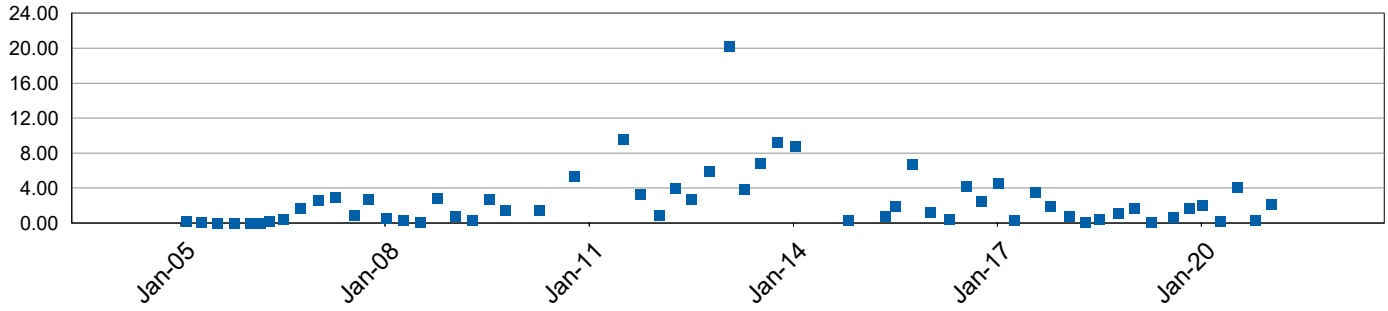


Carbon Dioxide (% v/v)
WH/BH45/1



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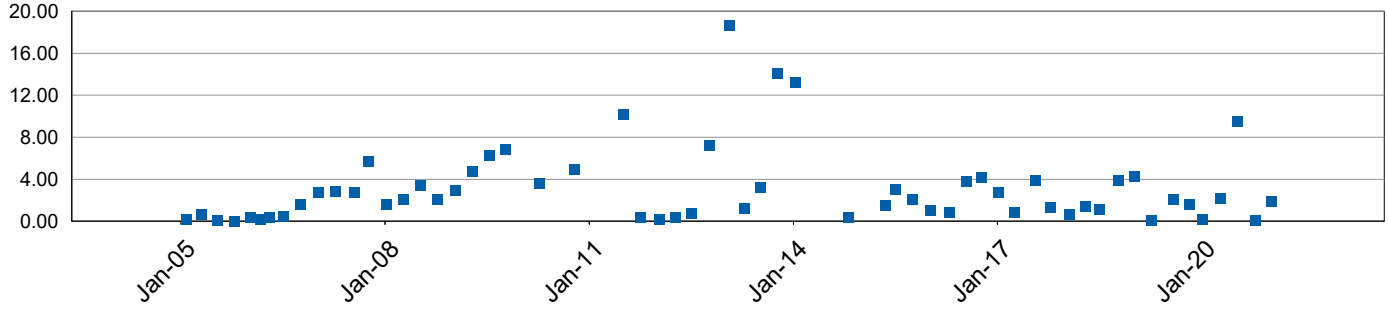

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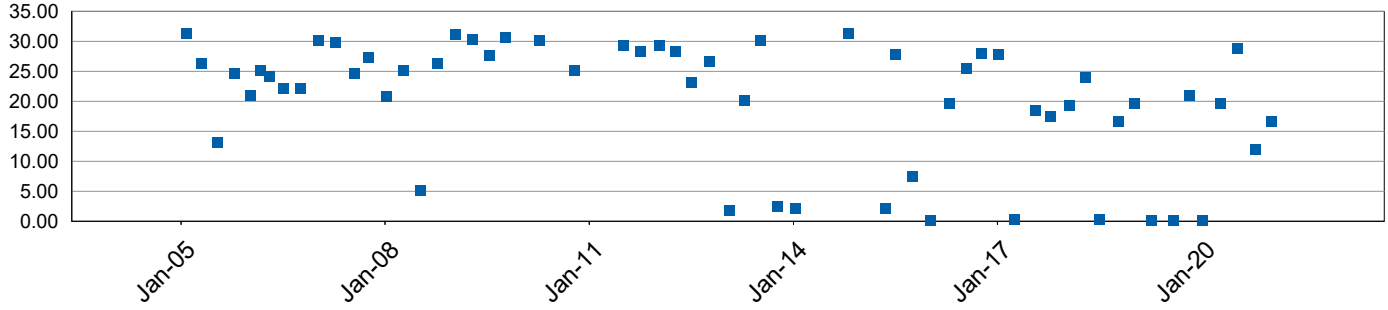

Carbon Dioxide (% v/v)
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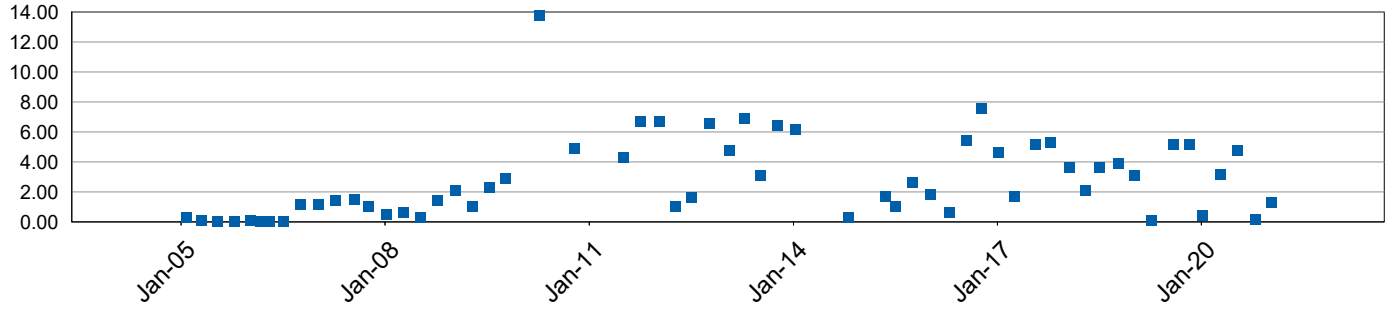

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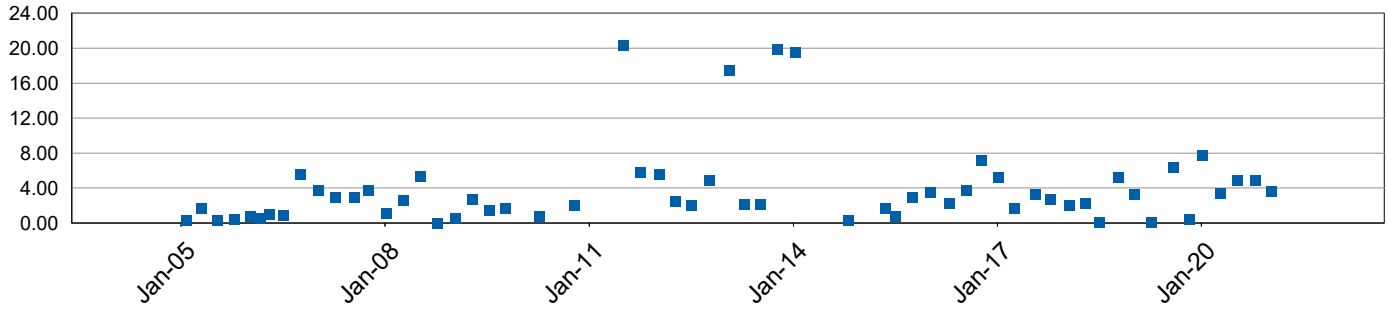

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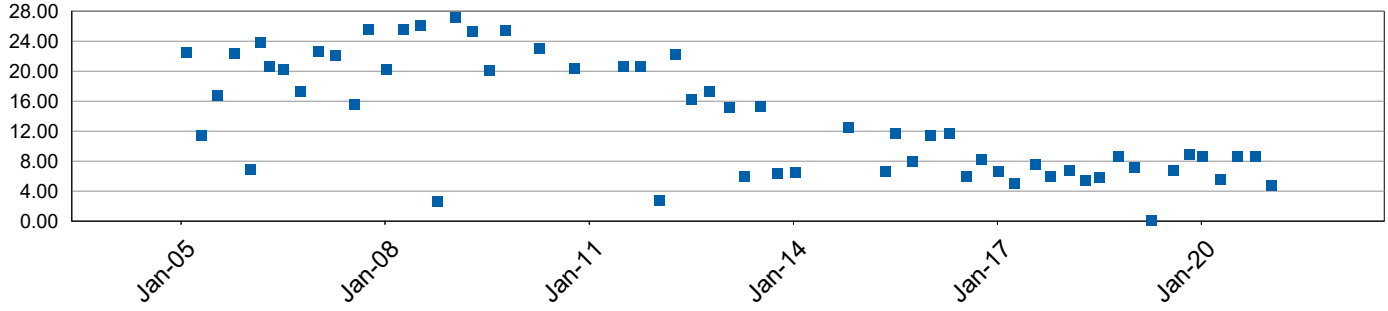
WH/BH46/2



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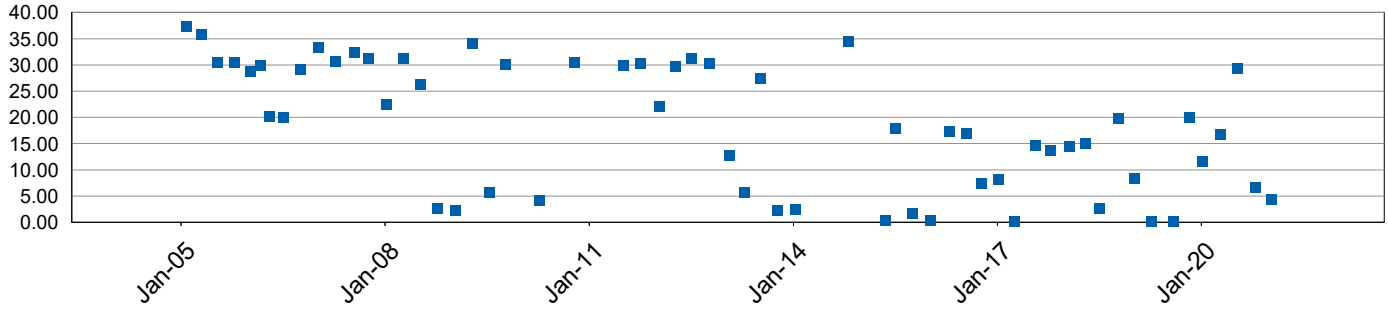
WH/BH46/3



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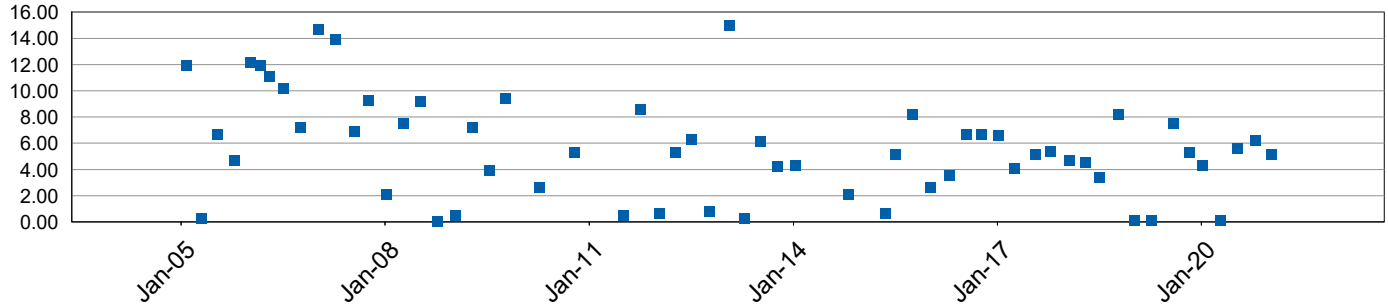

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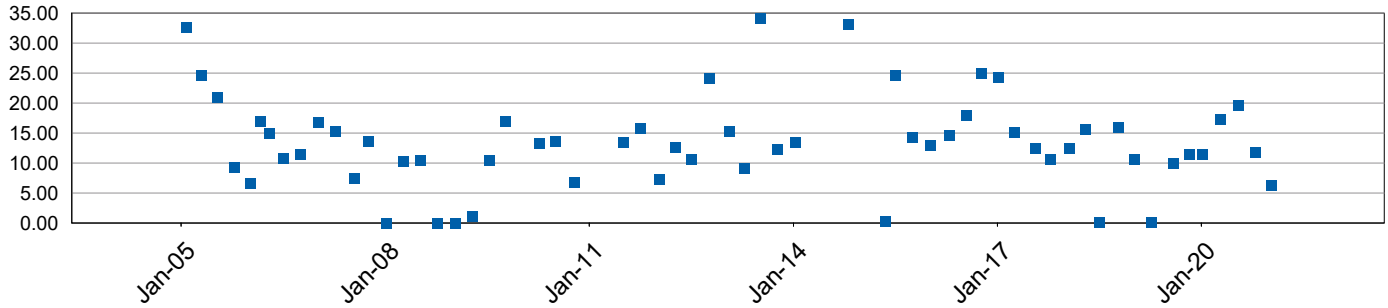

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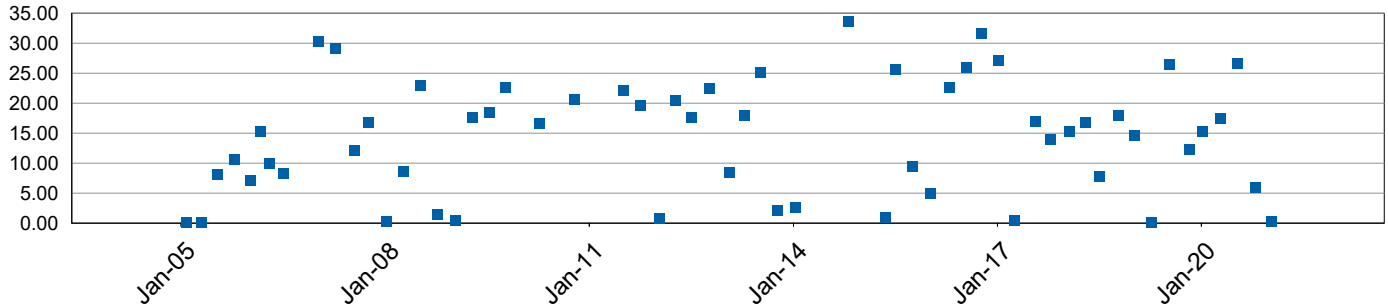

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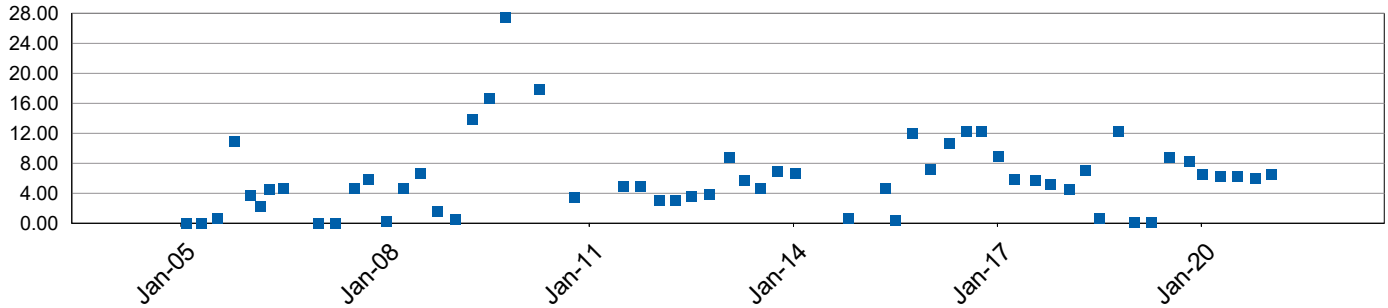
WH/BH48/2



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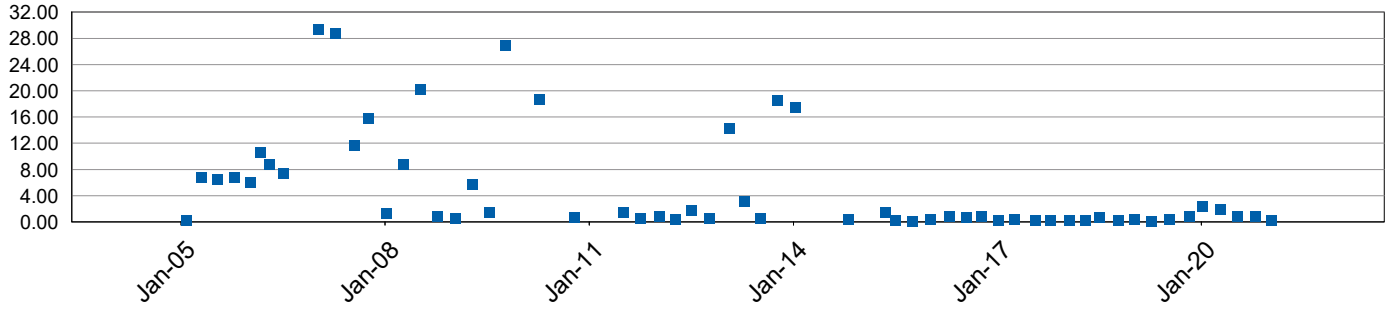

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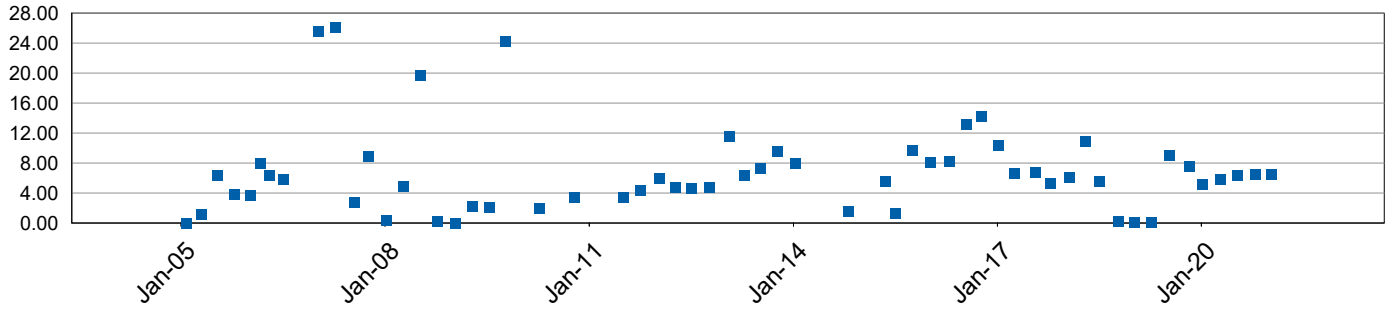

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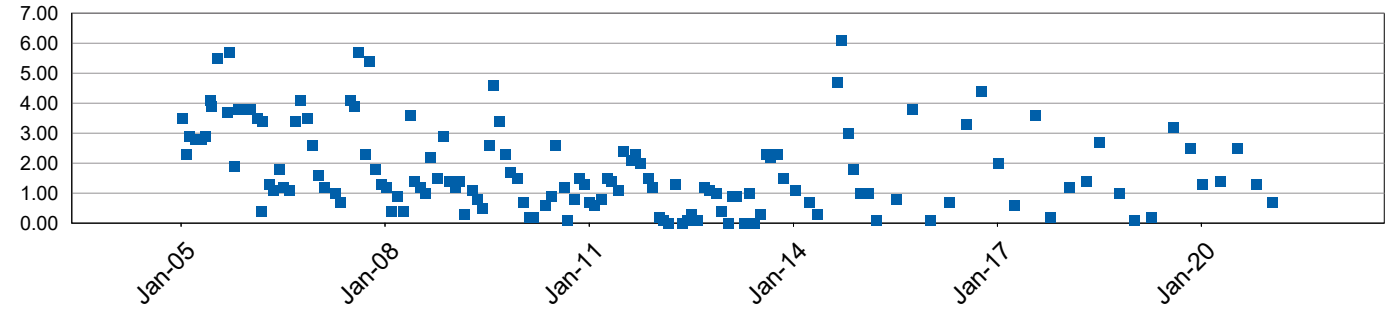

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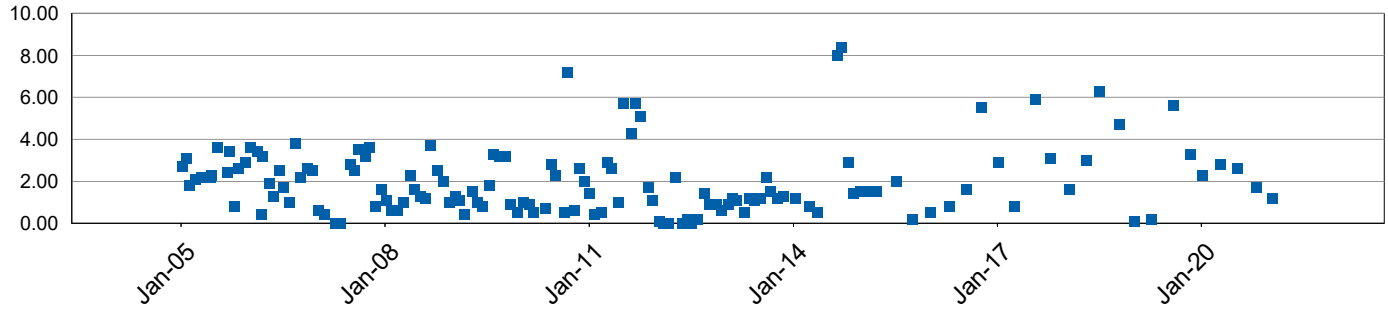
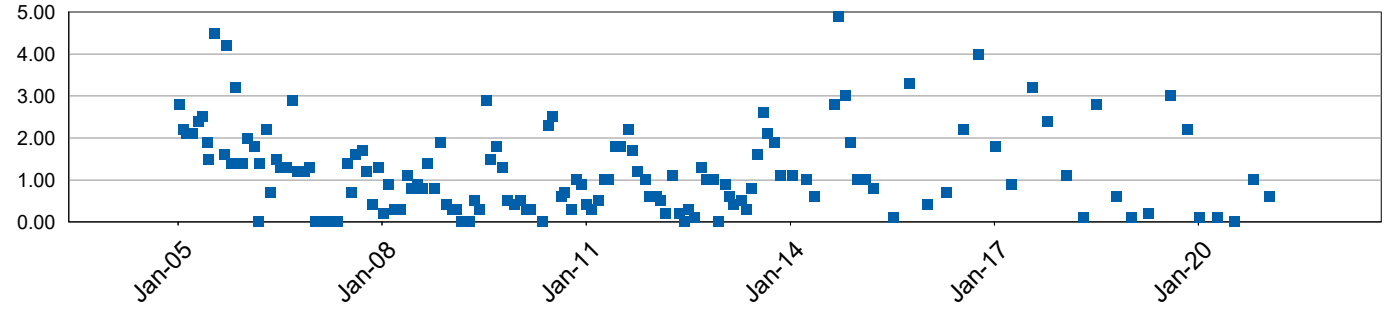
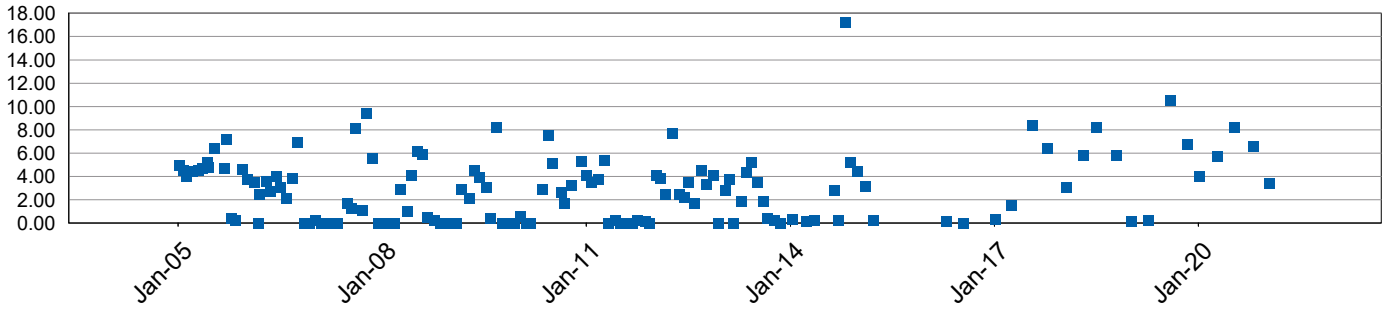


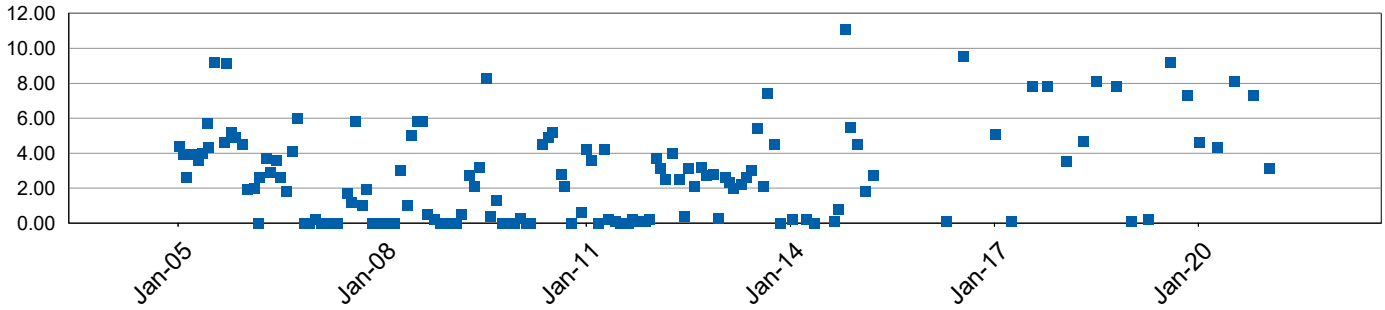
Carbon Dioxide (% v/v)
WH/BH49/3



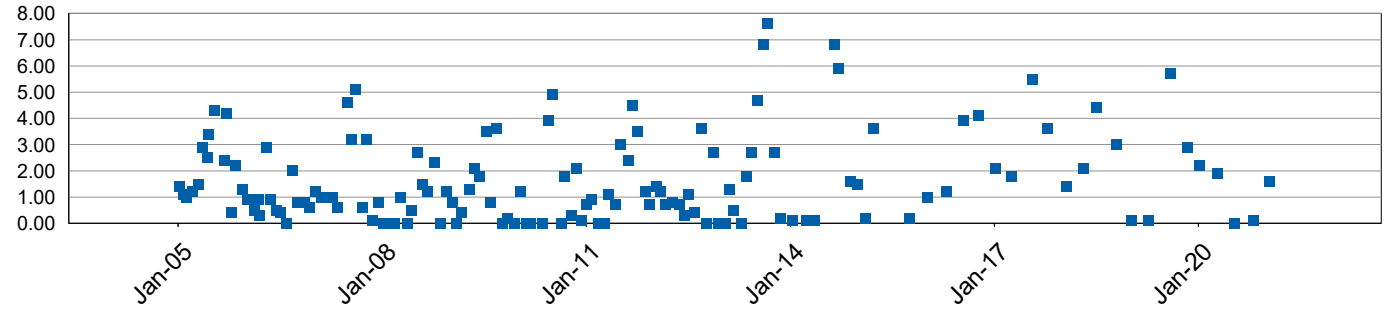
Carbon Dioxide (% v/v)
WH/BH50/1



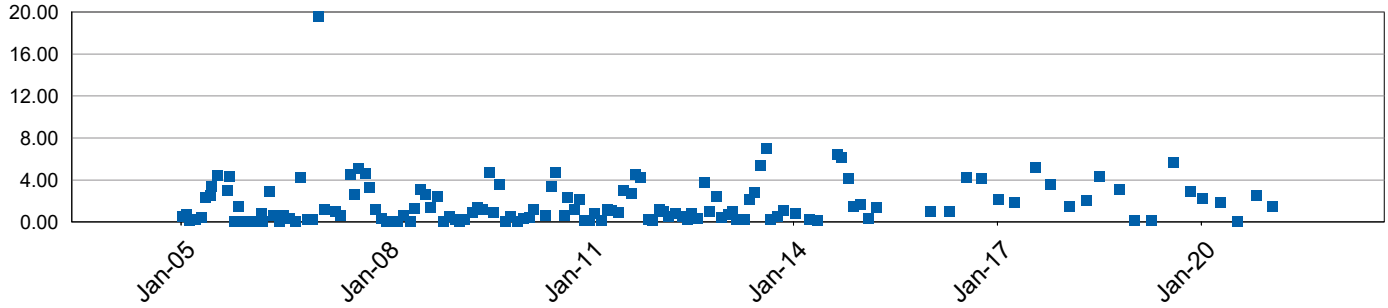
Carbon Dioxide (% v/v)
WH/BH50/2



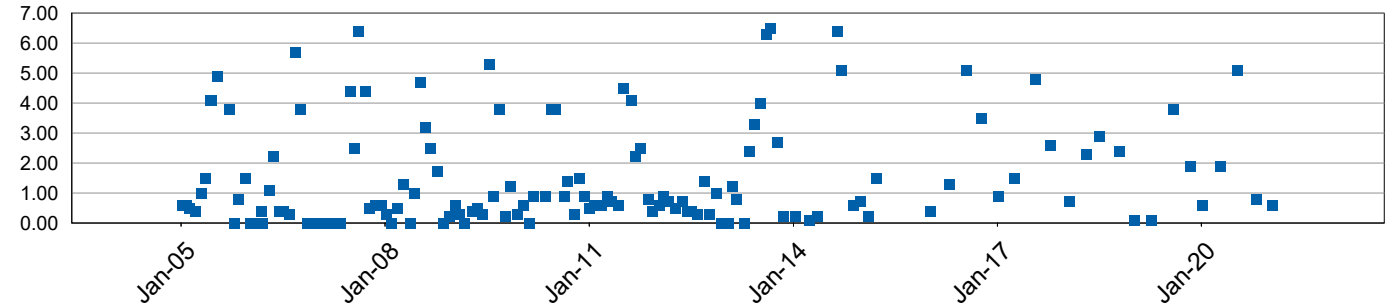
Carbon Dioxide (% v/v)
WH/BH51/1



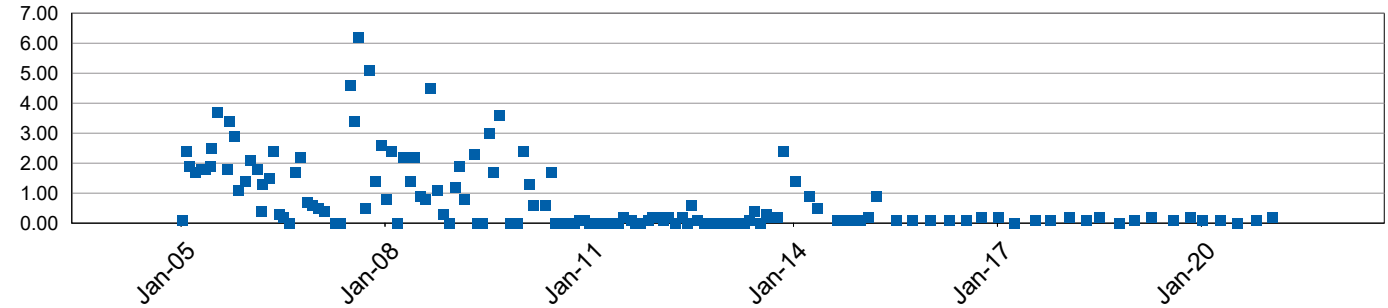
Carbon Dioxide (% v/v)
WH/BH51/2



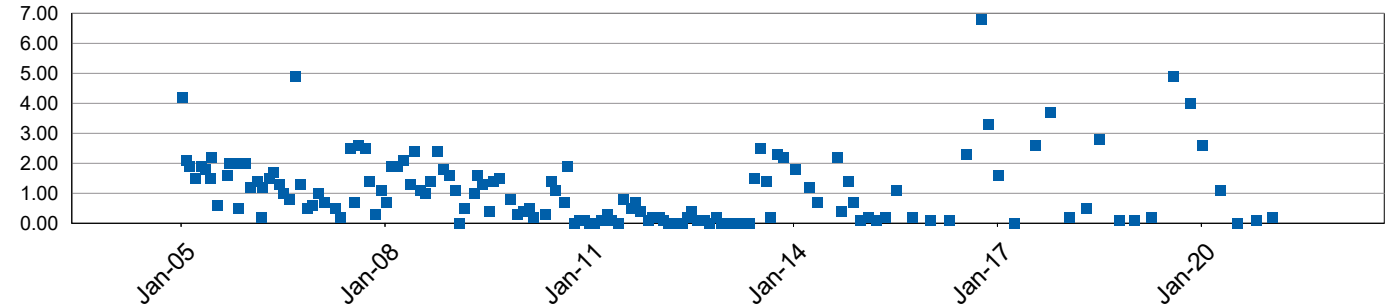
Carbon Dioxide (% v/v)
WH/BH51/3



Carbon Dioxide (% v/v)
WH/BH52/1



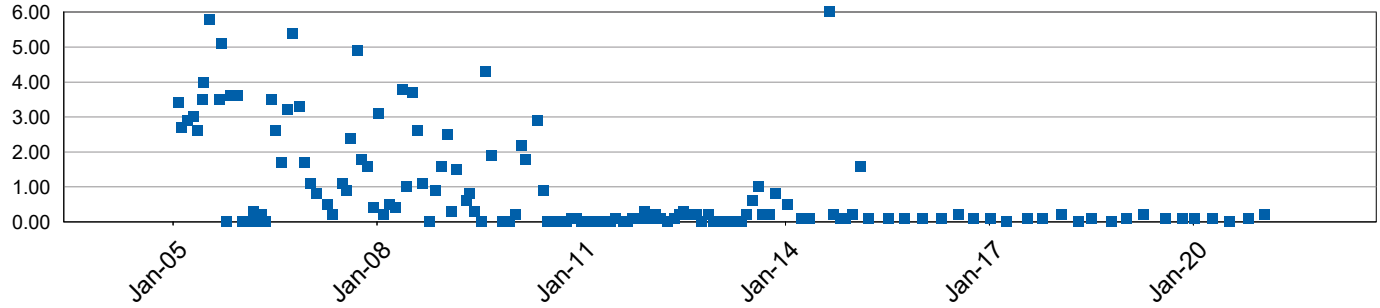
Carbon Dioxide (% v/v)
WH/BH52/2



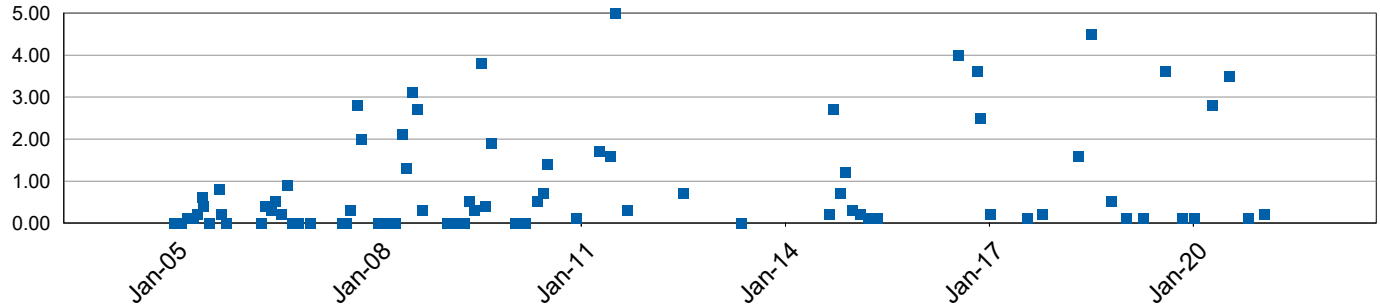
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

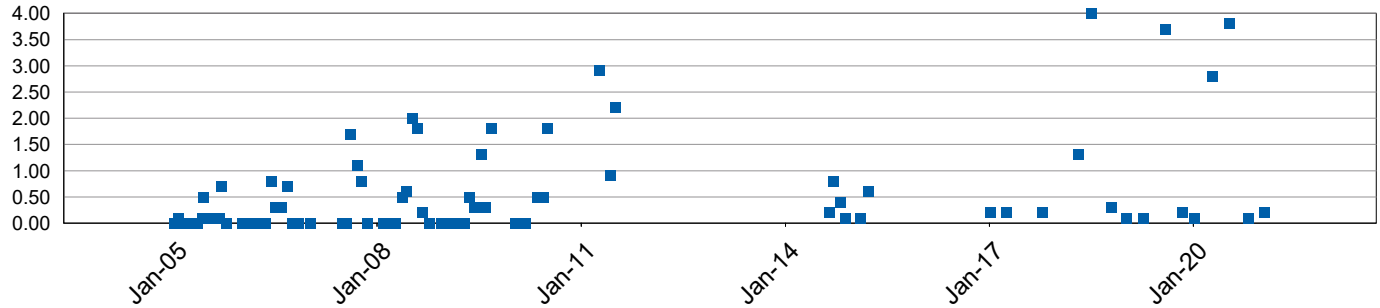
Carbon Dioxide (% v/v)
WH/BH52/3



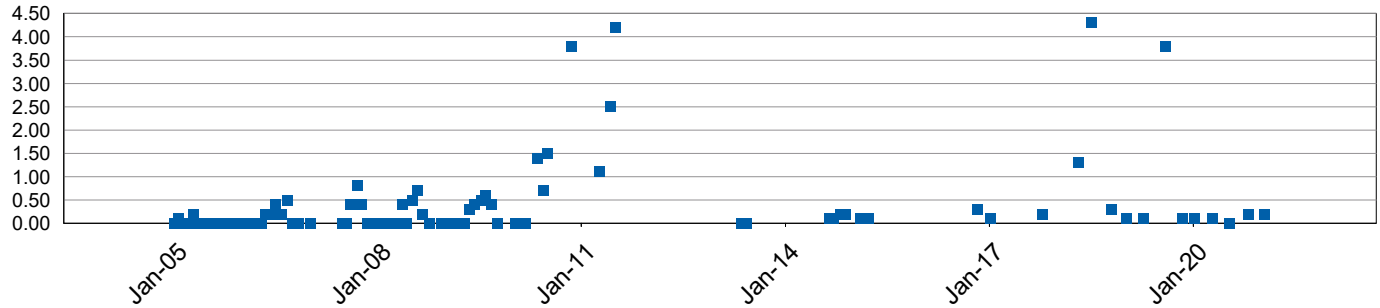
Carbon Dioxide (% v/v)
WH/BH53/1



Carbon Dioxide (% v/v)
WH/BH53/2



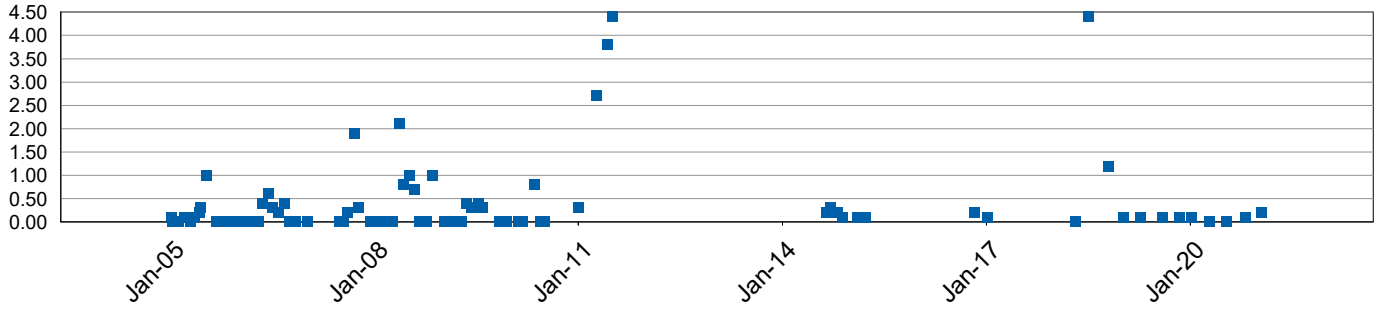
Carbon Dioxide (% v/v)
WH/BH53/3



Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

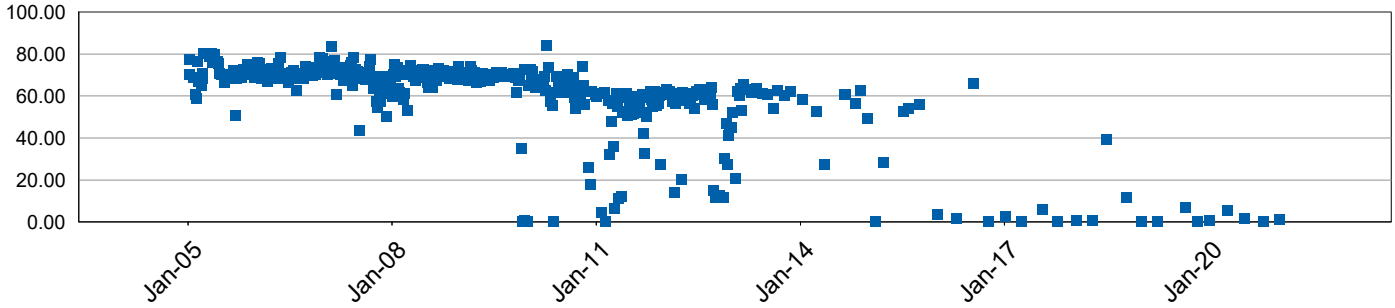
Carbon Dioxide (% v/v)
WH/BH53/4



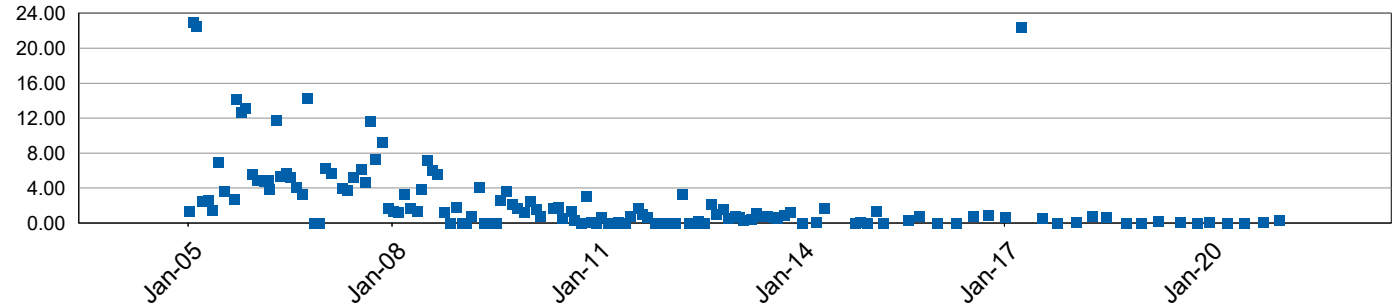
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

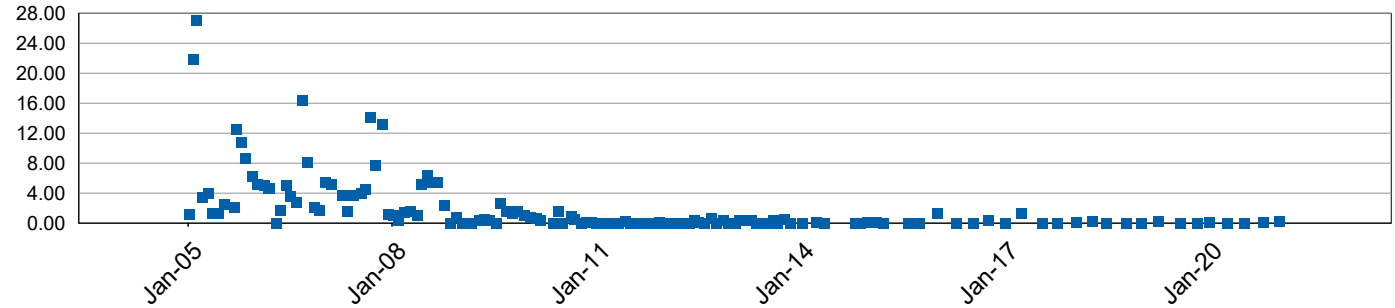
Methane (% v/v)
WH/BH13A



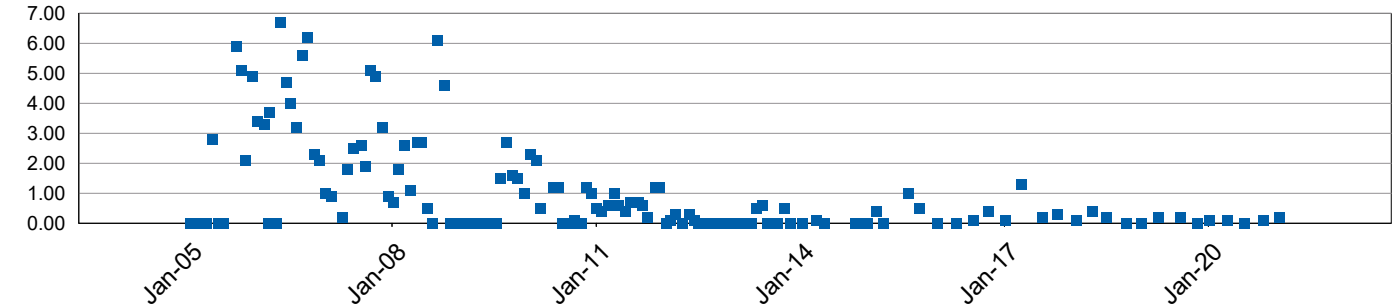
Methane (% v/v)
WH/BH2/1



Methane (% v/v)
WH/BH2/2



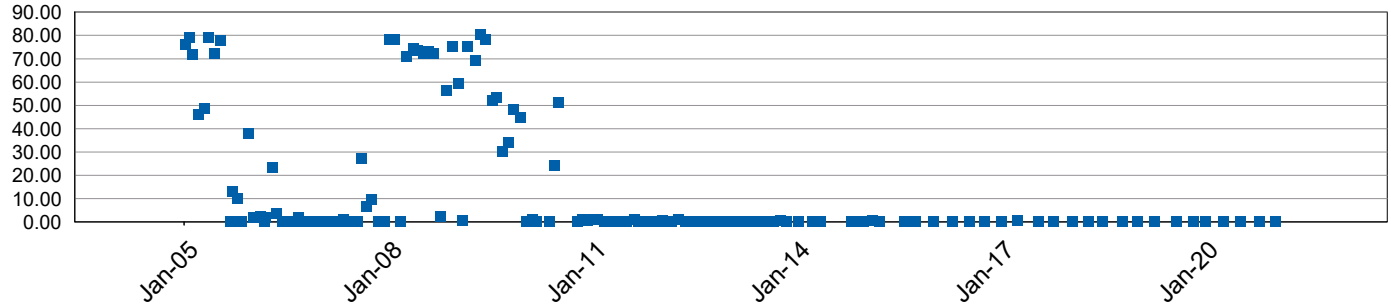
Methane (% v/v)
WH/BH2/3



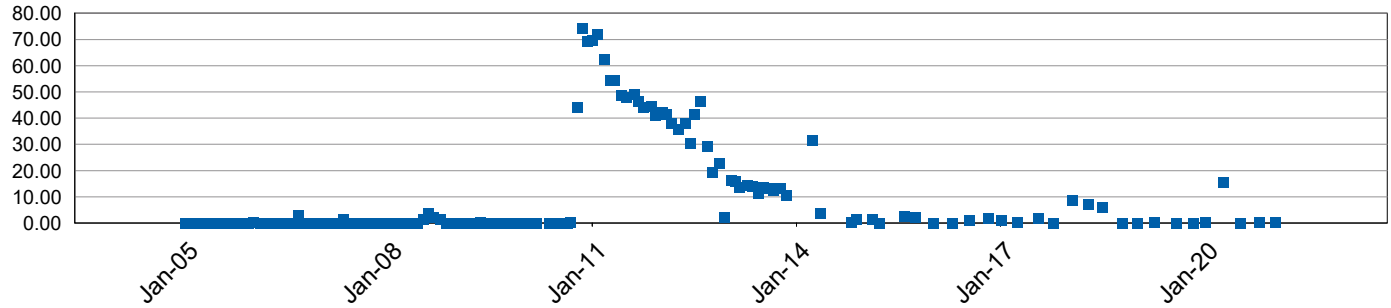
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

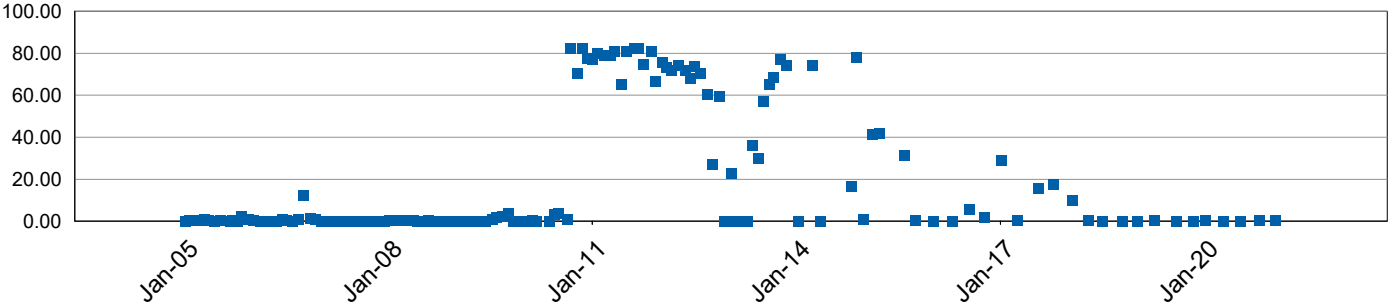
Methane (% v/v)
WH/BH2/4



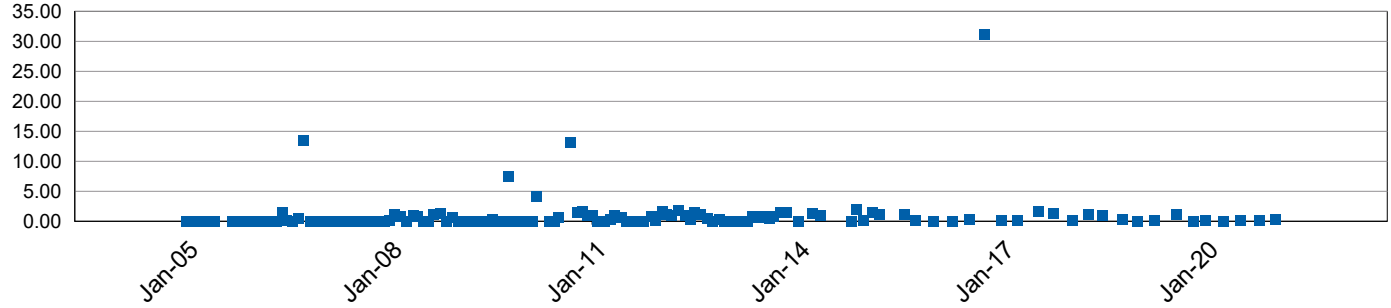
Methane (% v/v)
WH/BH2/5



Methane (% v/v)
WH/BH3/1



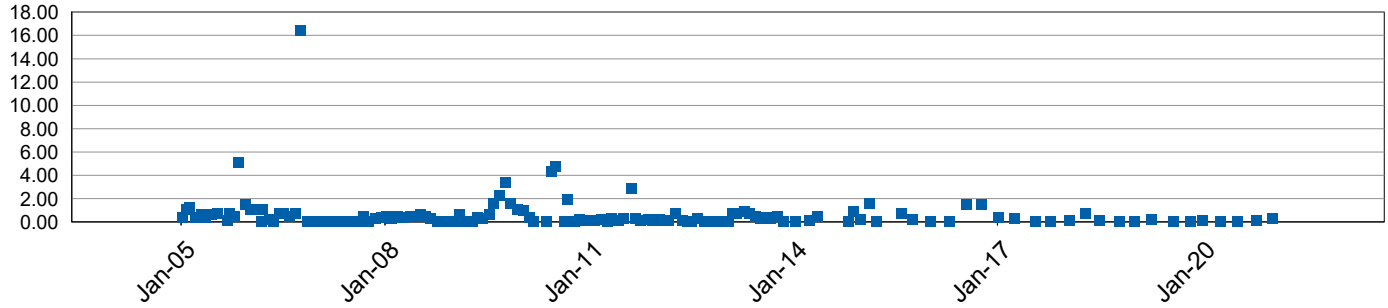
Methane (% v/v)
WH/BH3/2



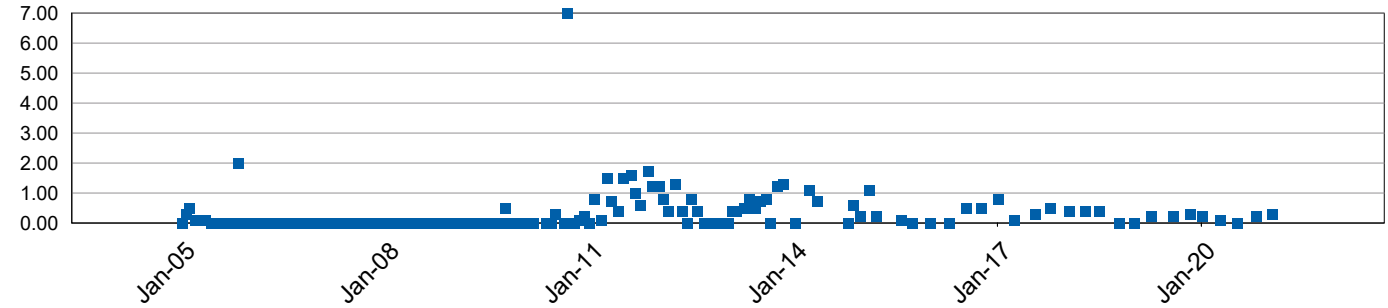
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

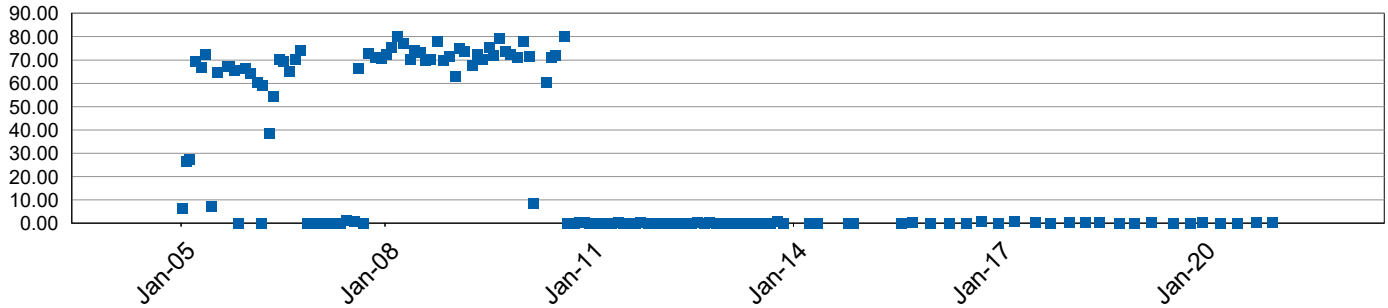
Methane (% v/v)
WH/BH3/3



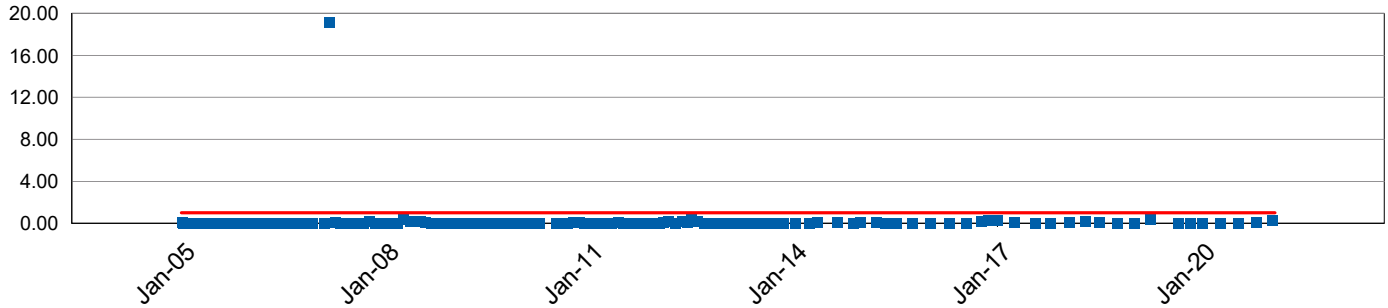
Methane (% v/v)
WH/BH3/4



Methane (% v/v)
WH/BH3/5



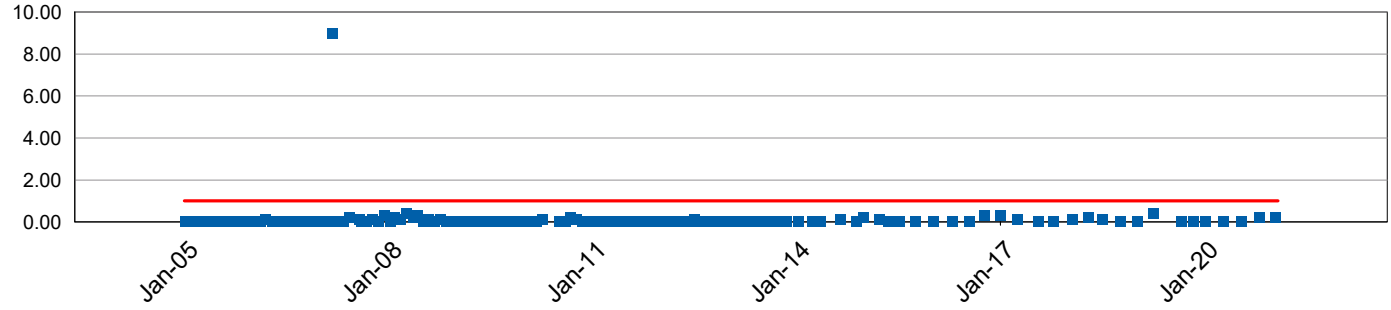
Methane (% v/v)
WH/BH34



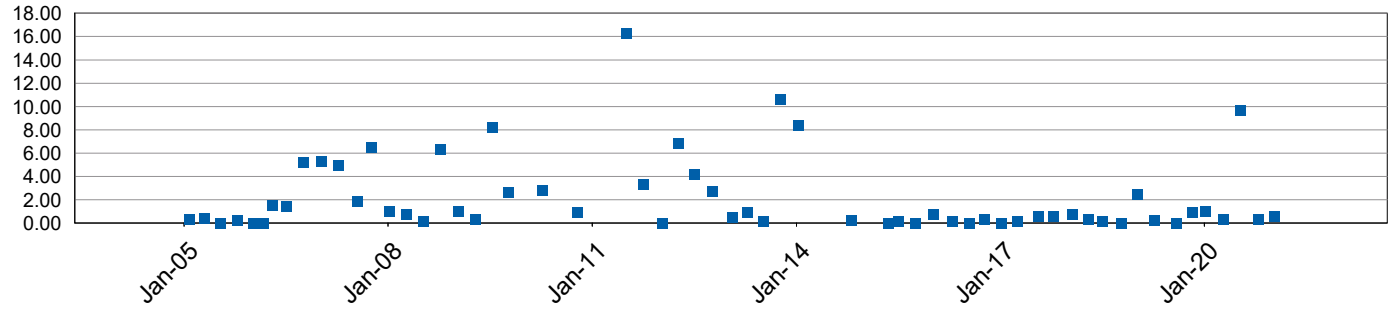
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

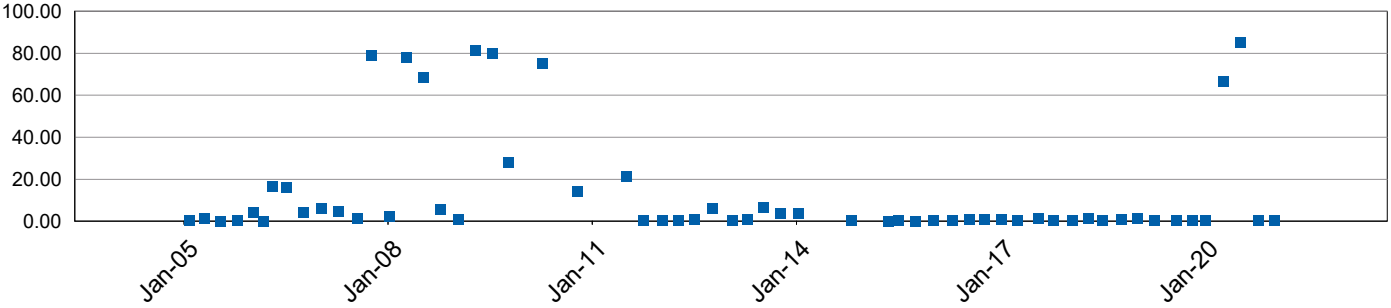
Methane (% v/v)
WH/BH35



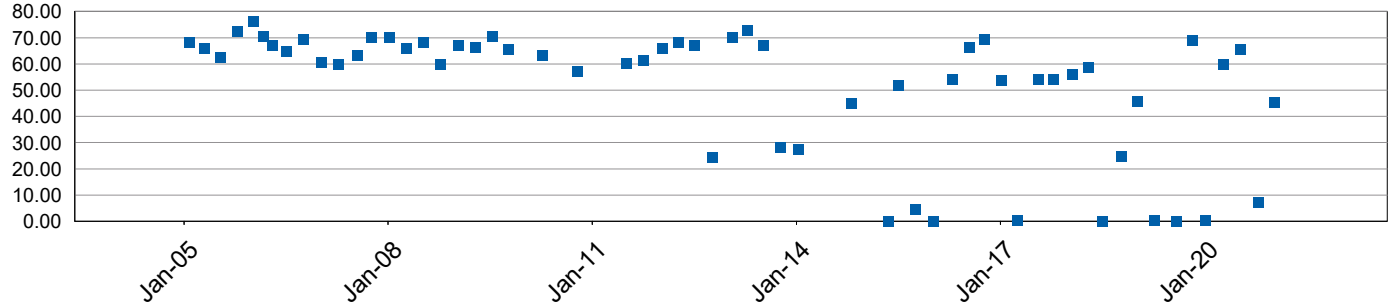
Methane (% v/v)
WH/BH45/1



Methane (% v/v)
WH/BH45/2



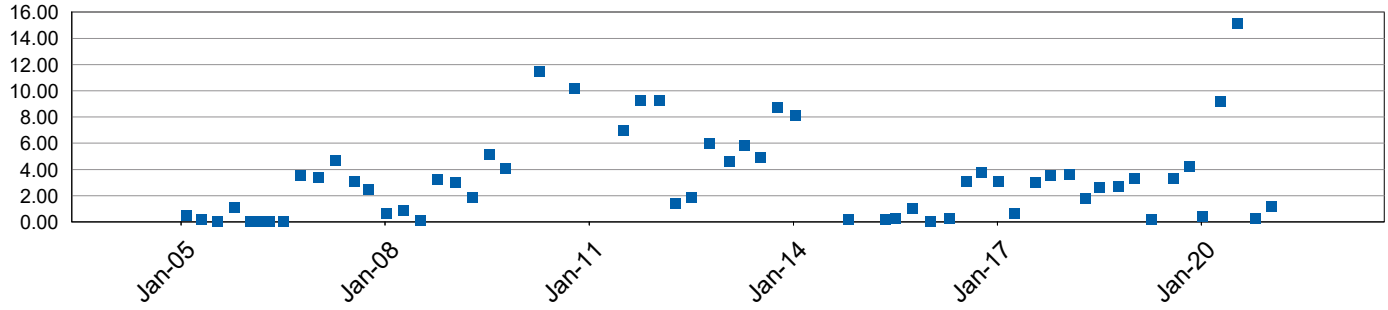
Methane (% v/v)
WH/BH45/3



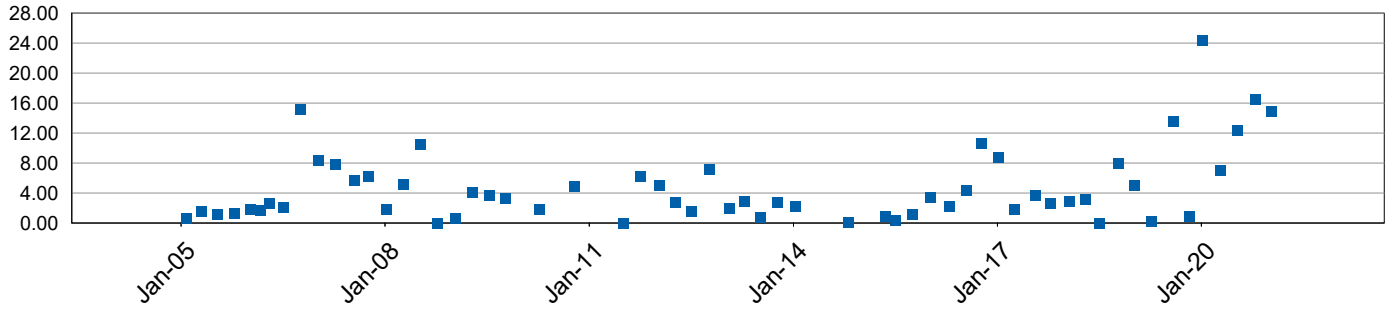
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

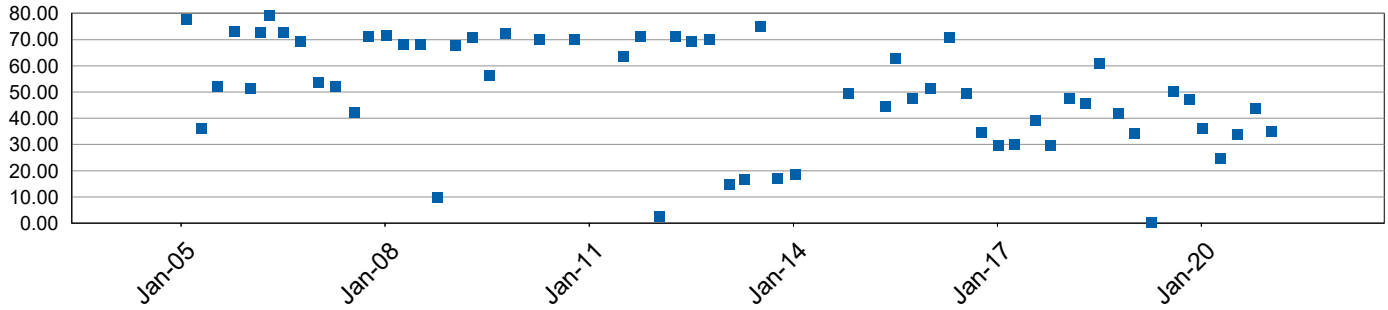
Methane (% v/v)
WH/BH45/4



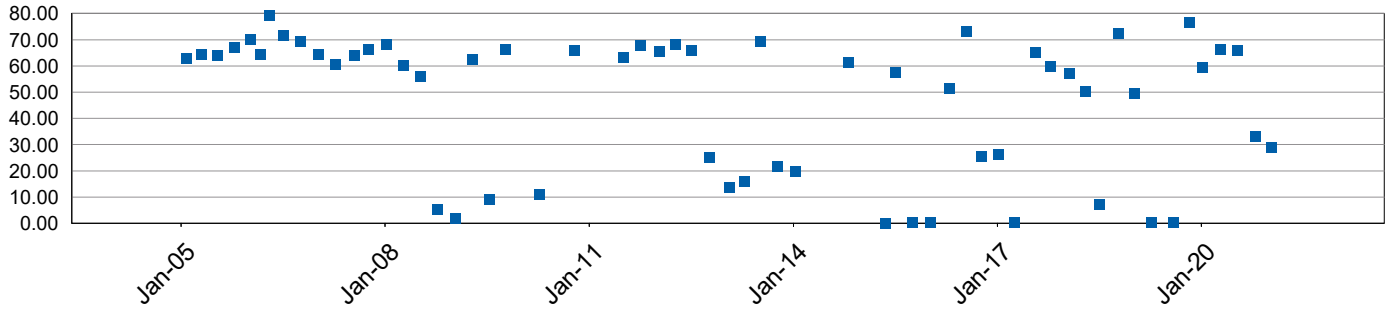
Methane (% v/v)
WH/BH46/1



Methane (% v/v)
WH/BH46/2



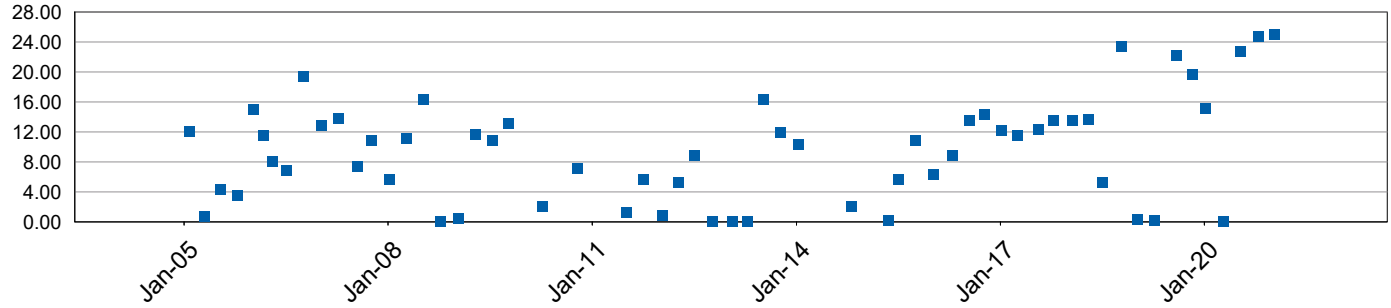
Methane (% v/v)
WH/BH46/3



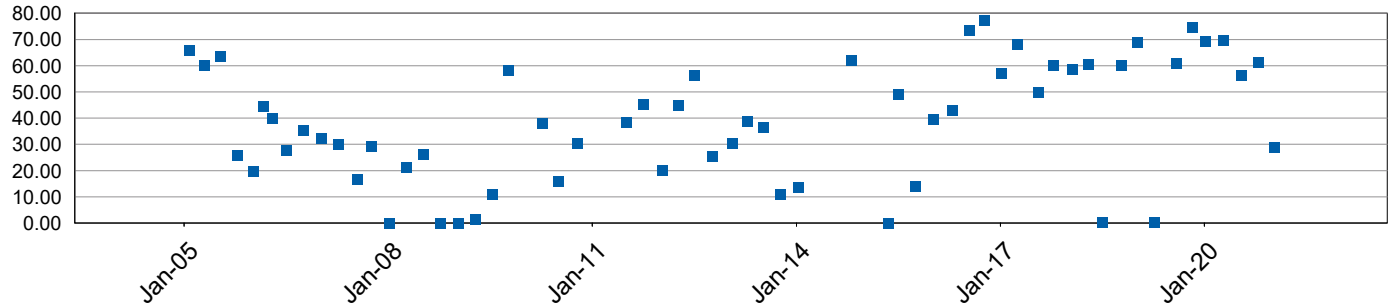
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

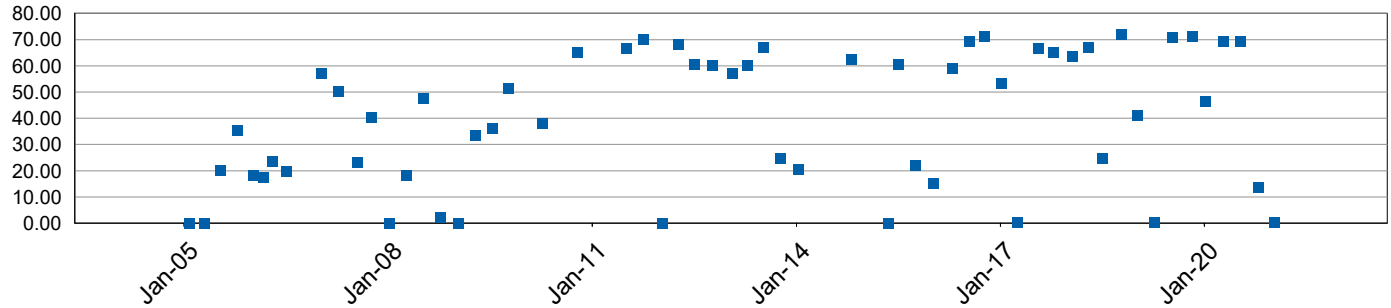
Methane (% v/v)
WH/BH46/4



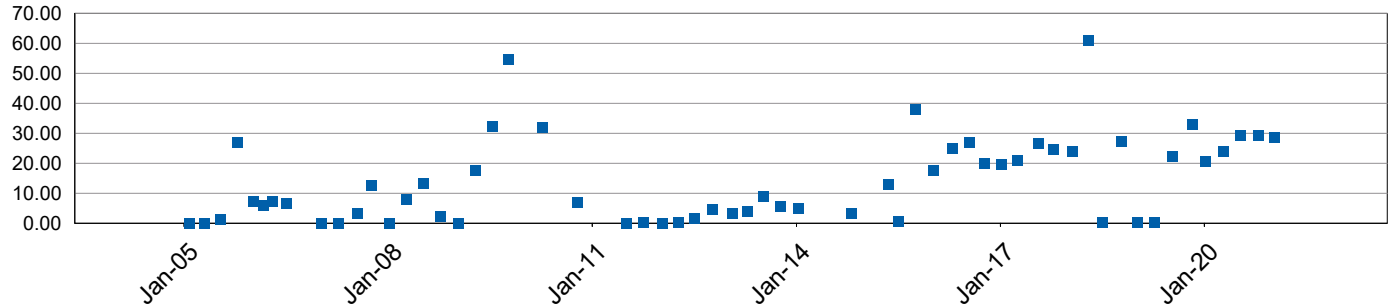
Methane (% v/v)
WH/BH47



Methane (% v/v)
WH/BH48/1



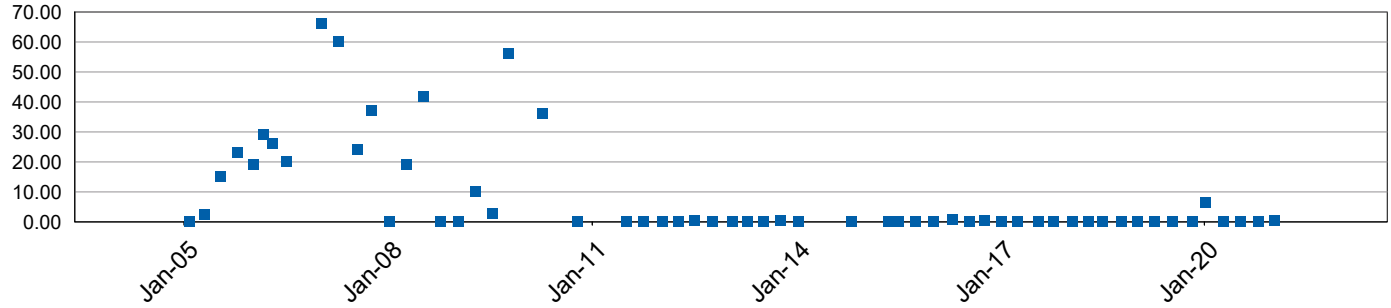
Methane (% v/v)
WH/BH48/2



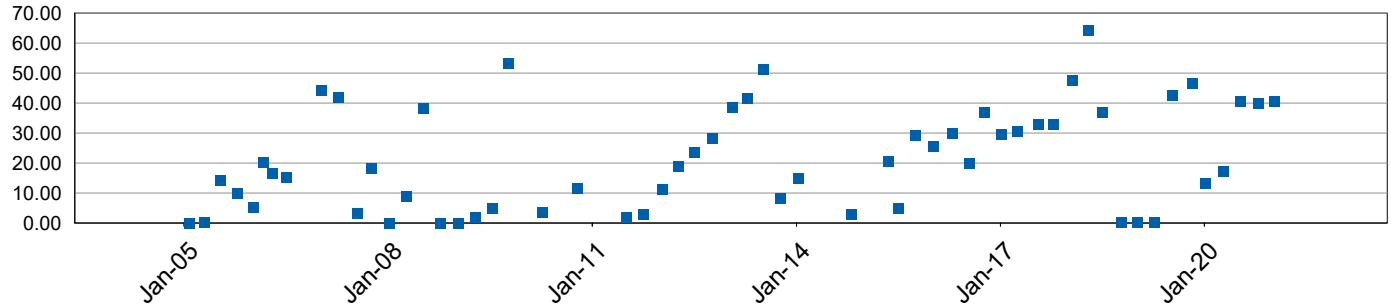
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

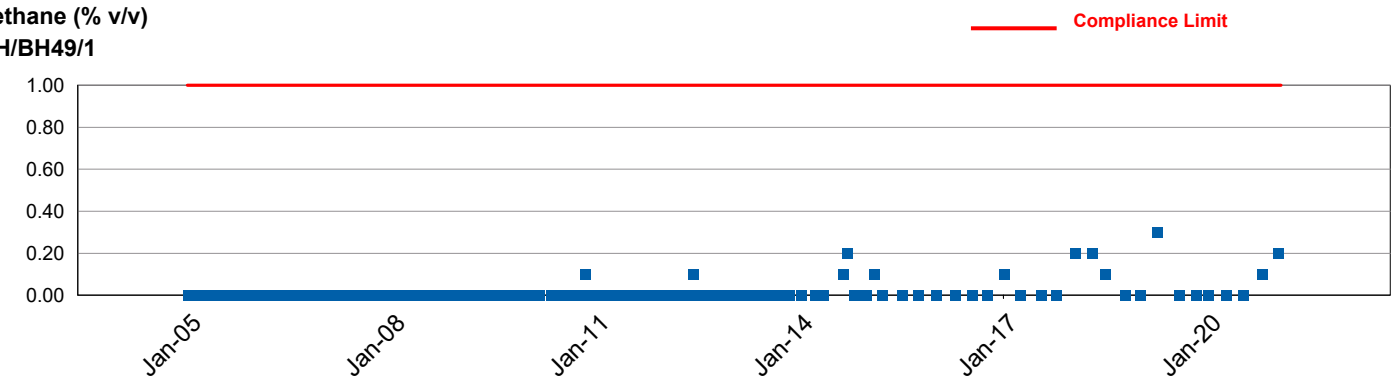
Methane (% v/v)
WH/BH48/3



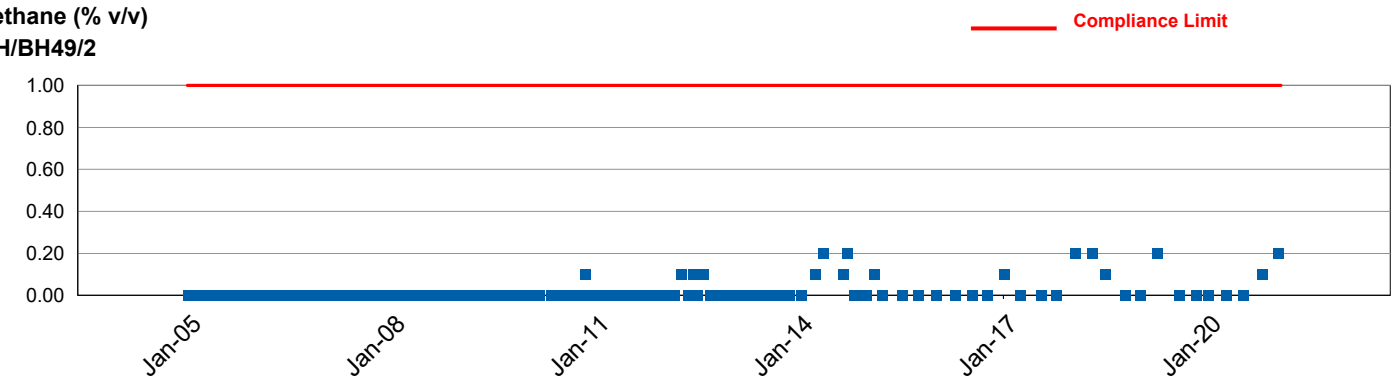
Methane (% v/v)
WH/BH48/4



Methane (% v/v)
WH/BH49/1



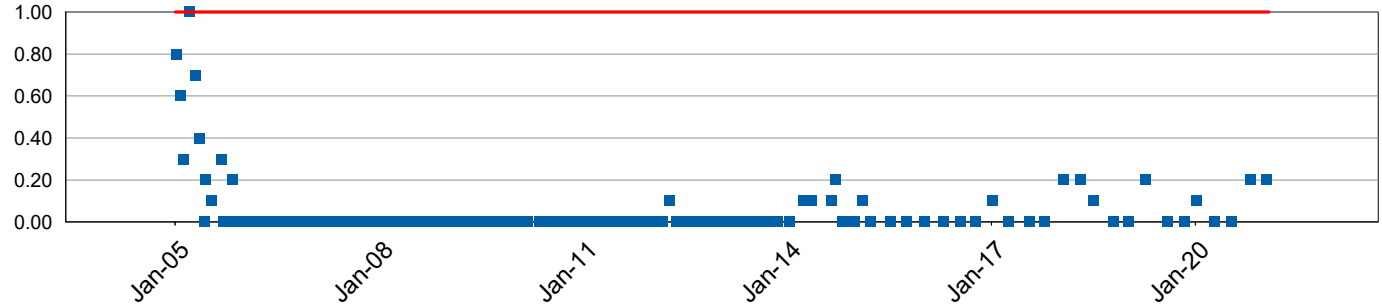
Methane (% v/v)
WH/BH49/2



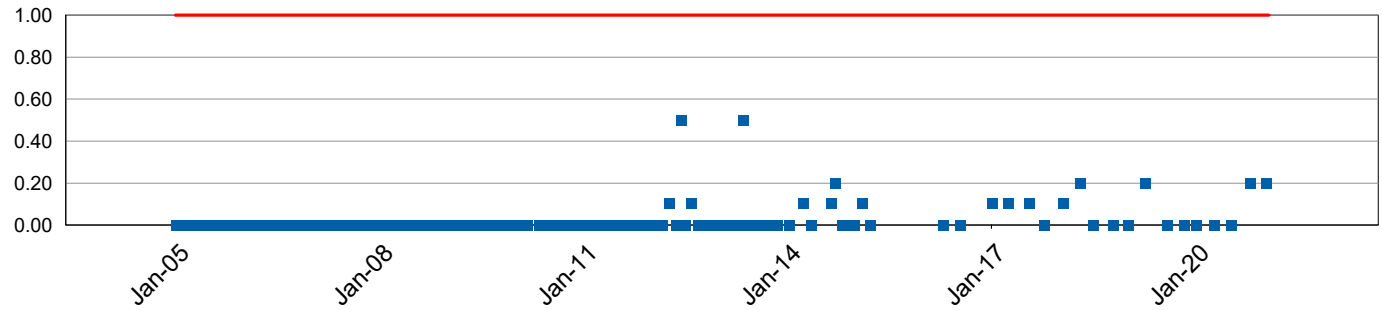
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

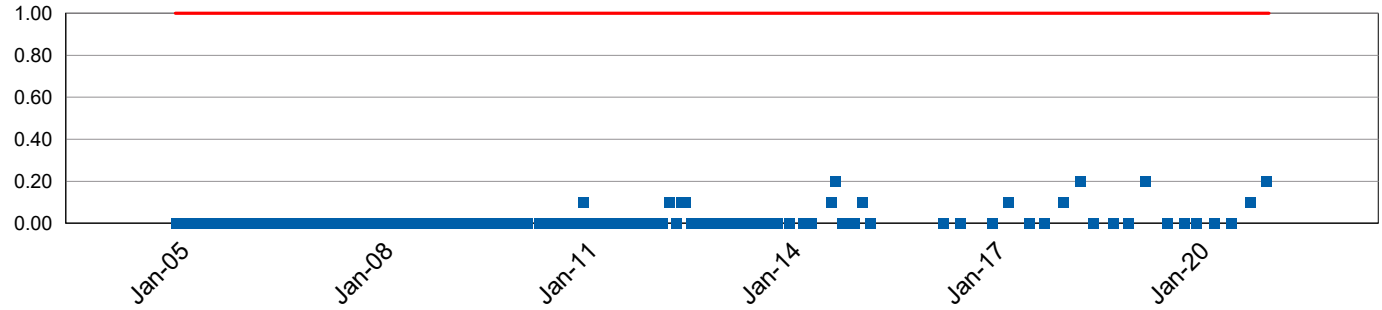
Methane (% v/v)
WH/BH49/3



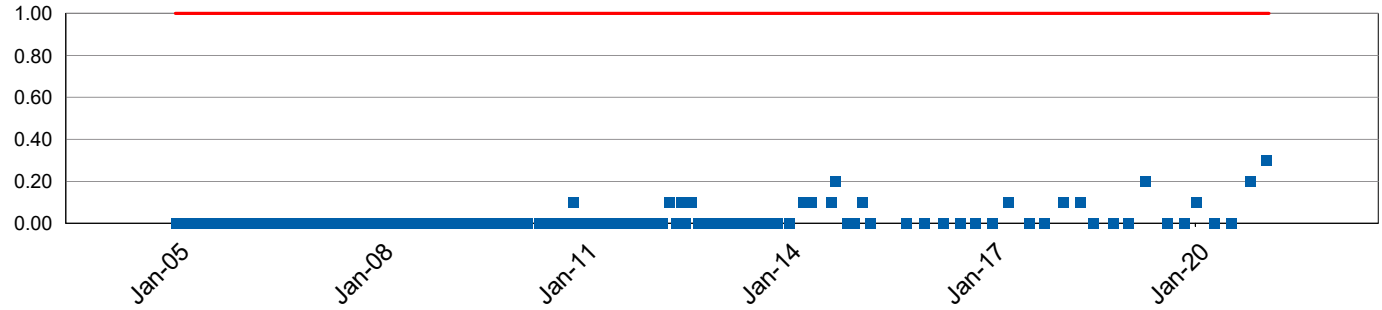
Methane (% v/v)
WH/BH50/1



Methane (% v/v)
WH/BH50/2



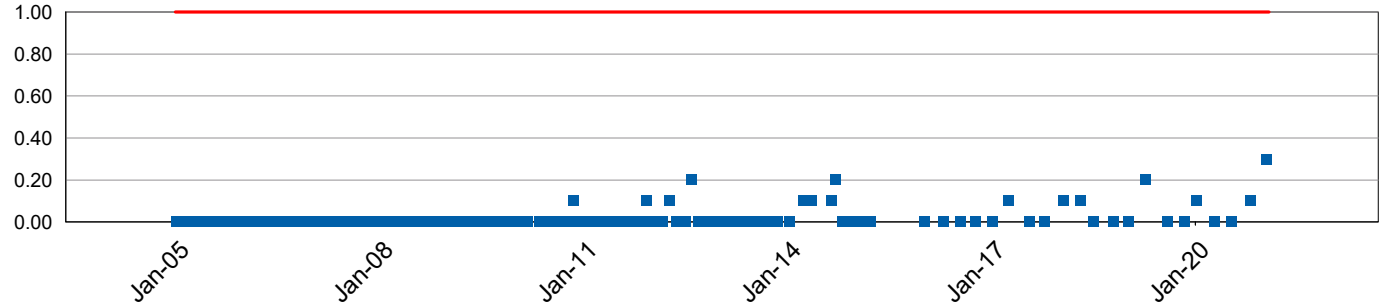
Methane (% v/v)
WH/BH51/1



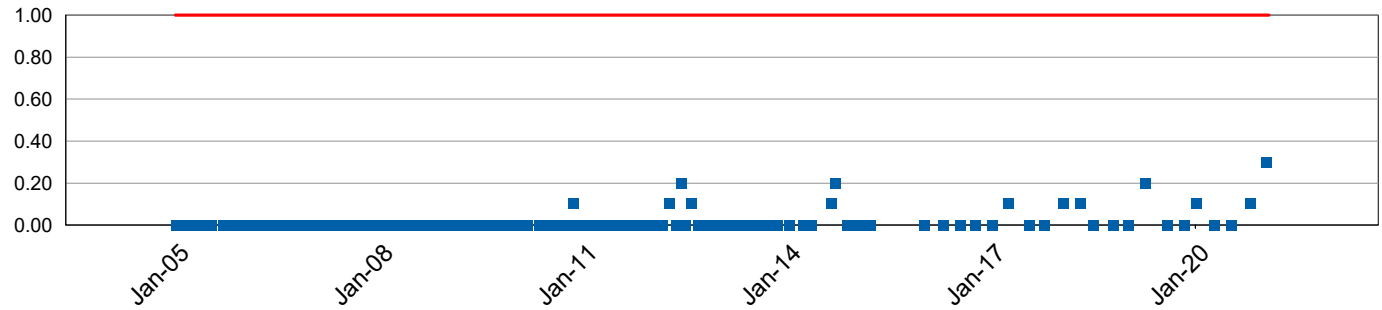
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

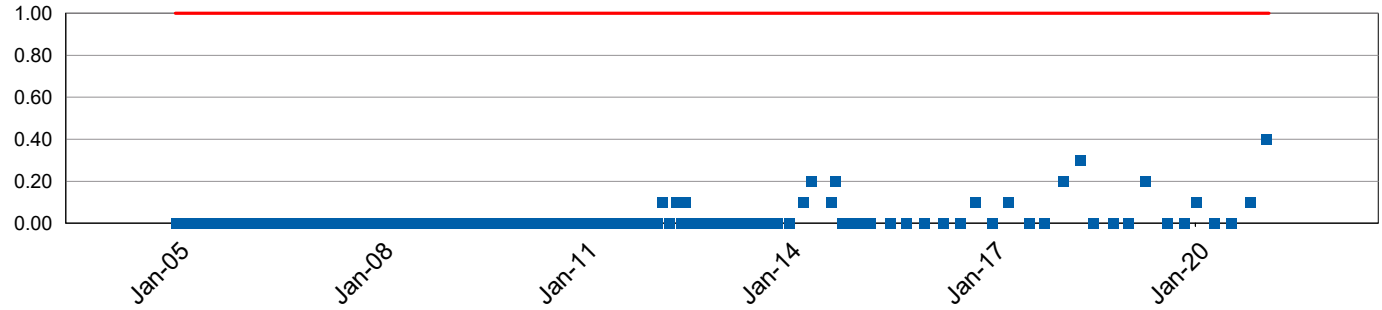
Methane (% v/v)
WH/BH51/2



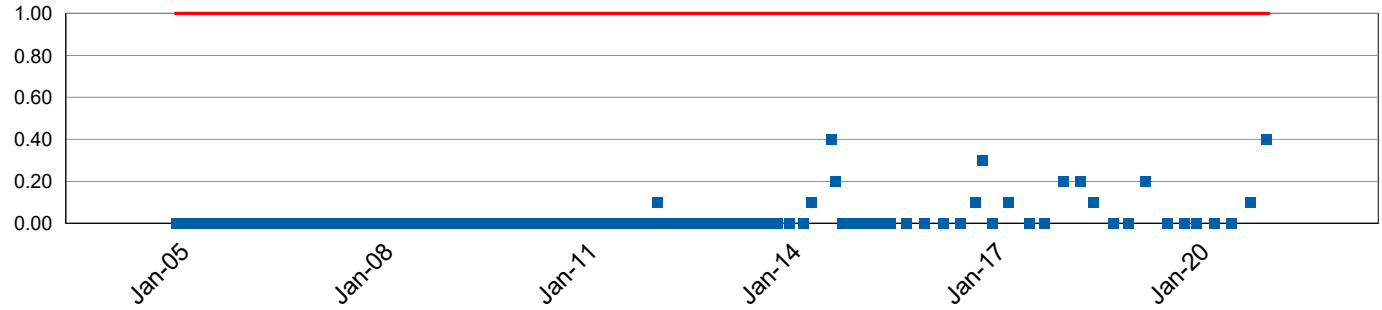
Methane (% v/v)
WH/BH51/3



Methane (% v/v)
WH/BH52/1



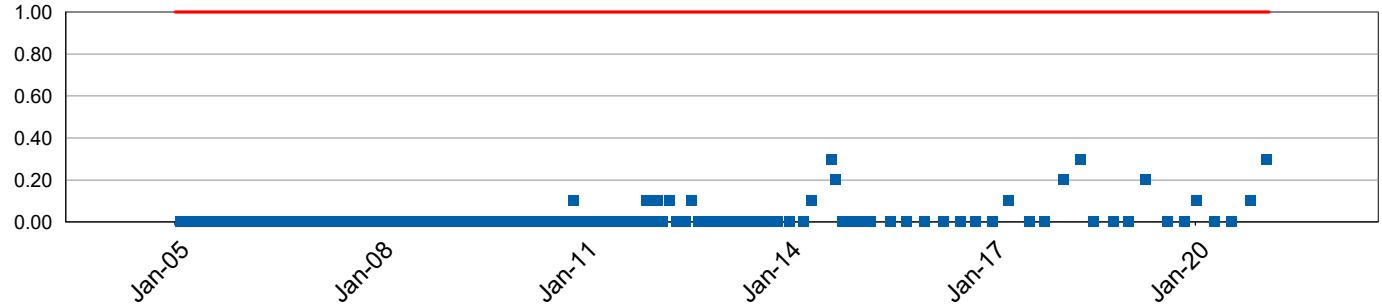
Methane (% v/v)
WH/BH52/2



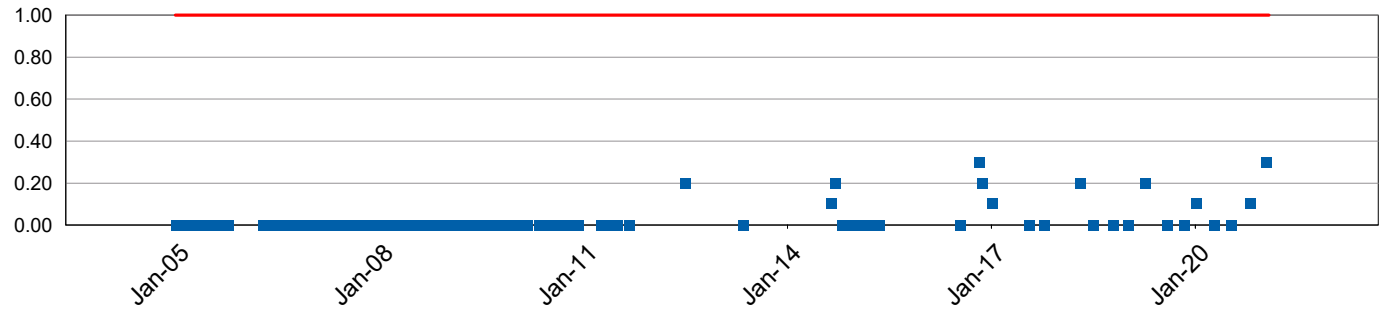
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

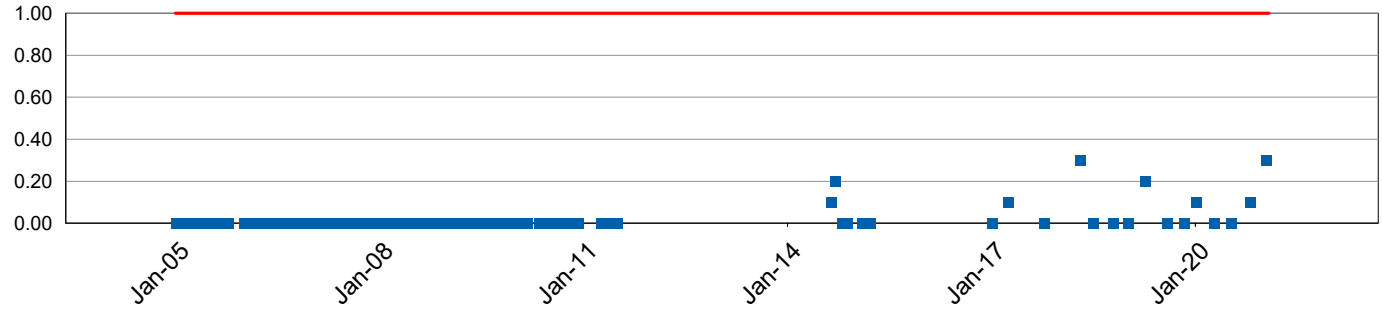
Methane (% v/v)
WH/BH52/3



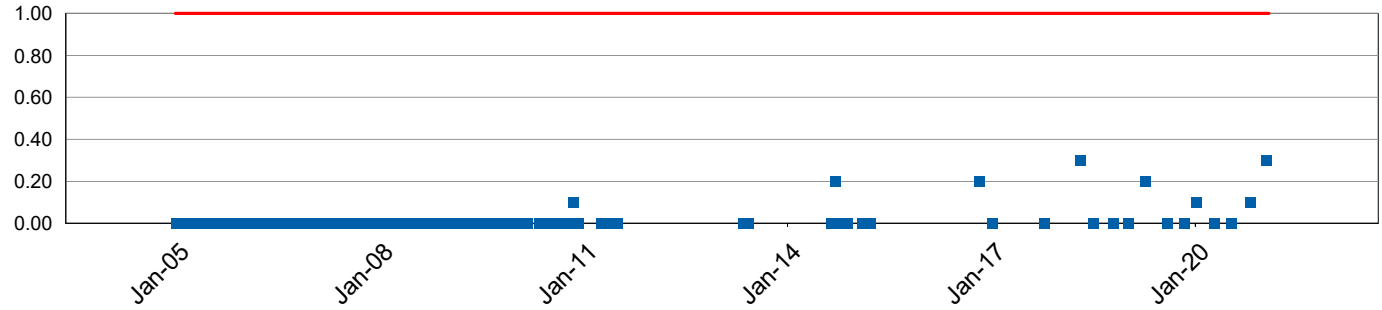
Methane (% v/v)
WH/BH53/1



Methane (% v/v)
WH/BH53/2



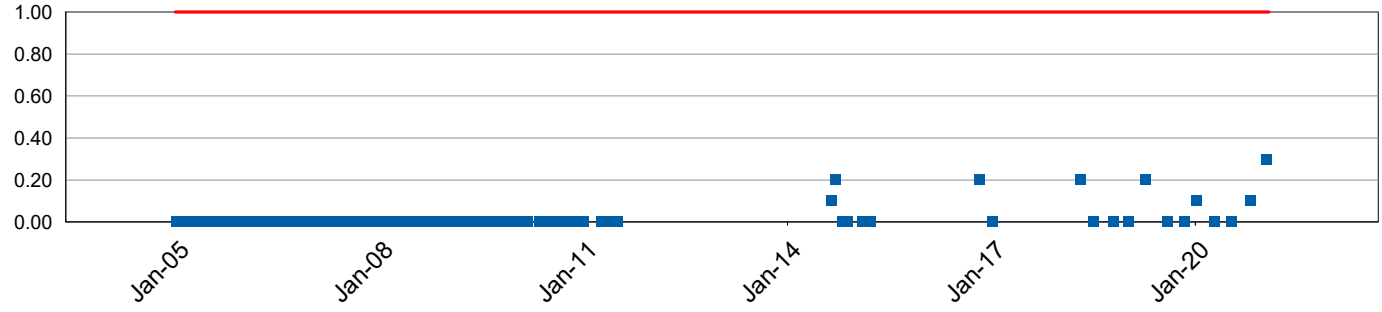
Methane (% v/v)
WH/BH53/3



Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

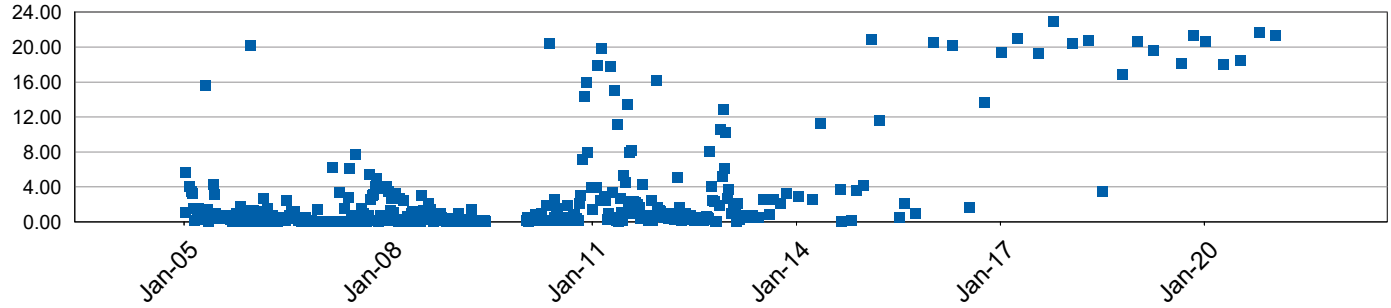
Methane (% v/v)
WH/BH53/4



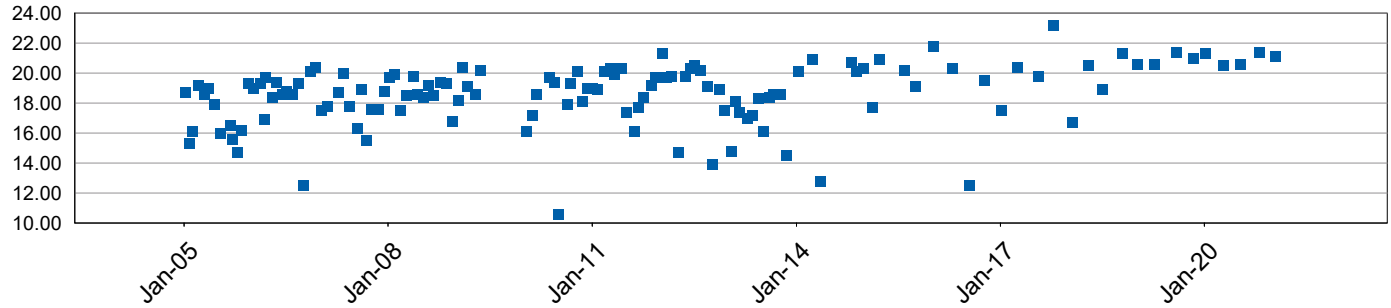
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

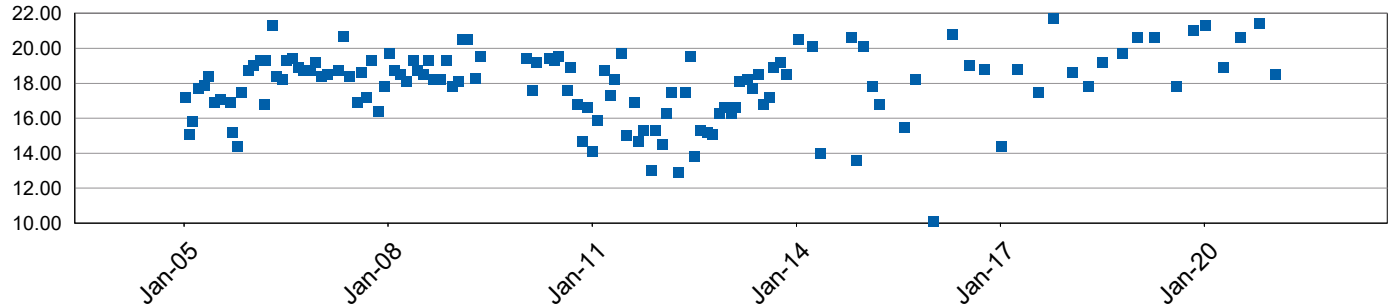
Oxygen (% v/v)
WH/BH13A



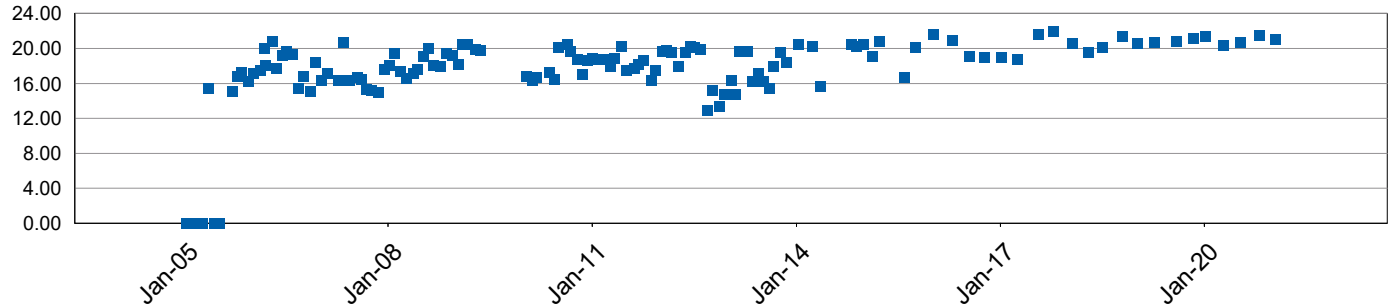
Oxygen (% v/v)
WH/BH2/1



Oxygen (% v/v)
WH/BH2/2



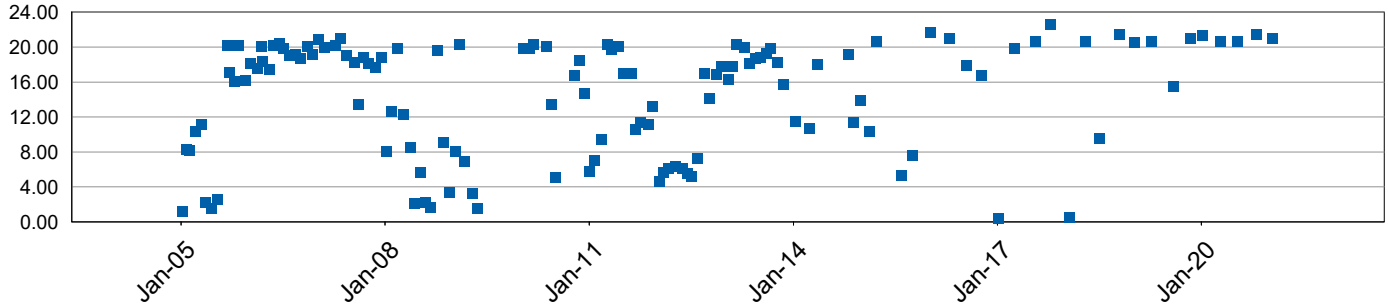
Oxygen (% v/v)
WH/BH2/3



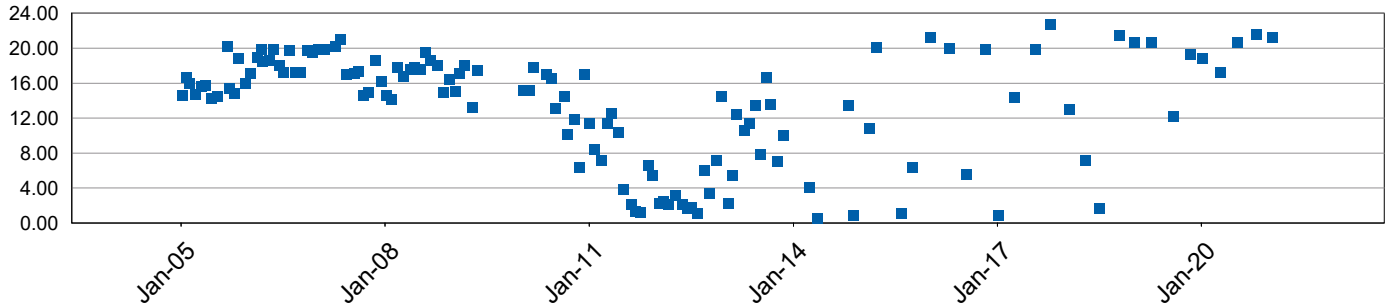
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

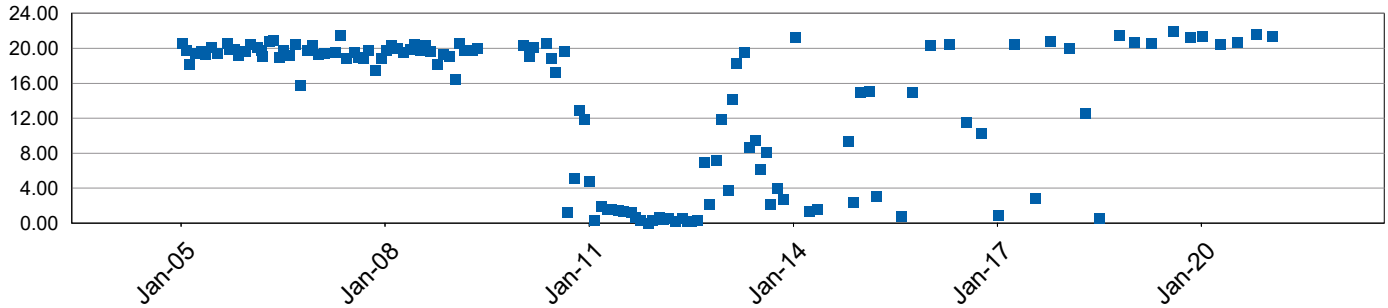
Oxygen (% v/v)
WH/BH2/4



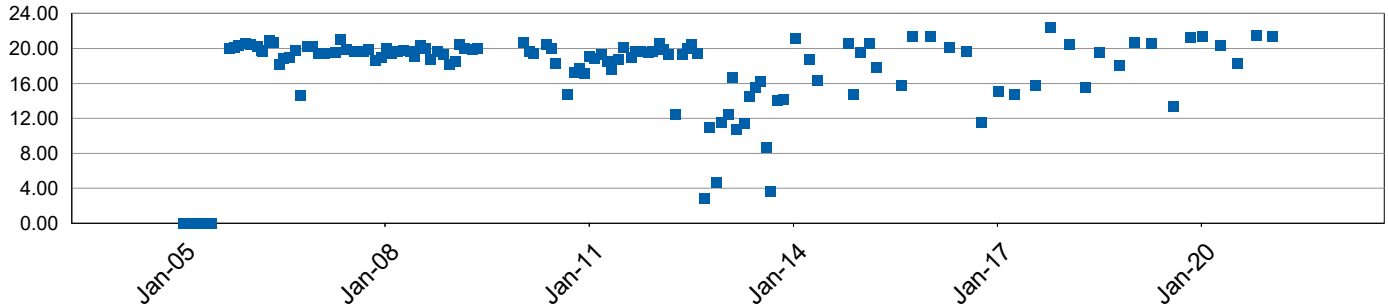
Oxygen (% v/v)
WH/BH2/5



Oxygen (% v/v)
WH/BH3/1



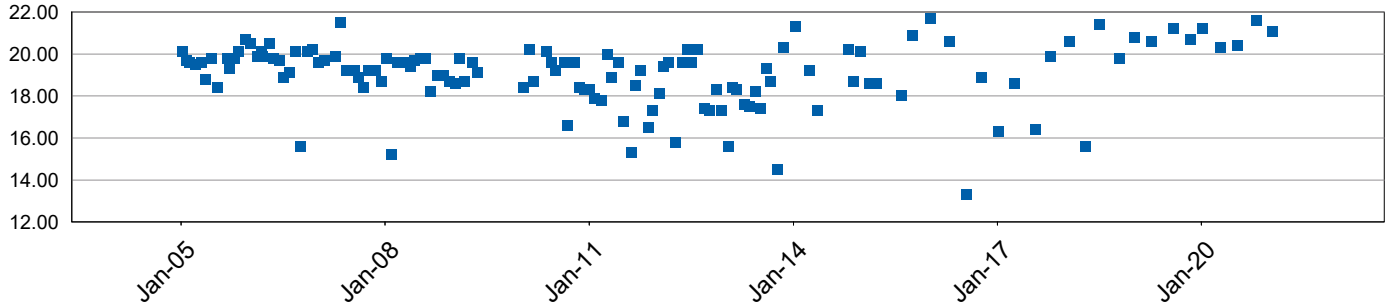
Oxygen (% v/v)
WH/BH3/2



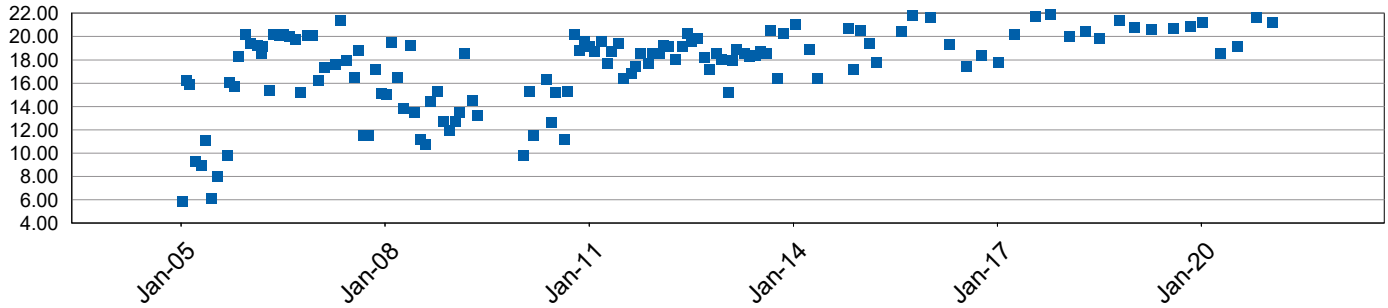
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

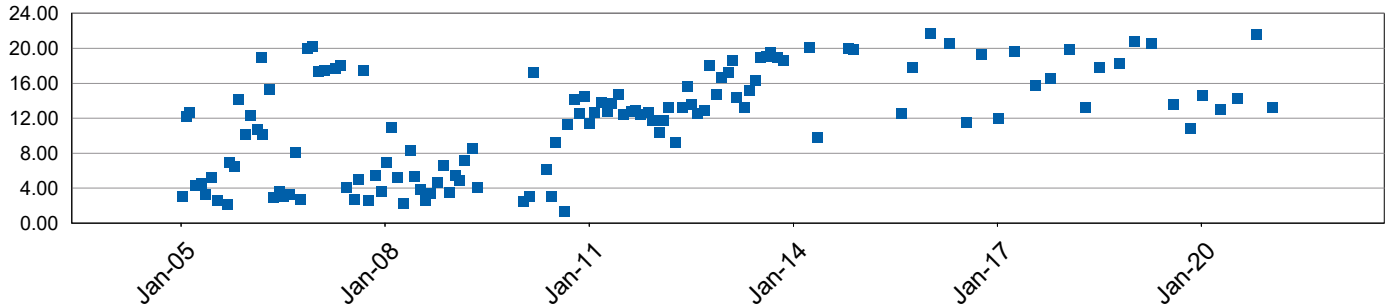
Oxygen (% v/v)
WH/BH3/3



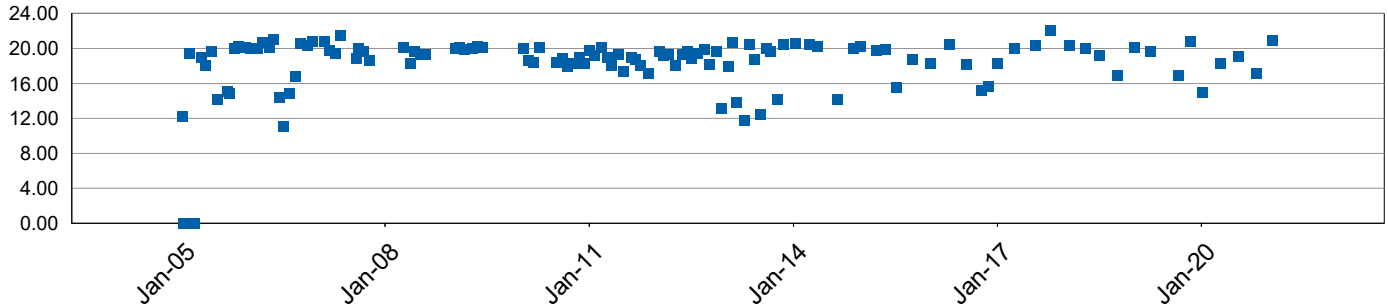
Oxygen (% v/v)
WH/BH3/4



Oxygen (% v/v)
WH/BH3/5



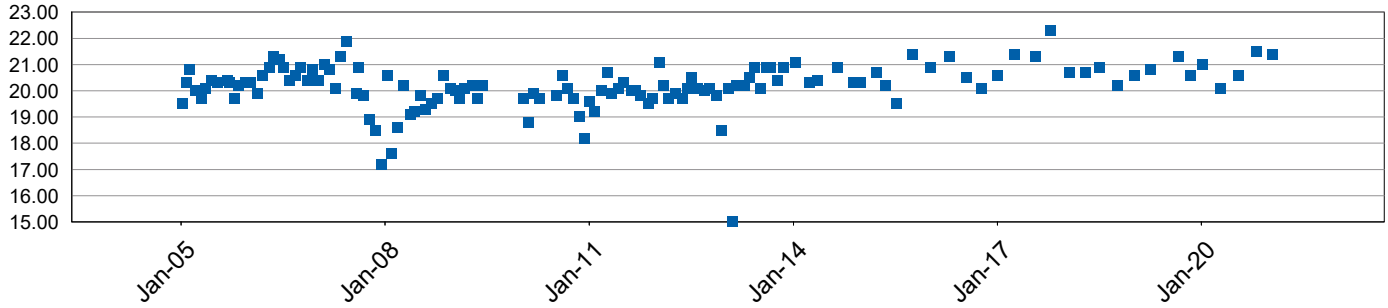
Oxygen (% v/v)
WH/BH34



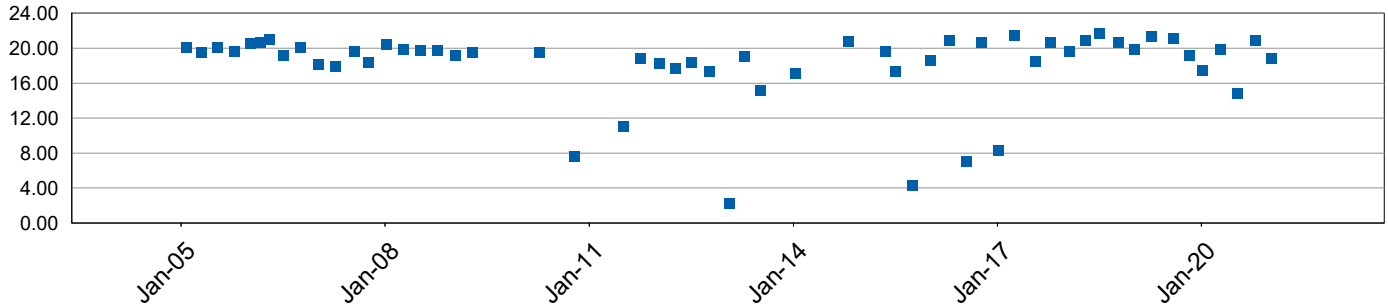
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

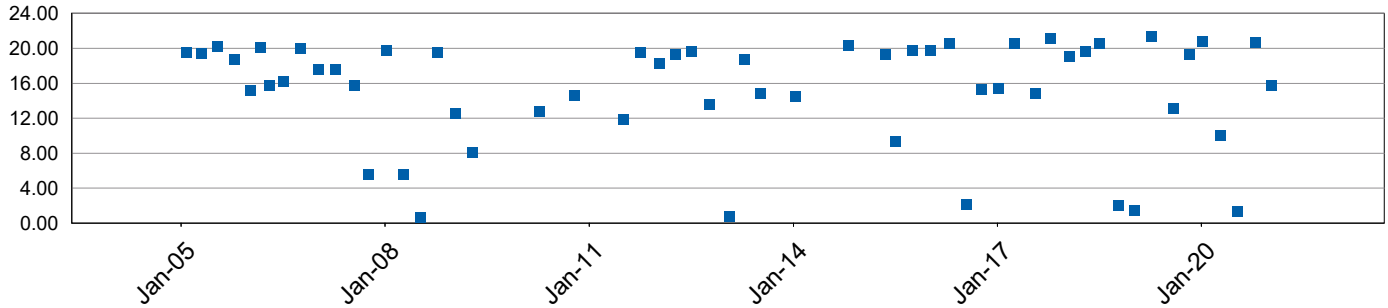
Oxygen (% v/v)
WH/BH35



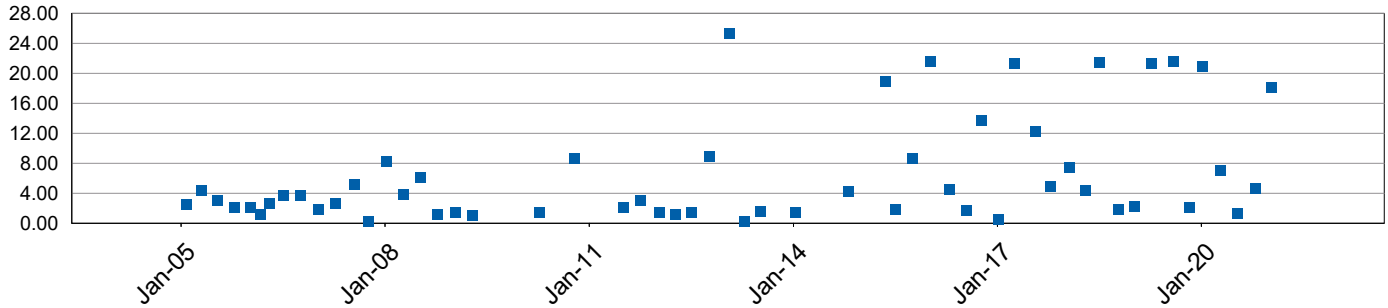
Oxygen (% v/v)
WH/BH45/1



Oxygen (% v/v)
WH/BH45/2



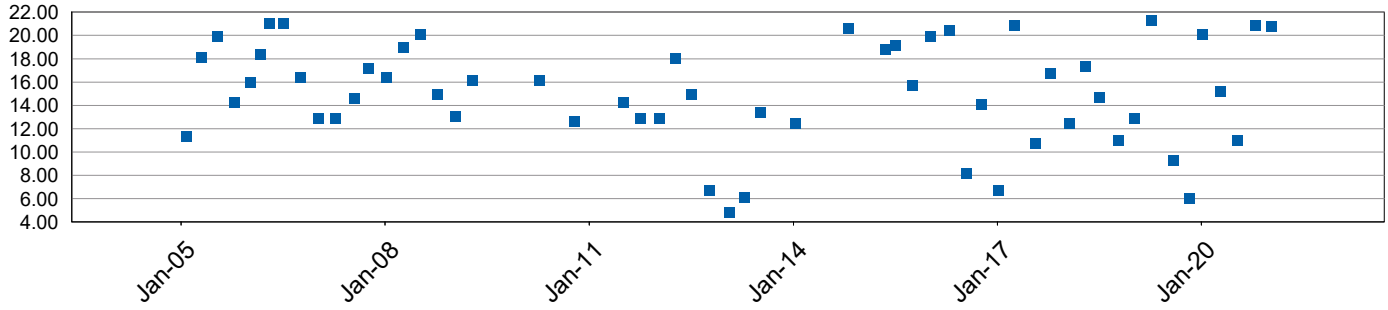
Oxygen (% v/v)
WH/BH45/3



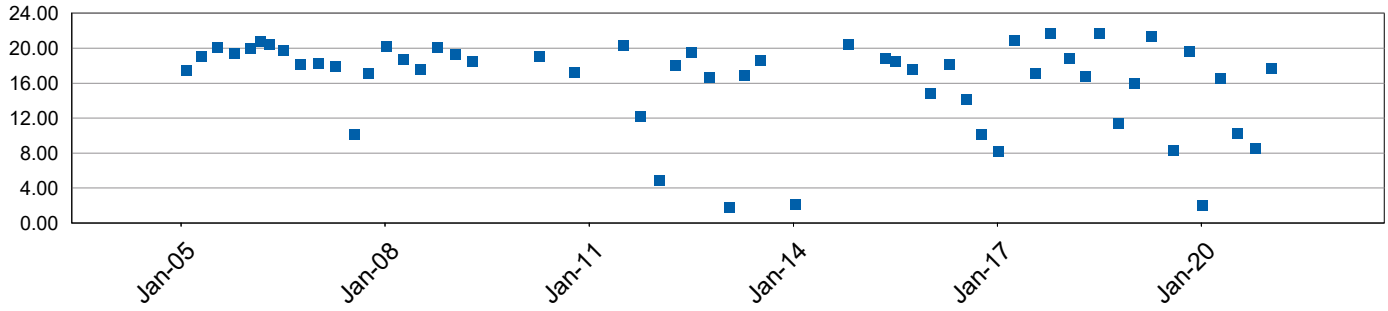
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

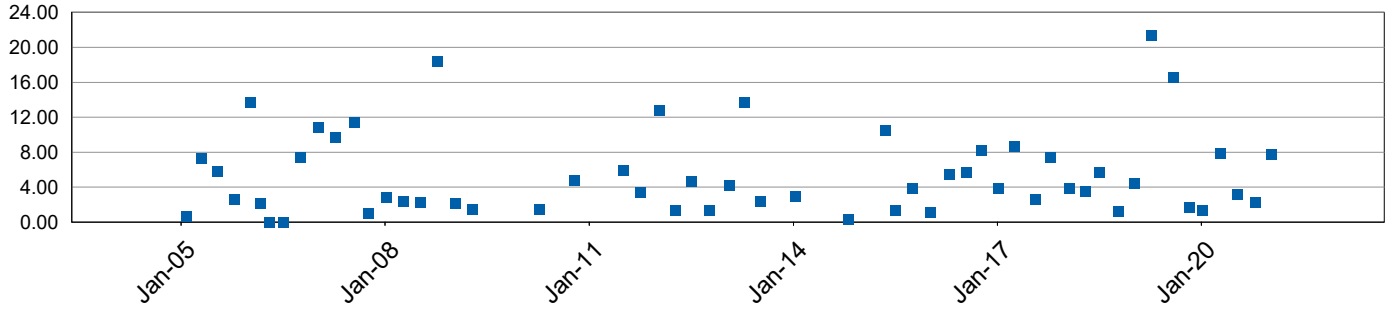
Oxygen (% v/v)
WH/BH45/4



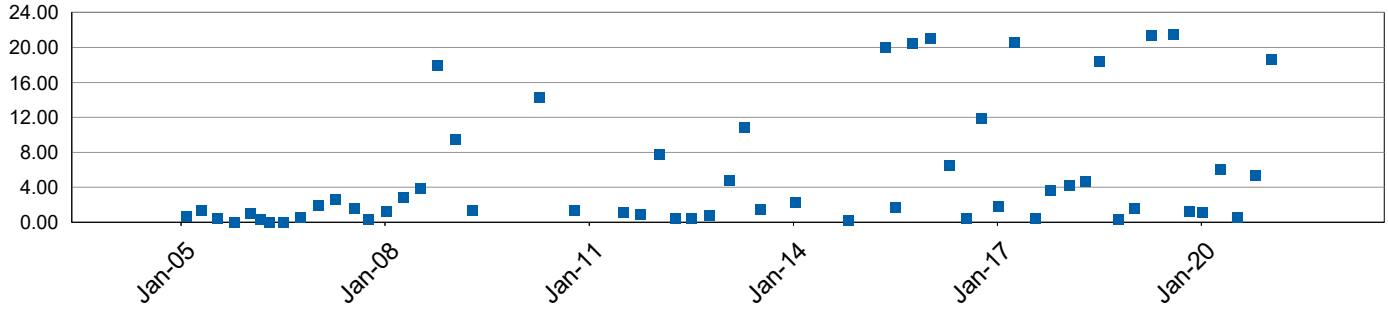
Oxygen (% v/v)
WH/BH46/1



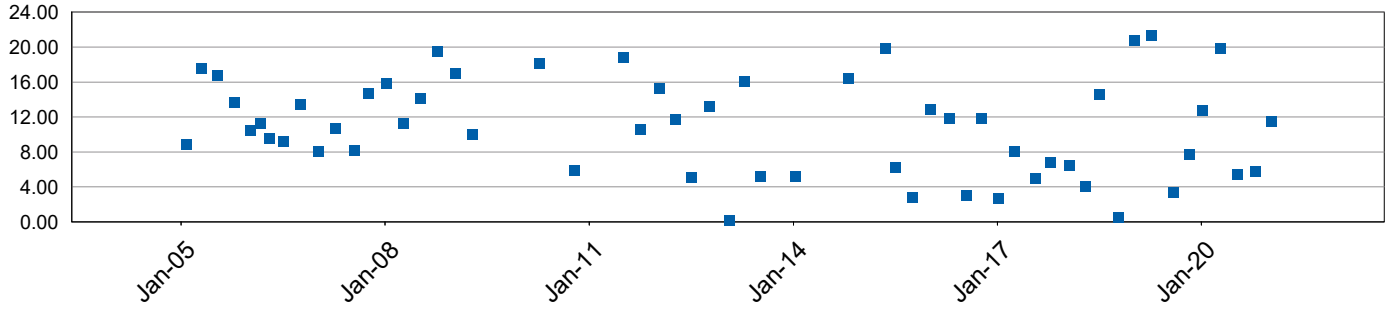
Oxygen (% v/v)
WH/BH46/2



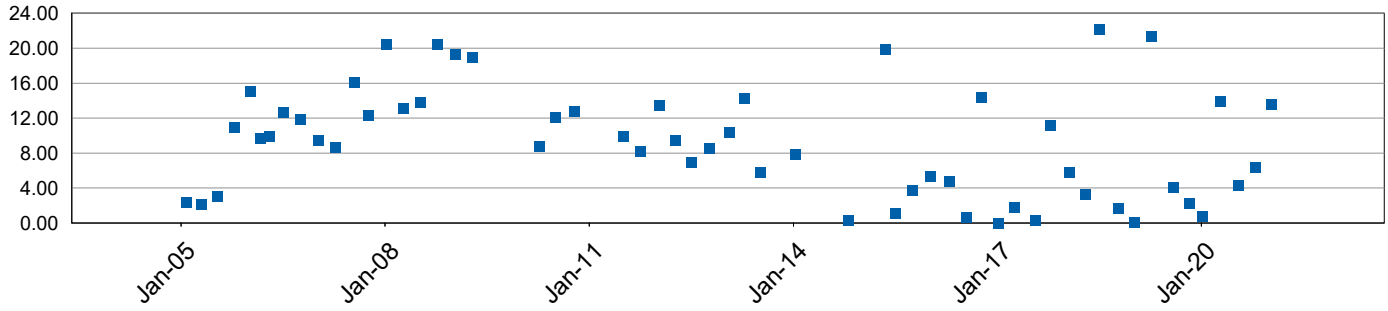
Oxygen (% v/v)
WH/BH46/3



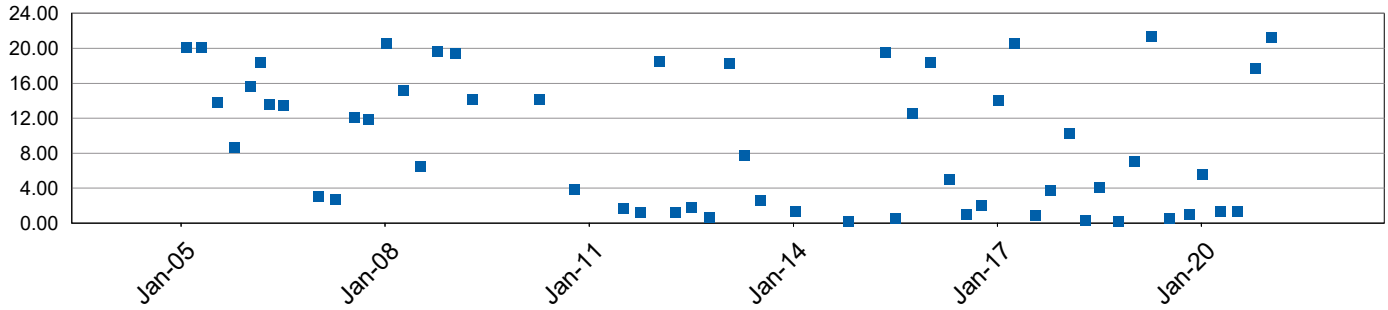
Oxygen (% v/v)
WH/BH46/4



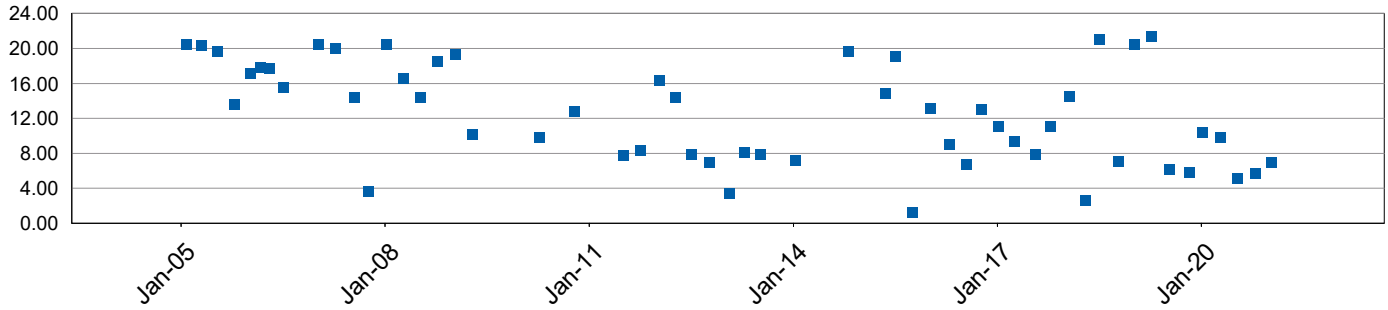
Oxygen (% v/v)
WH/BH47



Oxygen (% v/v)
WH/BH48/1



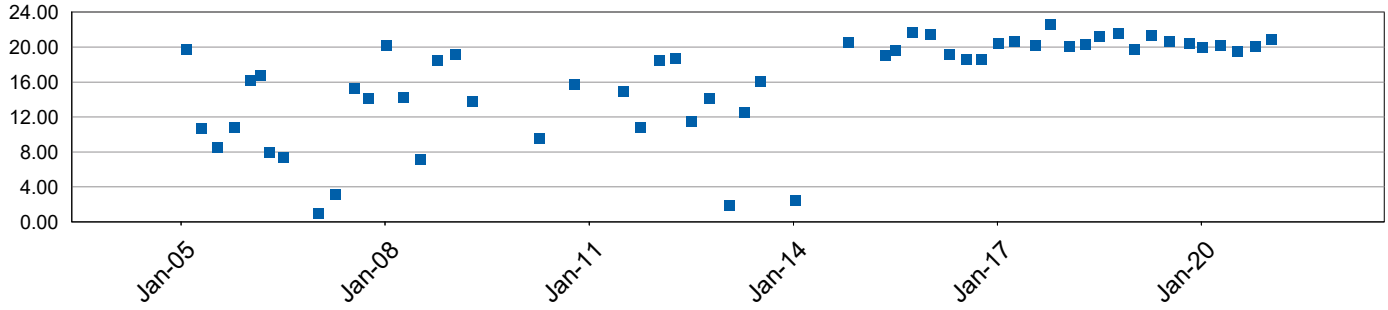
Oxygen (% v/v)
WH/BH48/2



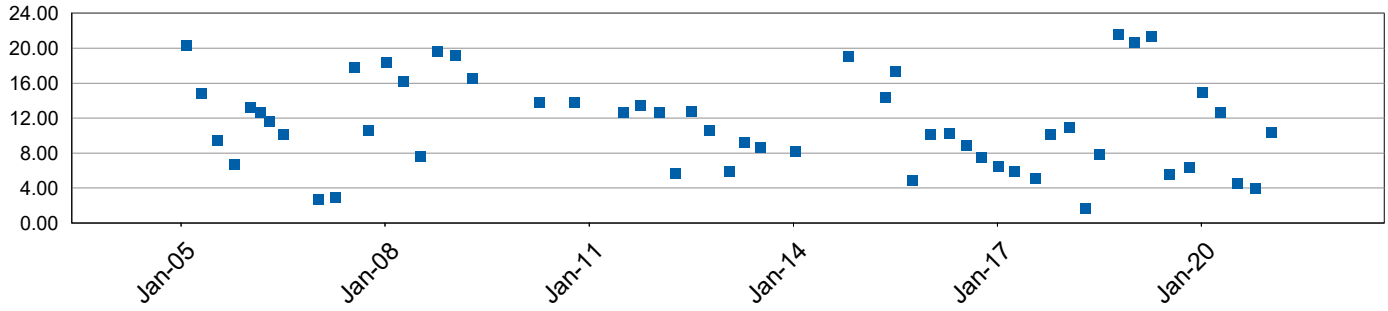
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

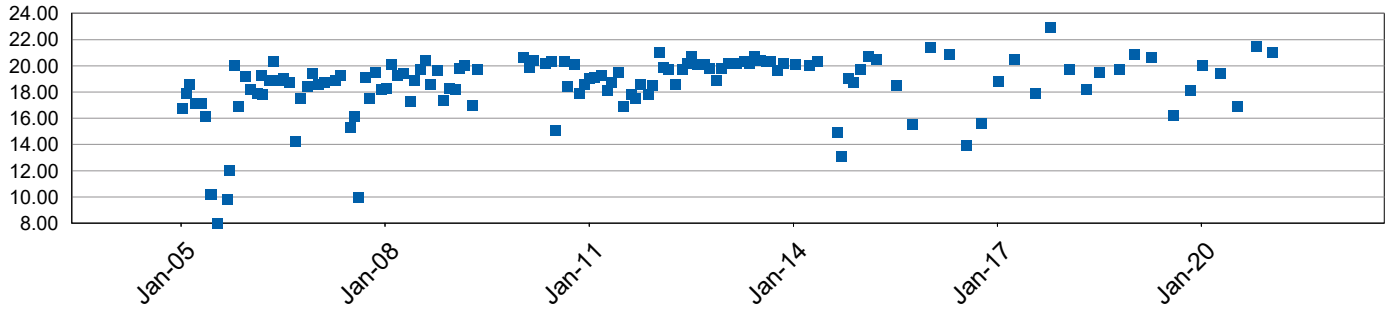
Oxygen (% v/v)
WH/BH48/3



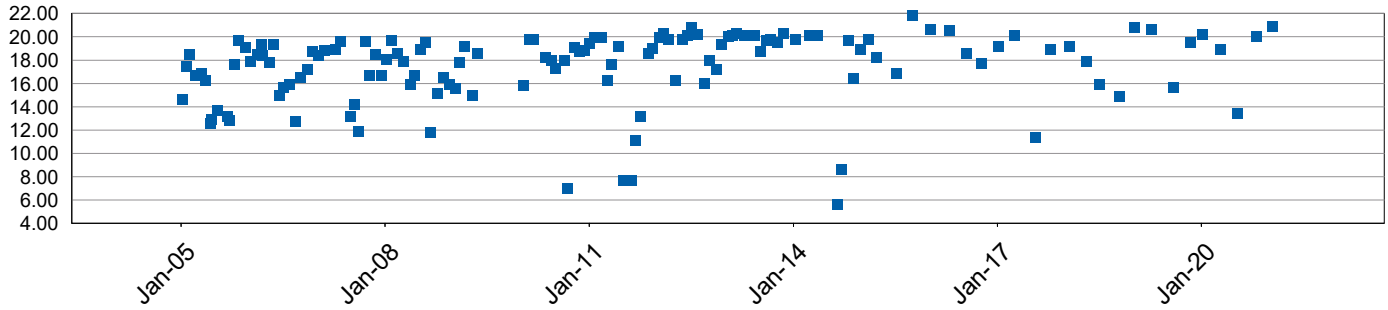
Oxygen (% v/v)
WH/BH48/4



Oxygen (% v/v)
WH/BH49/1



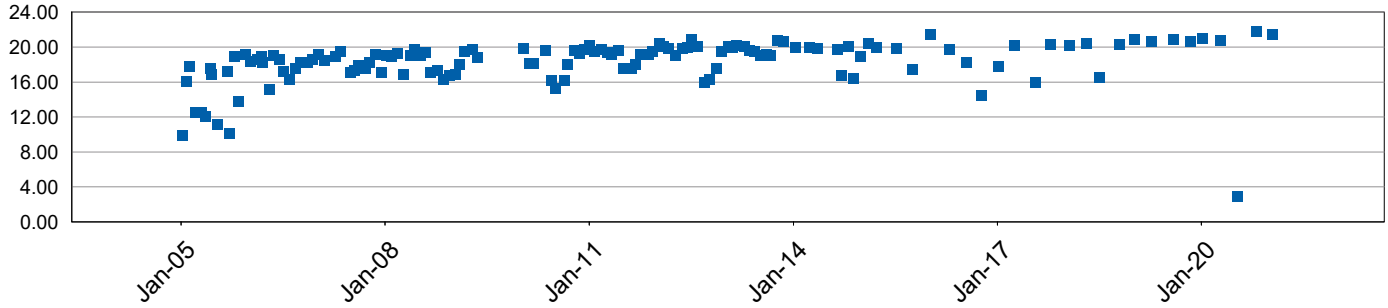
Oxygen (% v/v)
WH/BH49/2



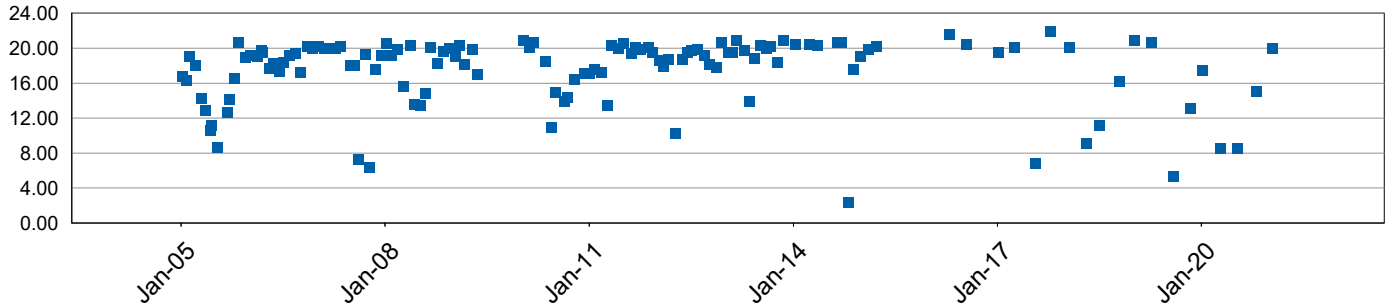
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

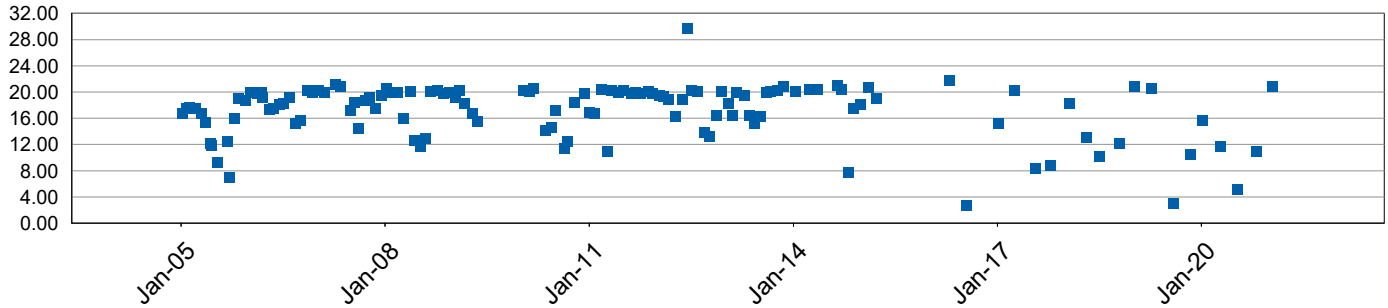
Oxygen (% v/v)
WH/BH49/3



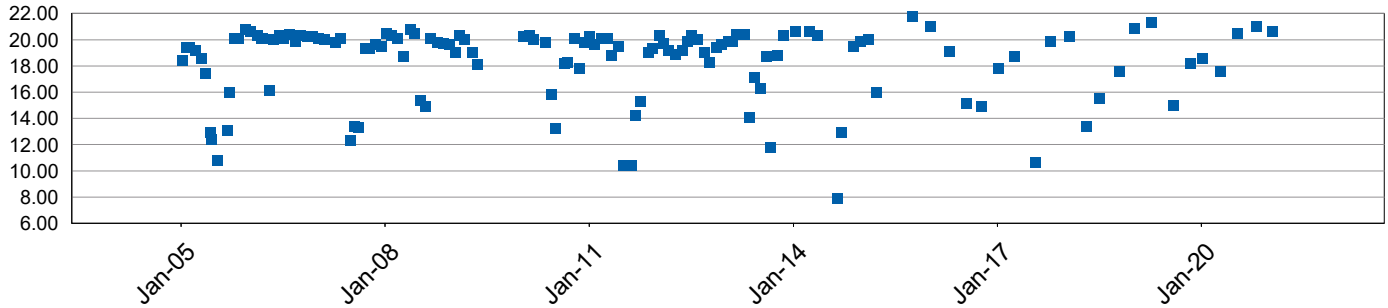
Oxygen (% v/v)
WH/BH50/1



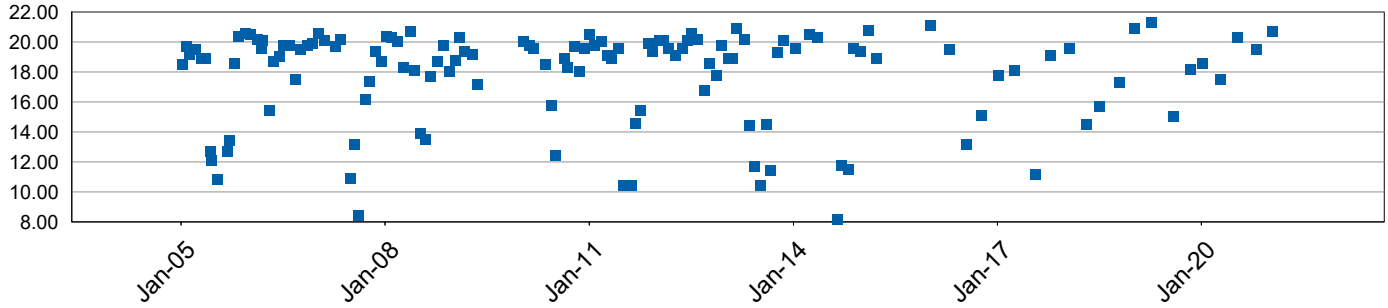
Oxygen (% v/v)
WH/BH50/2



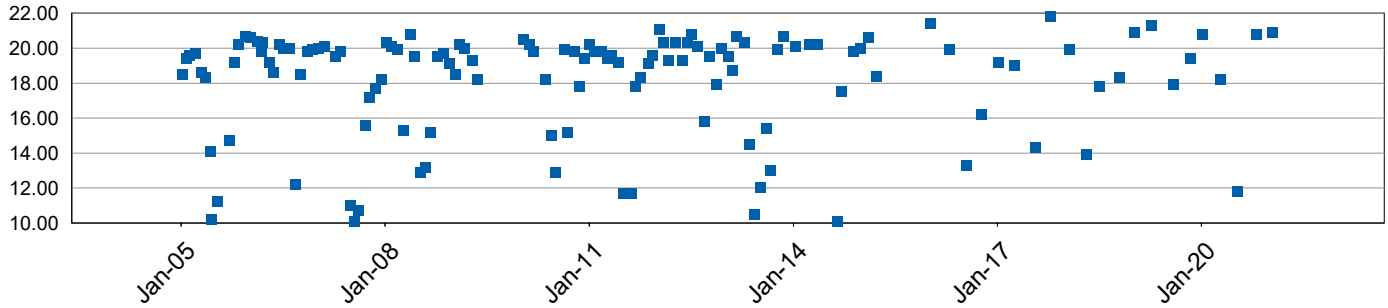
Oxygen (% v/v)
WH/BH51/1



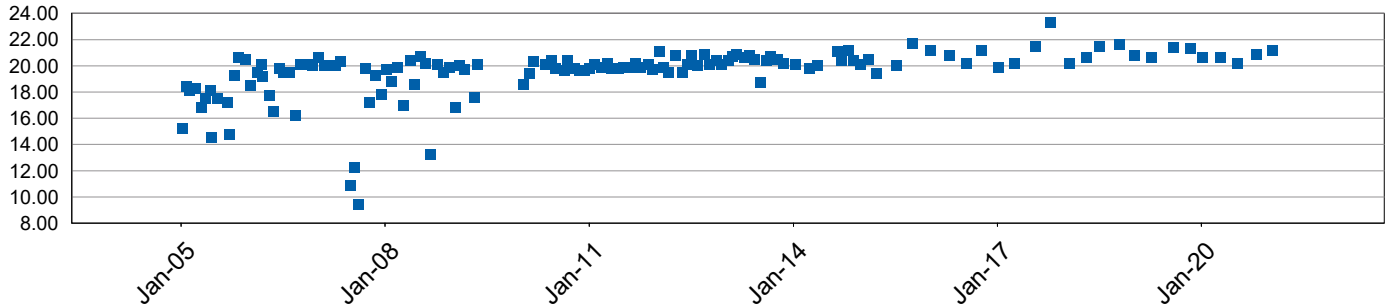
Oxygen (% v/v)
WH/BH51/2



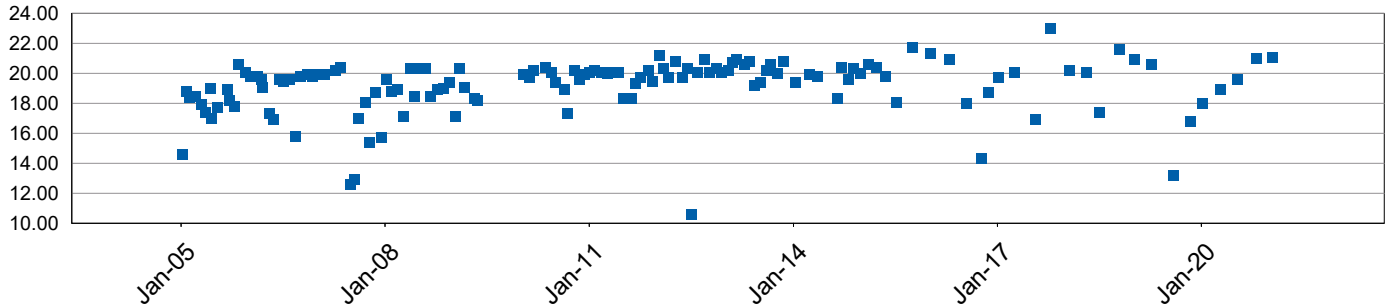
Oxygen (% v/v)
WH/BH51/3



Oxygen (% v/v)
WH/BH52/1



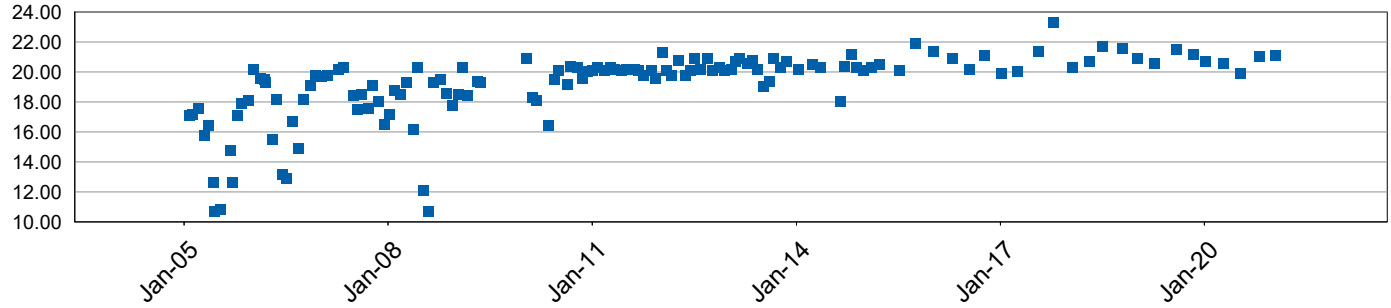
Oxygen (% v/v)
WH/BH52/2



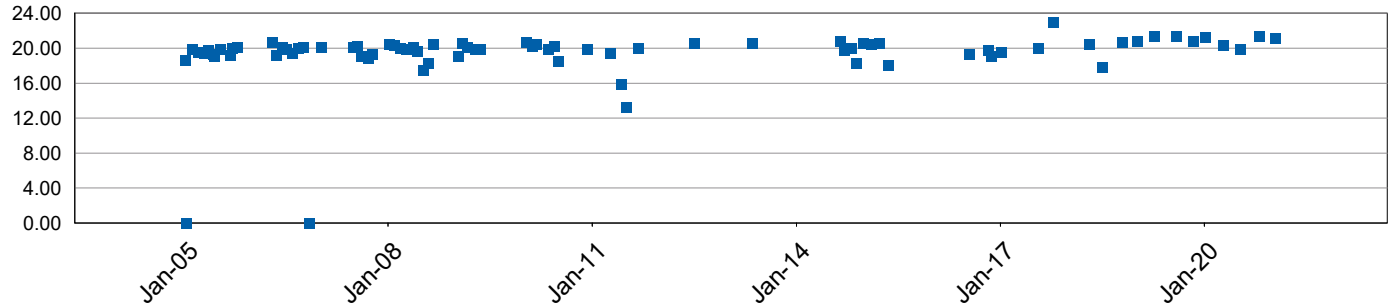
Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

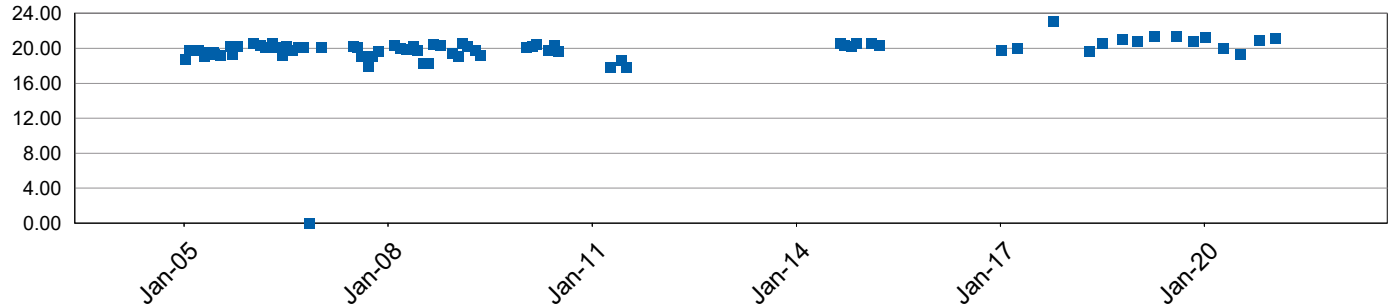
Oxygen (% v/v)
WH/BH52/3



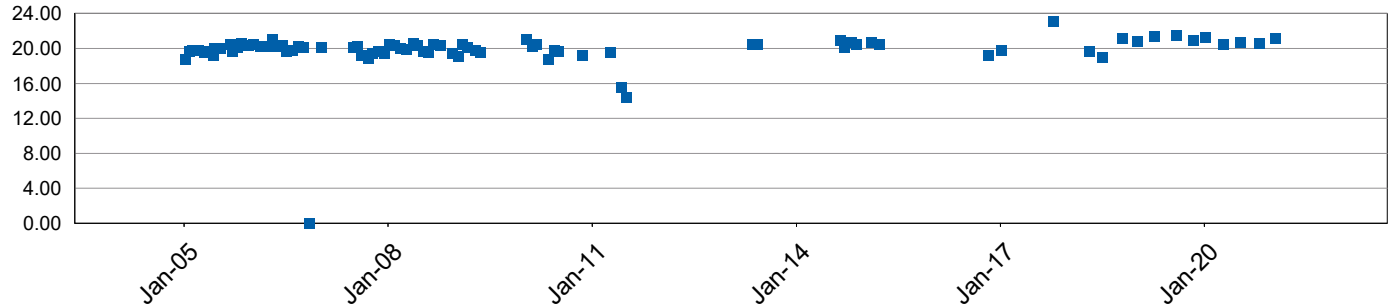
Oxygen (% v/v)
WH/BH53/1



Oxygen (% v/v)
WH/BH53/2



Oxygen (% v/v)
WH/BH53/3



Whinney Hill - Whinney Hill P1 Perimeter Gas Points

01/02/2005 to 28/02/2021

Oxygen (% v/v)
WH/BH53/4

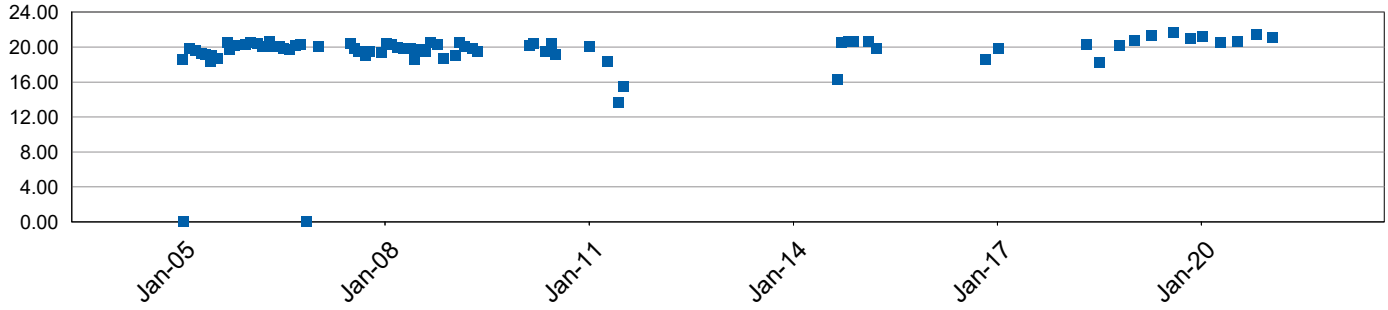
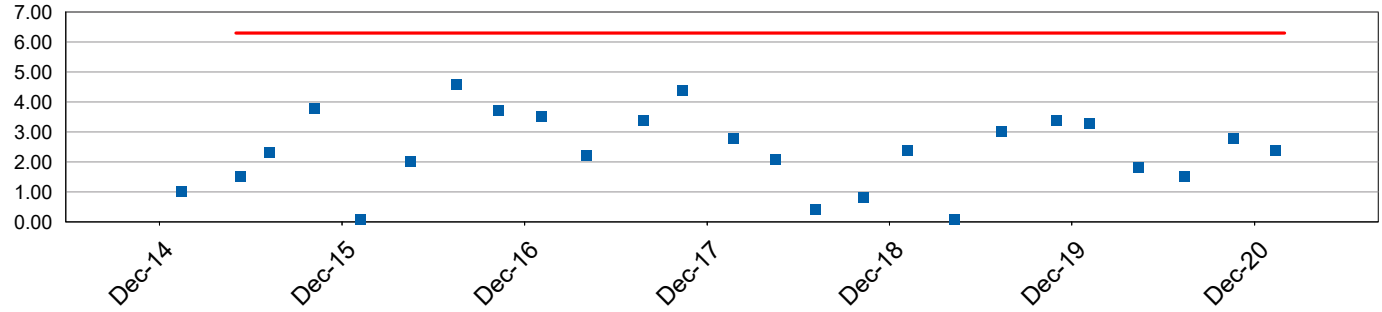


Figure 4. Carbon Dioxide and Methane Plots for Boreholes Within Phase 2

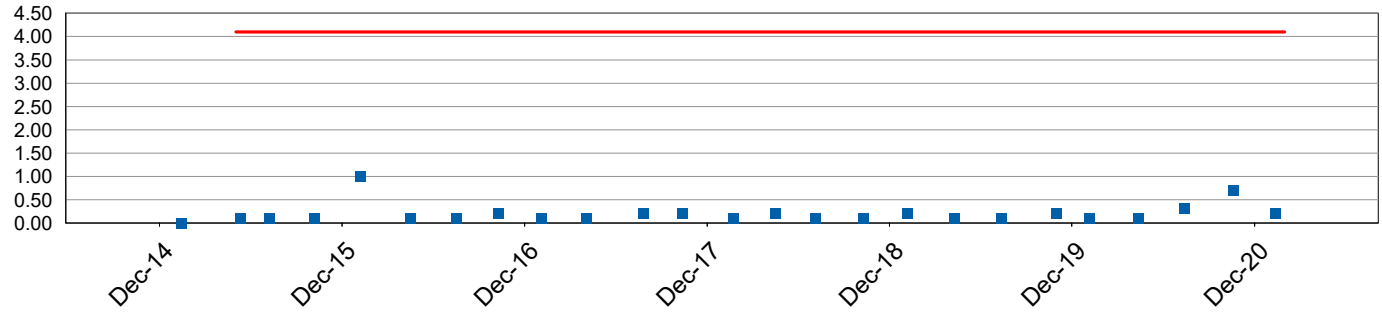
Whinney Hill - Whinney Hill P2 Perimeter Gas Points

01/01/2015 to 28/02/2021

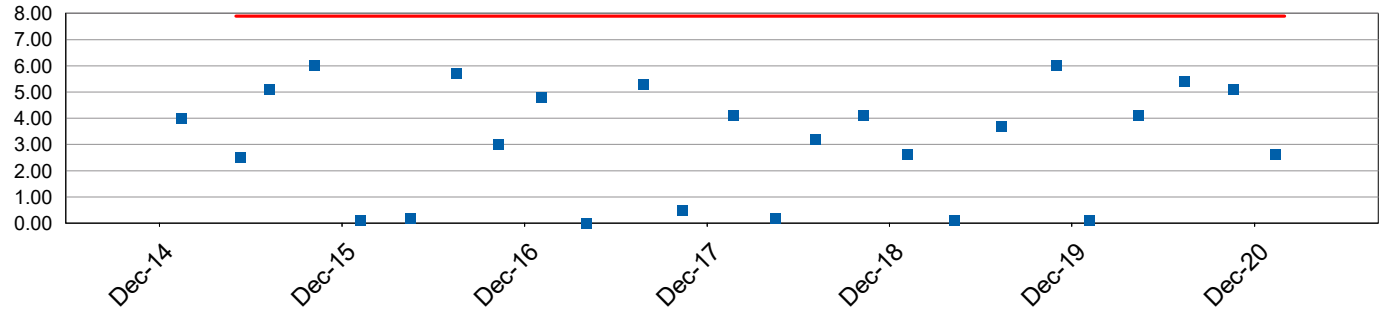
Carbon Dioxide (% v/v)
WH/BH65



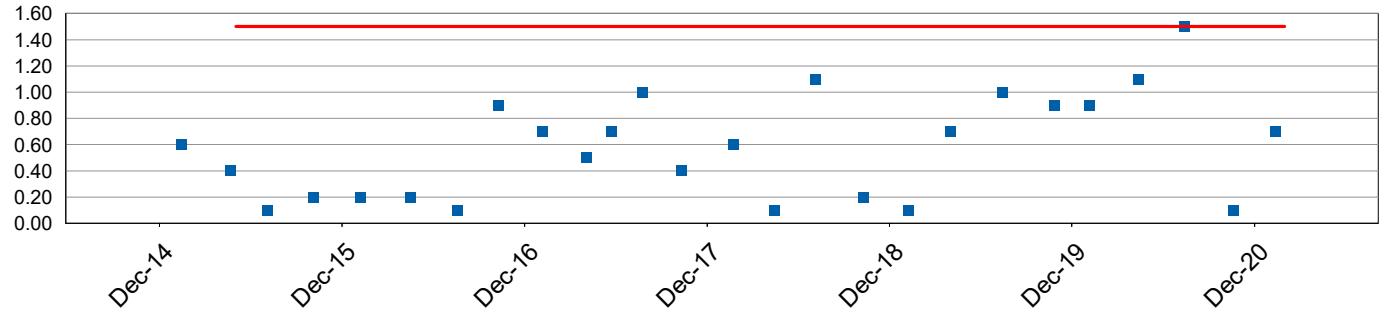
Carbon Dioxide (% v/v)
WH/BH66



Carbon Dioxide (% v/v)
WH/BH67



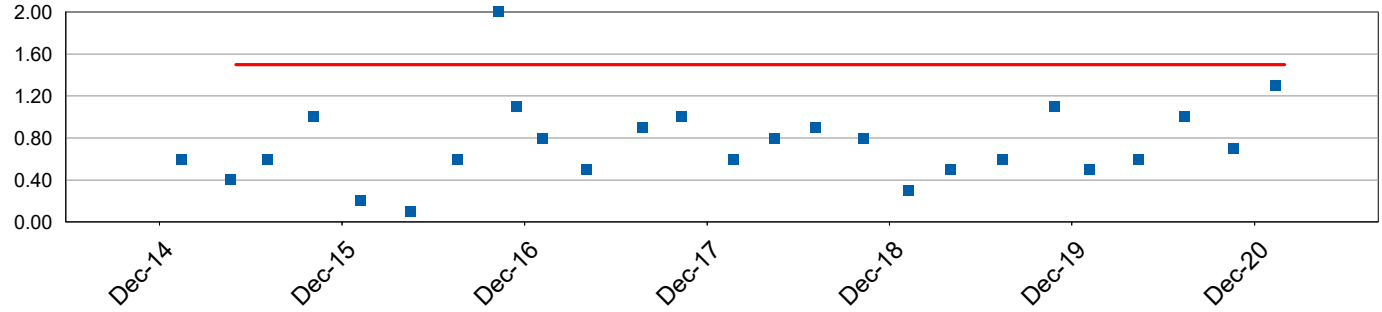
Carbon Dioxide (% v/v)
WH/BH68A



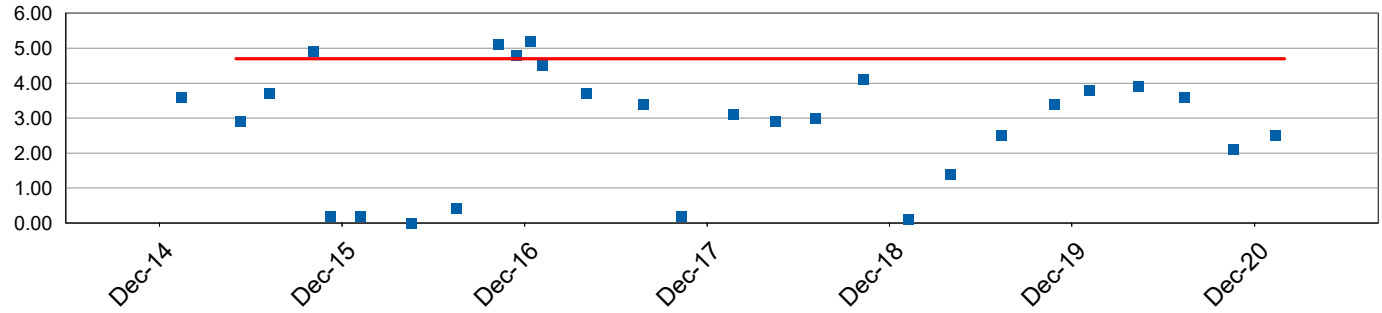
Whinney Hill - Whinney Hill P2 Perimeter Gas Points

01/01/2015 to 28/02/2021

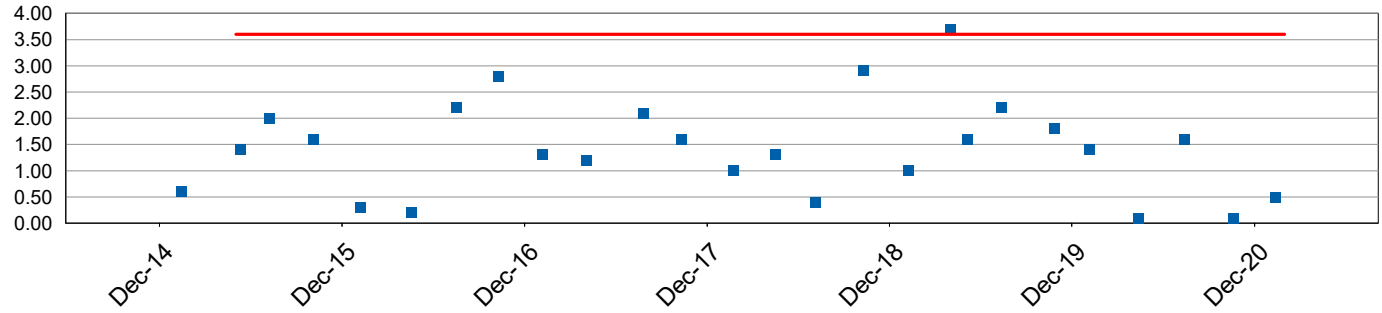
Carbon Dioxide (% v/v)
WH/BH68B



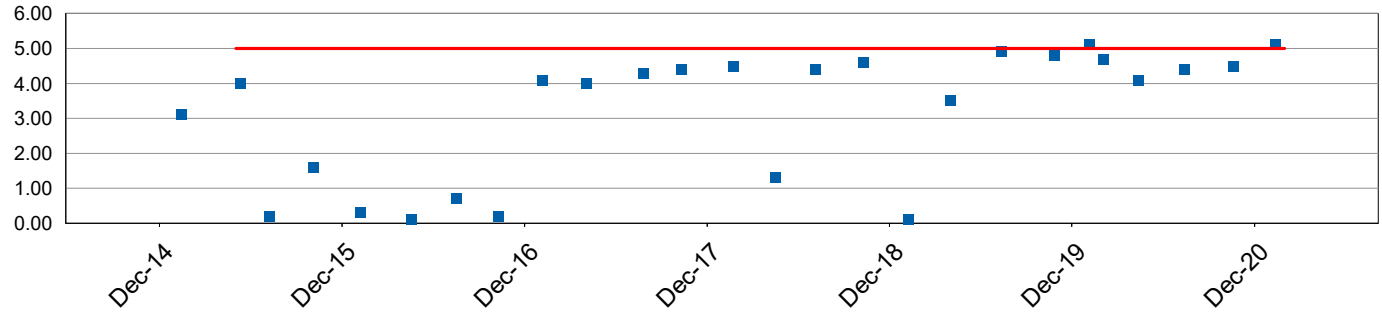
Carbon Dioxide (% v/v)
WH/BH69



Carbon Dioxide (% v/v)
WH/BH70



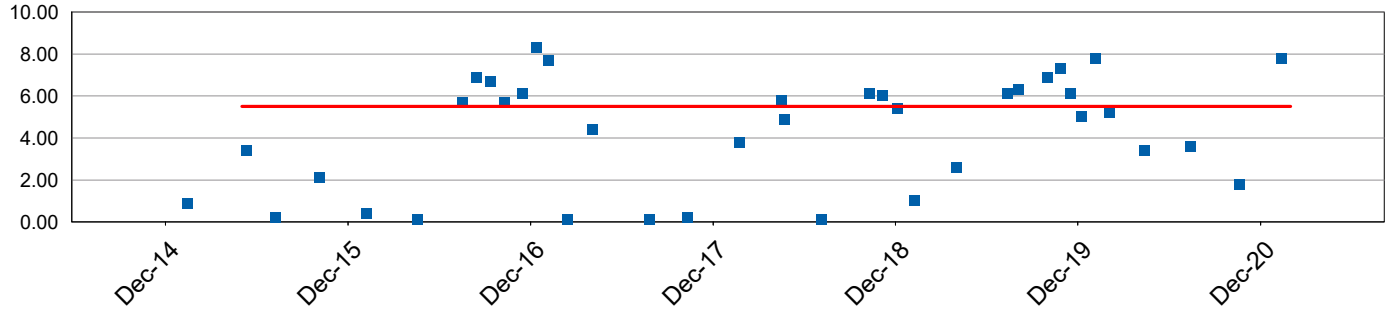
Carbon Dioxide (% v/v)
WH/BH71



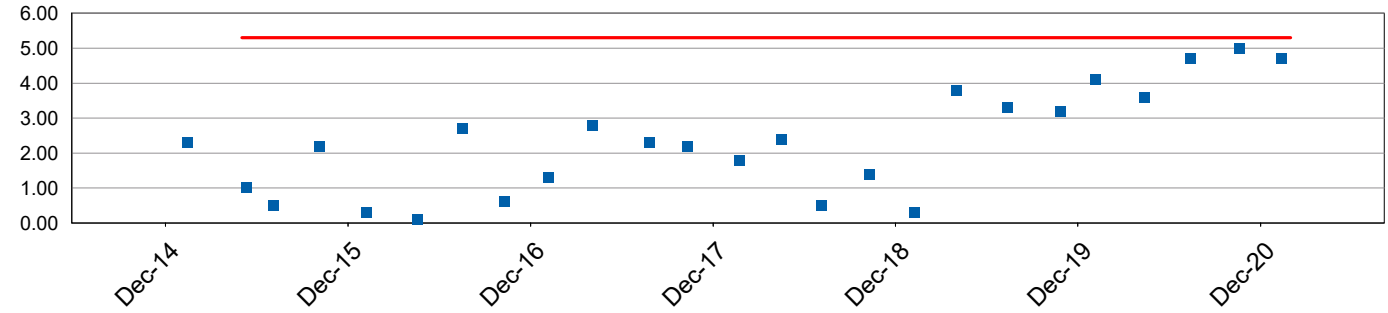
Whinney Hill - Whinney Hill P2 Perimeter Gas Points

01/01/2015 to 28/02/2021

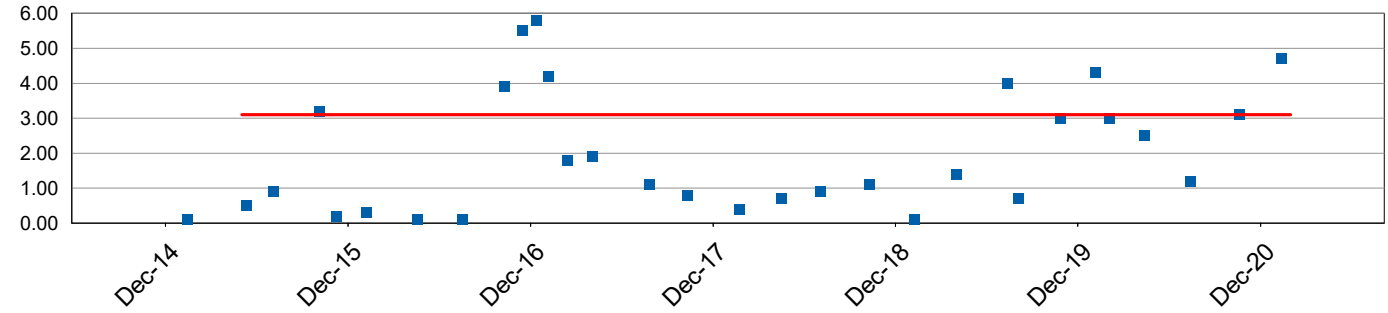
Carbon Dioxide (% v/v)
WH/BH72



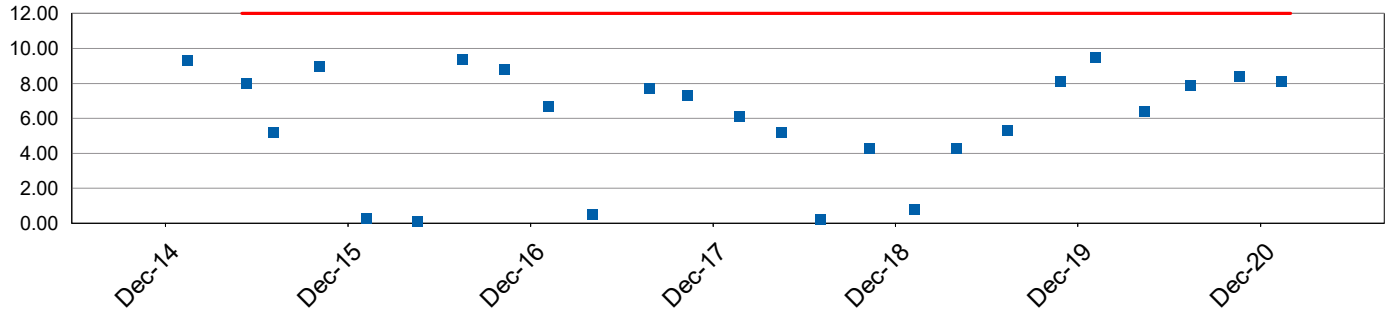
Carbon Dioxide (% v/v)
WH/BH73



Carbon Dioxide (% v/v)
WH/BH74



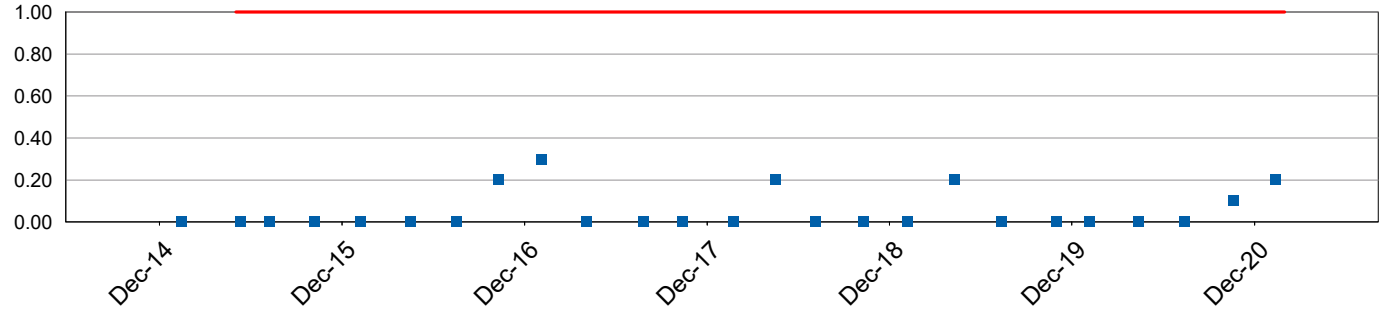
Carbon Dioxide (% v/v)
WH/BH75



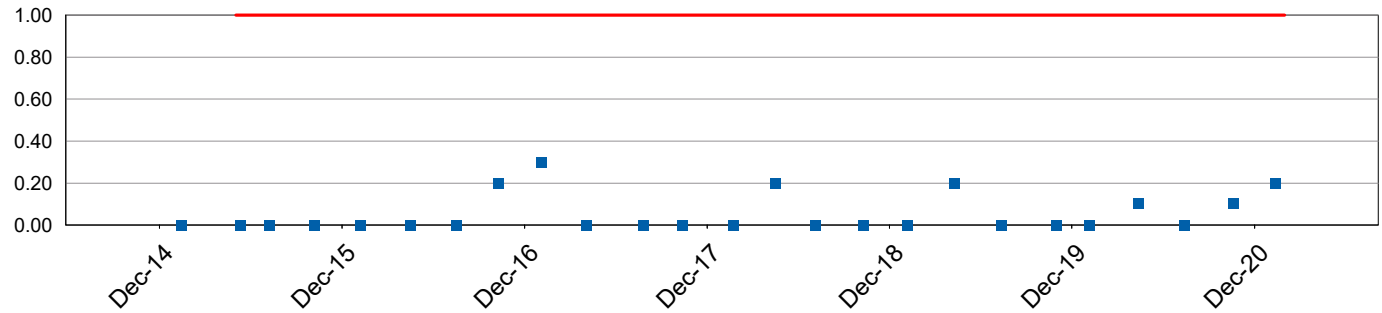
Whinney Hill - Whinney Hill P2 Perimeter Gas Points

01/01/2015 to 28/02/2021

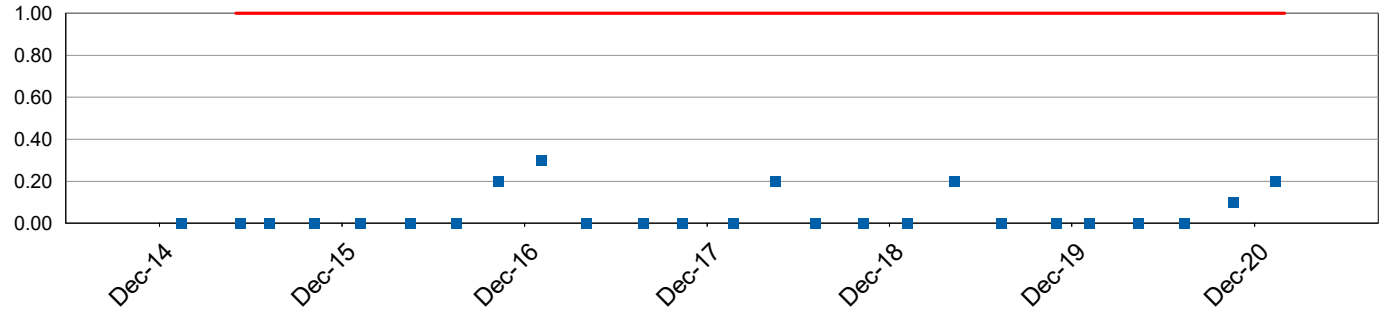
Methane (% v/v)
WH/BH65



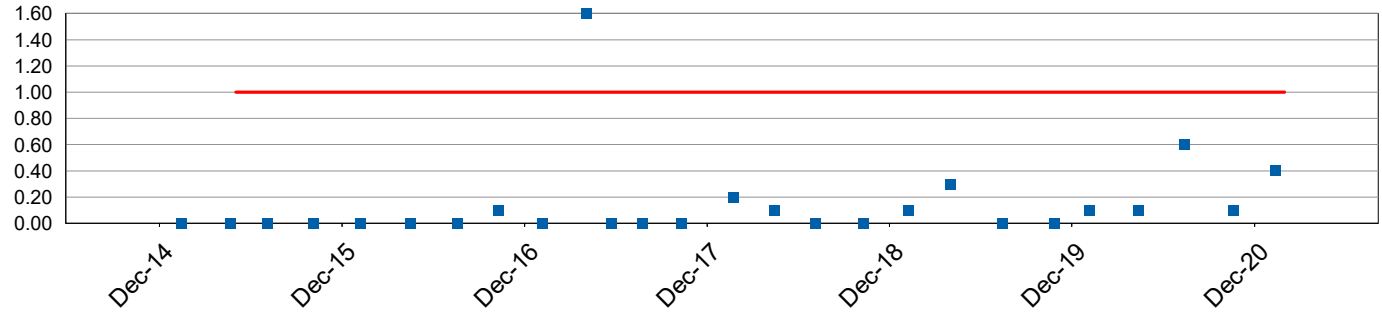
Methane (% v/v)
WH/BH66



Methane (% v/v)
WH/BH67



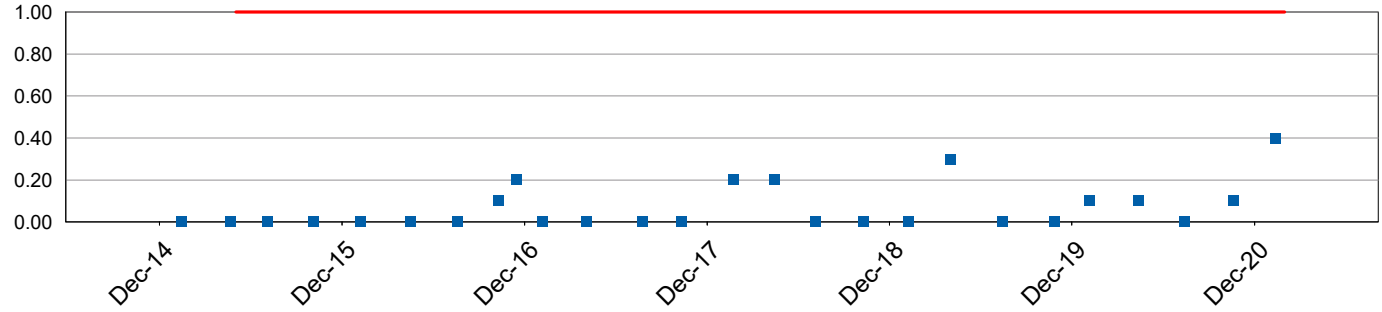
Methane (% v/v)
WH/BH68A



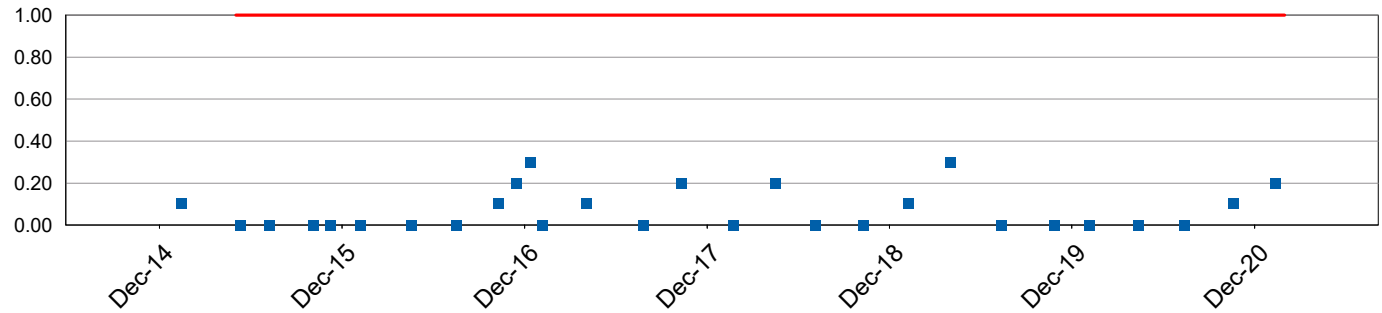
Whinney Hill - Whinney Hill P2 Perimeter Gas Points

01/01/2015 to 28/02/2021

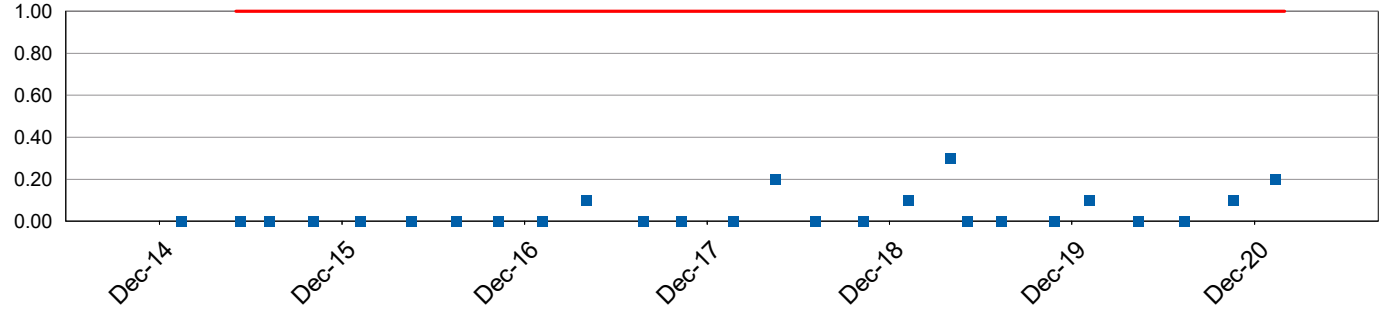
Methane (% v/v)
WH/BH68B



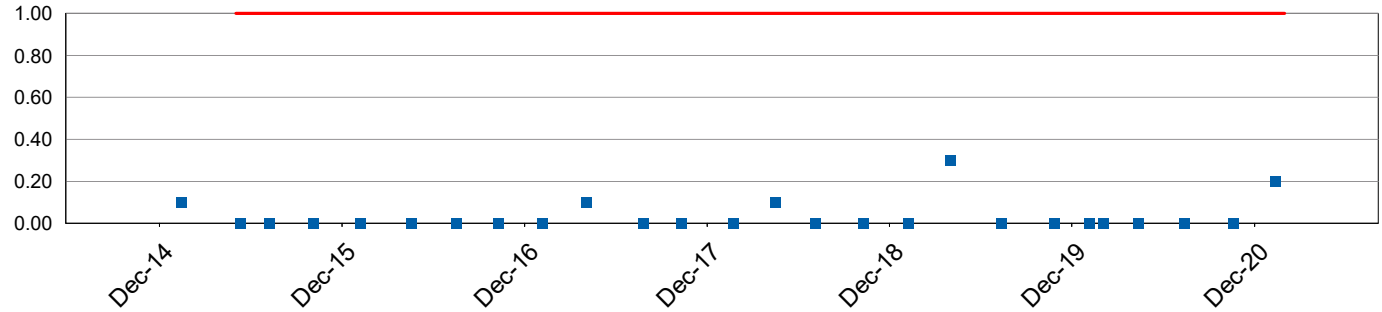
Methane (% v/v)
WH/BH69



Methane (% v/v)
WH/BH70



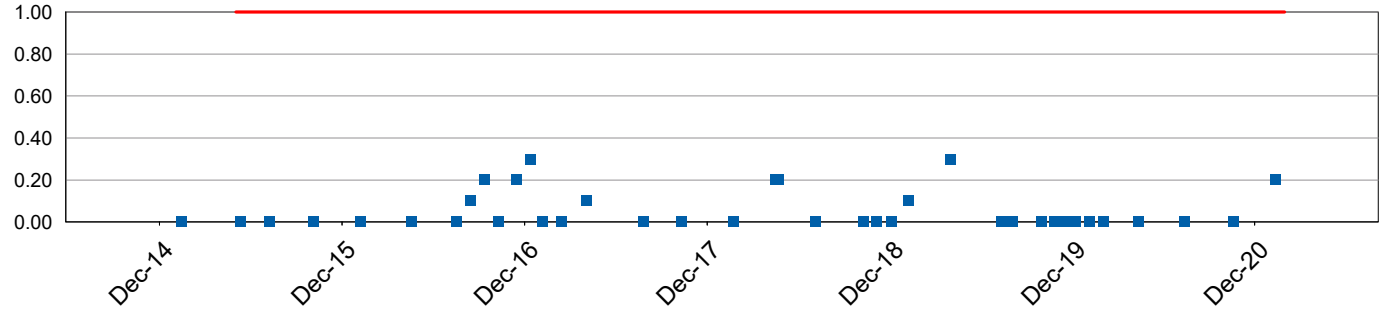
Methane (% v/v)
WH/BH71



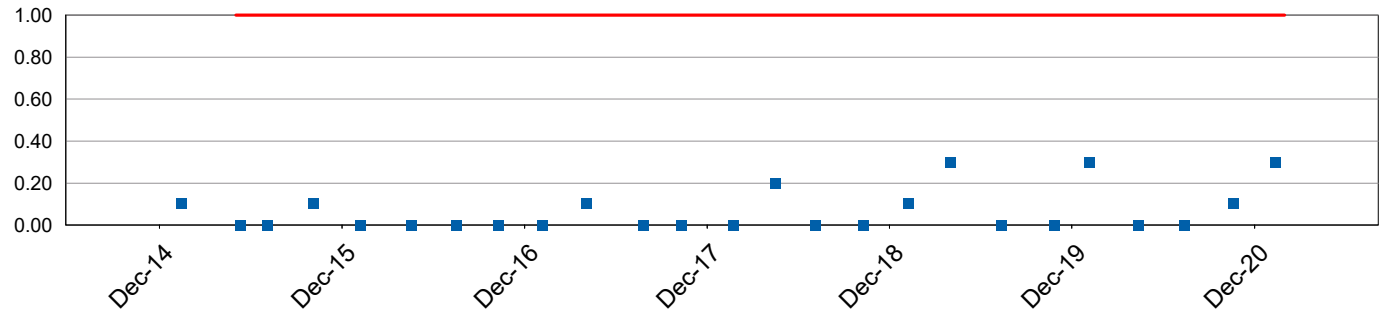
Whinney Hill - Whinney Hill P2 Perimeter Gas Points

01/01/2015 to 28/02/2021

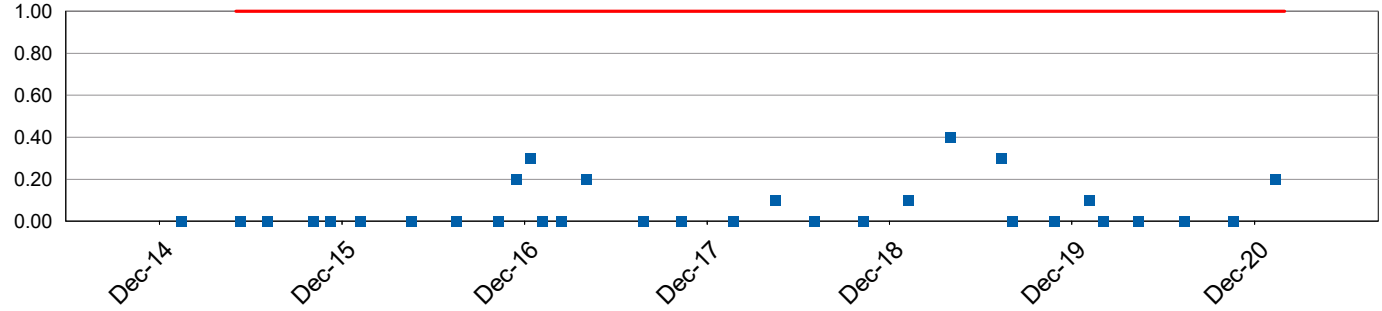
Methane (% v/v)
WH/BH72



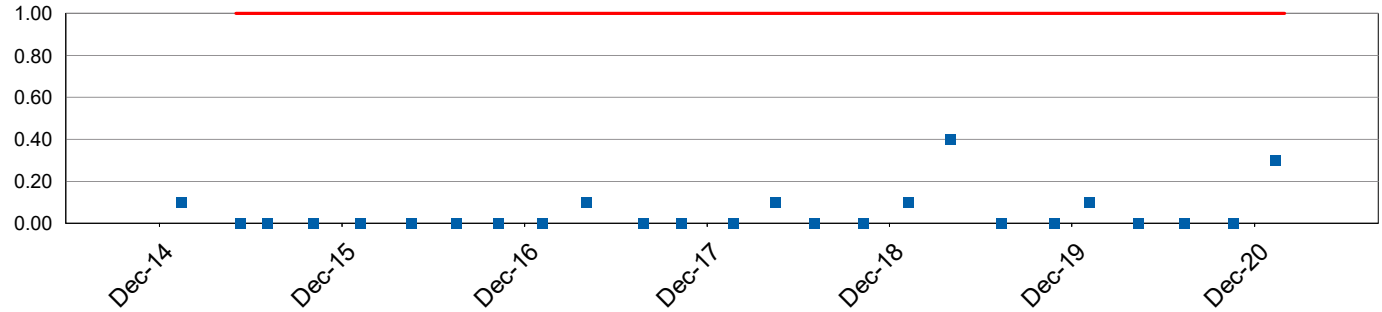
Methane (% v/v)
WH/BH73



Methane (% v/v)
WH/BH74



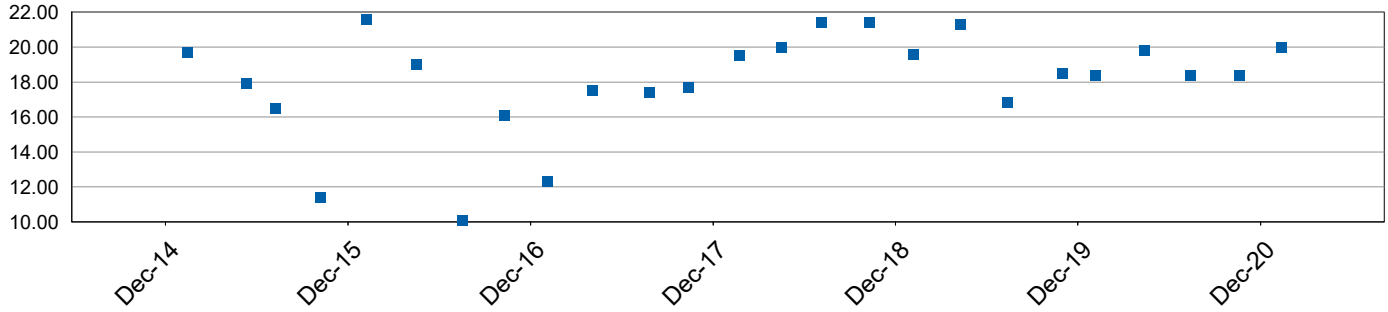
Methane (% v/v)
WH/BH75



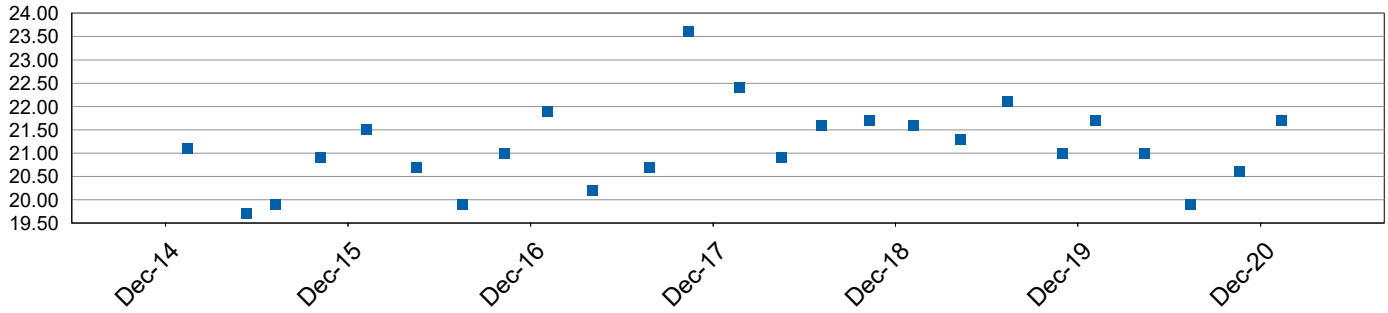
Whinney Hill - Whinney Hill P2 Perimeter Gas Points

01/01/2015 to 28/02/2021

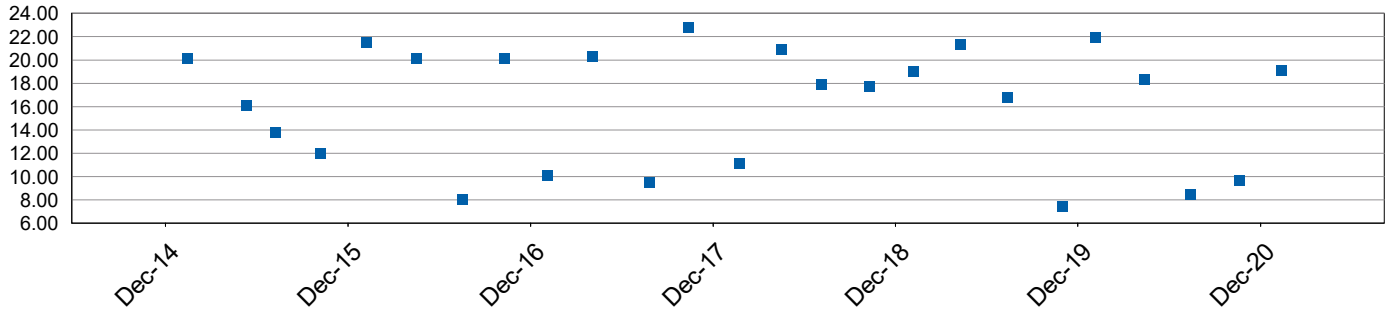
Oxygen (% v/v)
WH/BH65



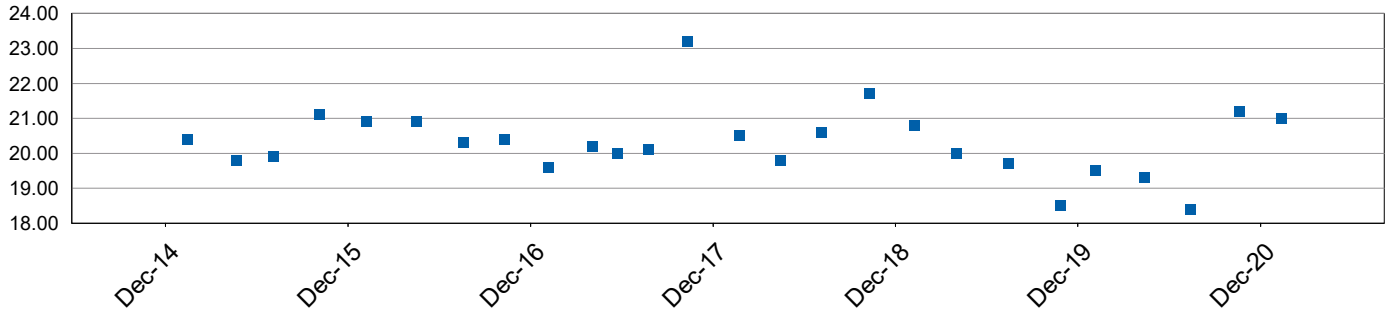
Oxygen (% v/v)
WH/BH66



Oxygen (% v/v)
WH/BH67



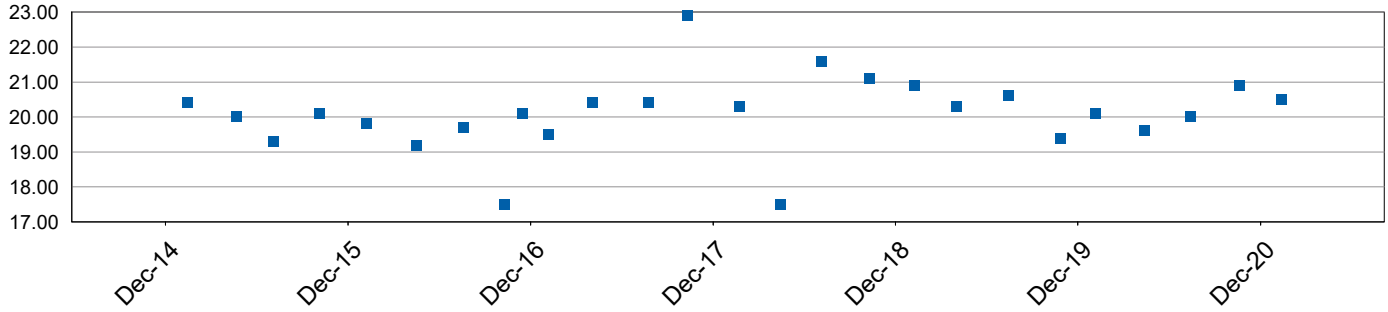
Oxygen (% v/v)
WH/BH68A



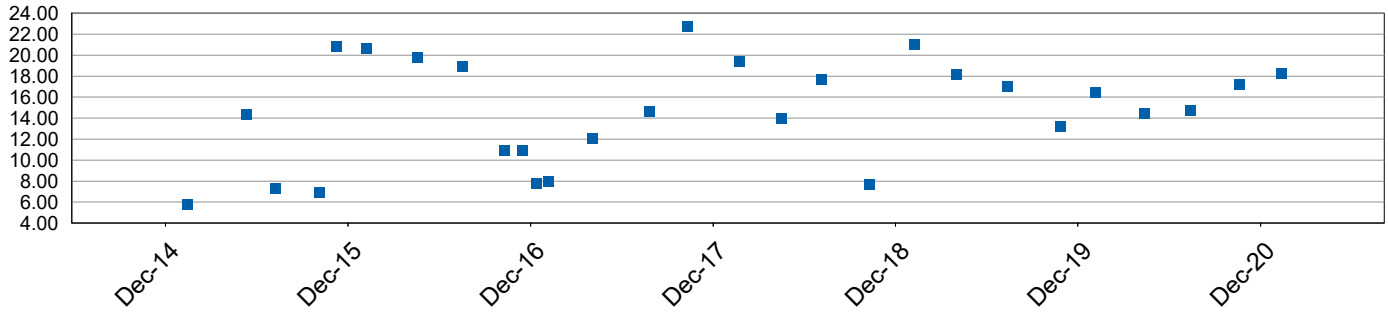
Whinney Hill - Whinney Hill P2 Perimeter Gas Points

01/01/2015 to 28/02/2021

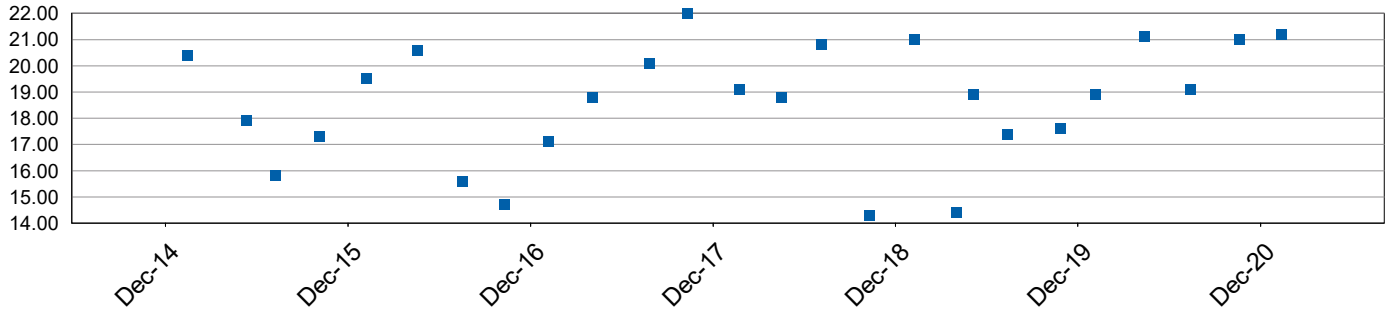
Oxygen (% v/v)
WH/BH68B



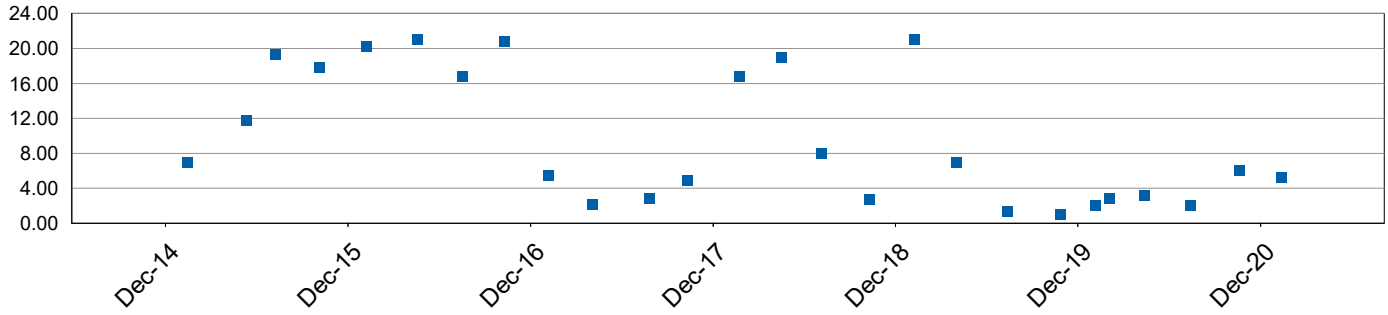
Oxygen (% v/v)
WH/BH69



Oxygen (% v/v)
WH/BH70



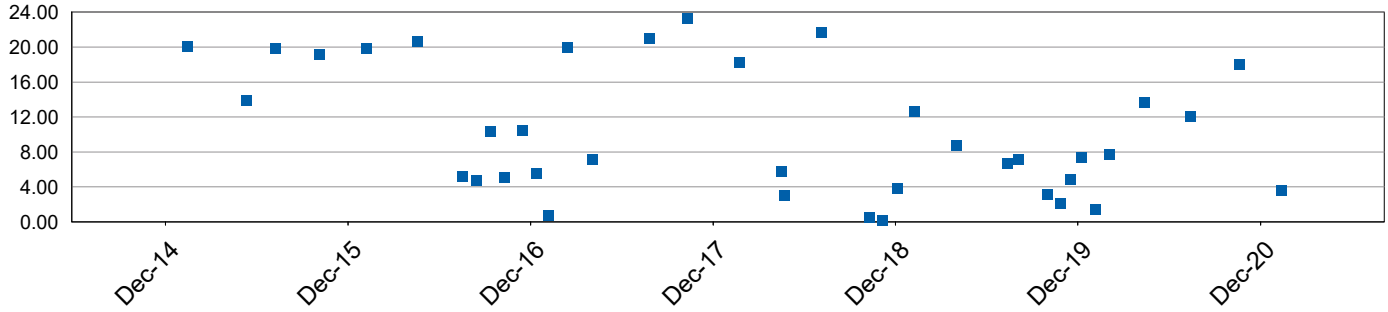
Oxygen (% v/v)
WH/BH71



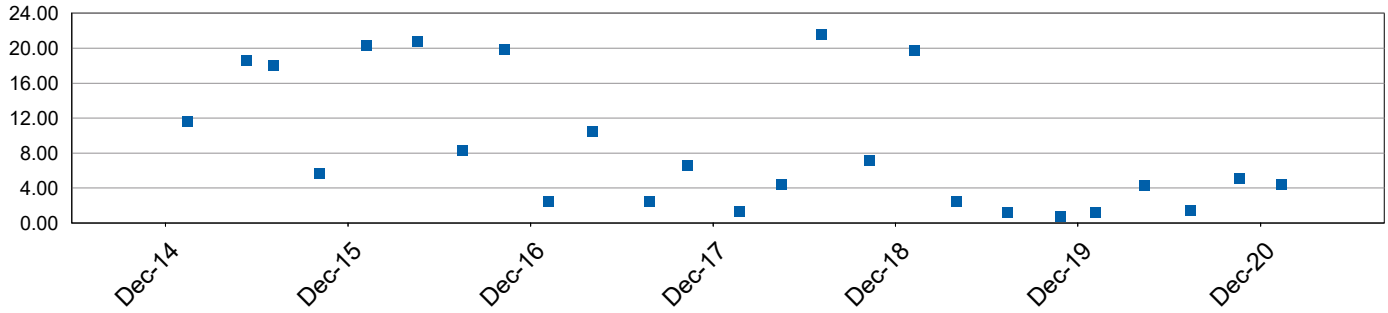
Whinney Hill - Whinney Hill P2 Perimeter Gas Points

01/01/2015 to 28/02/2021

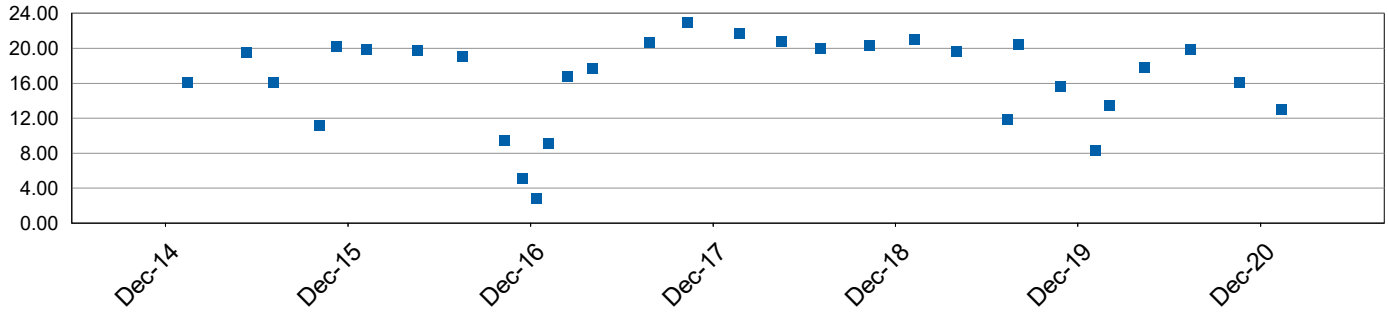
Oxygen (% v/v)
WH/BH72



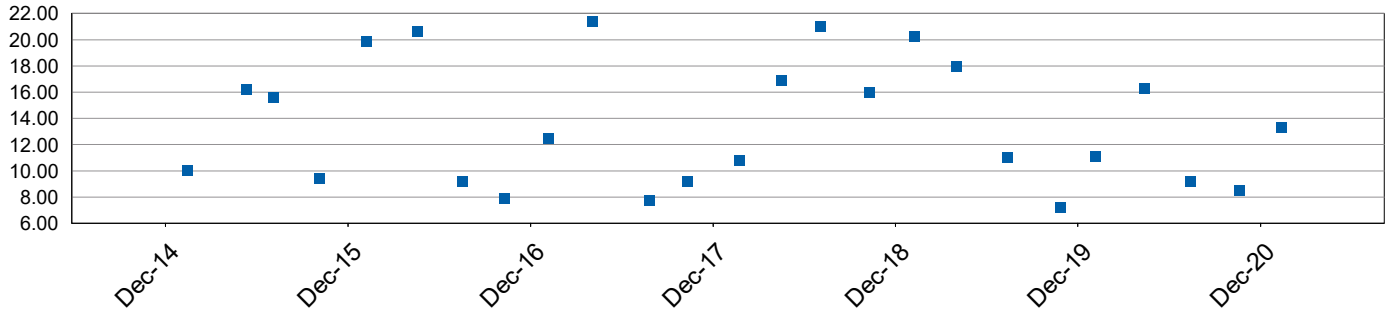
Oxygen (% v/v)
WH/BH73



Oxygen (% v/v)
WH/BH74



Oxygen (% v/v)
WH/BH75



Appendices

Appendix A. Perimeter Gas Monitoring Data (%v/v)

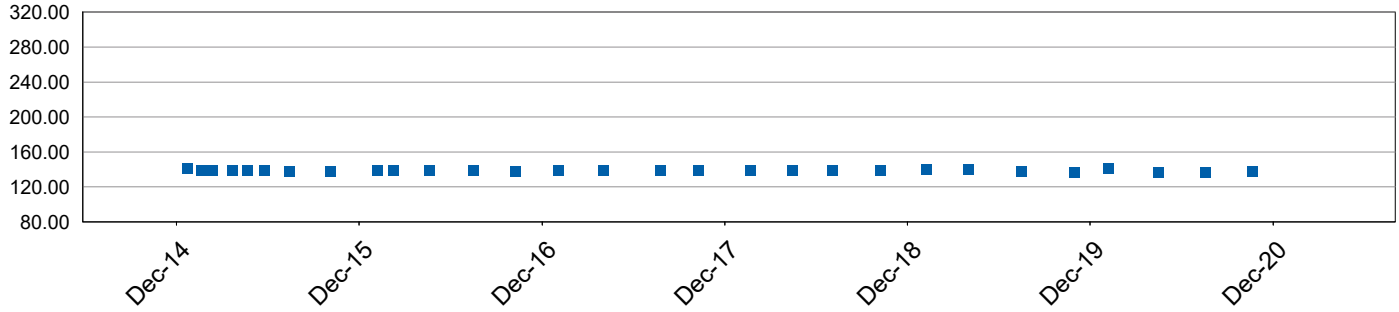
(appended as a separate spreadsheet file)

Appendix B. Groundwater Review Hydrographs

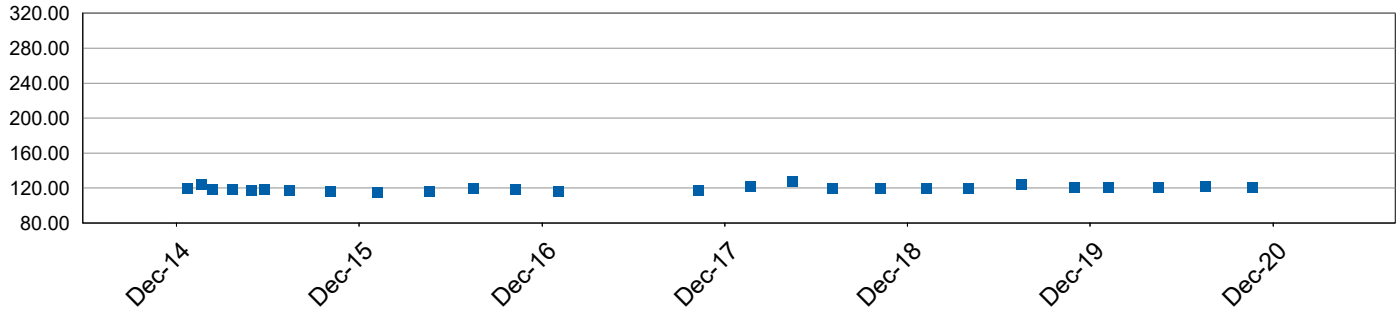
Whinney Hill - Whinney Hill P1 Groundwater Monitoring Points

01/01/2015 to 25/02/2021

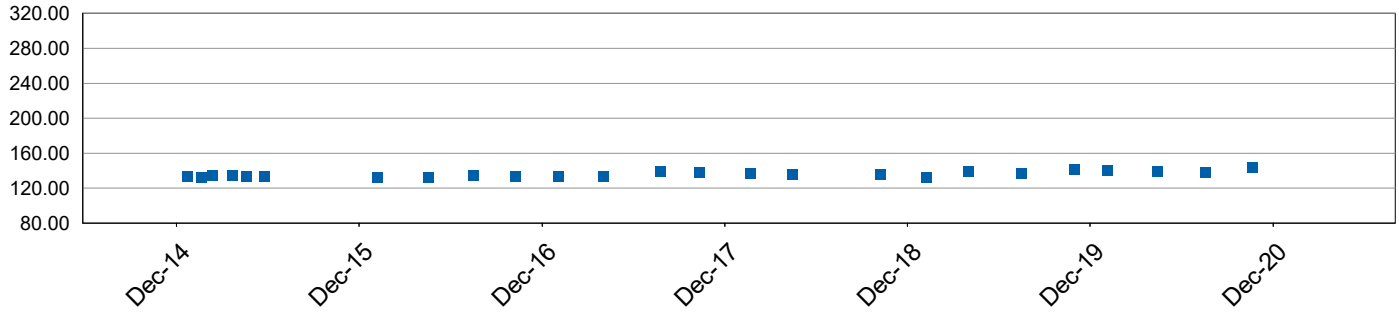
Groundwater Level (mAOD)
WH/0202AMR



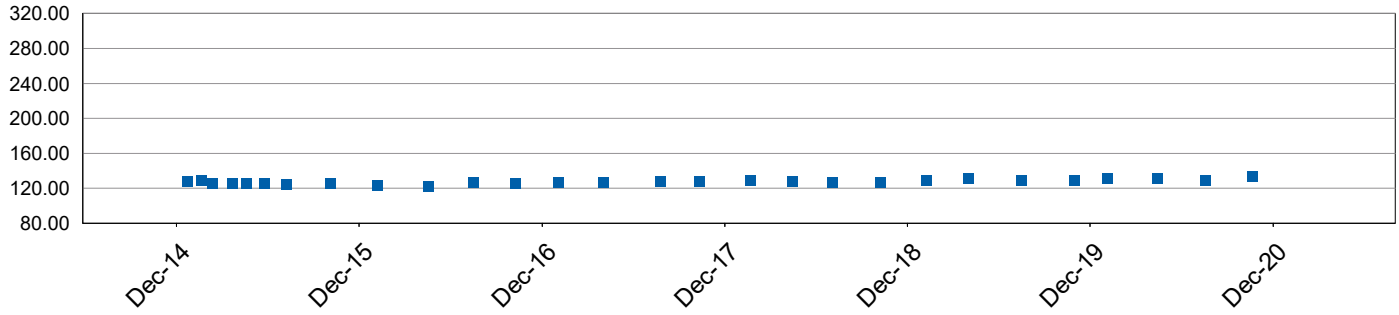
Groundwater Level (mAOD)
WH/0202DKF(R)



Groundwater Level (mAOD)
WH/0419AM



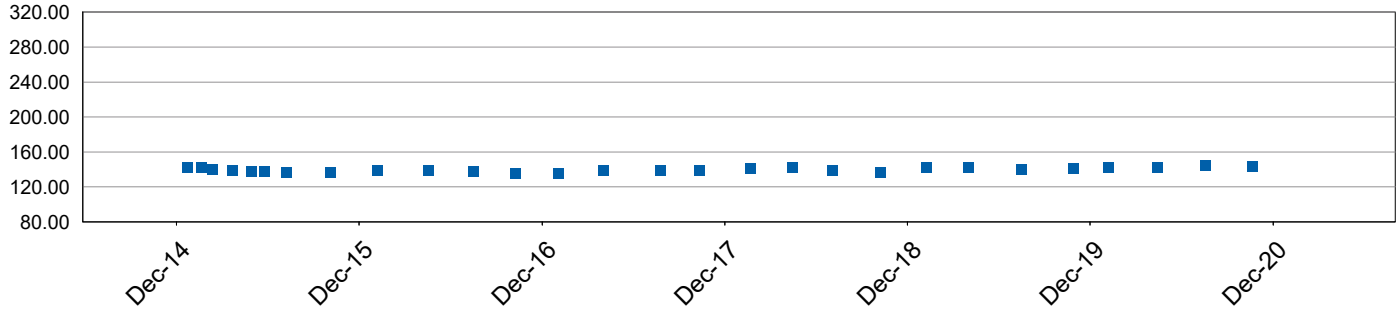
Groundwater Level (mAOD)
WH/0420DKF



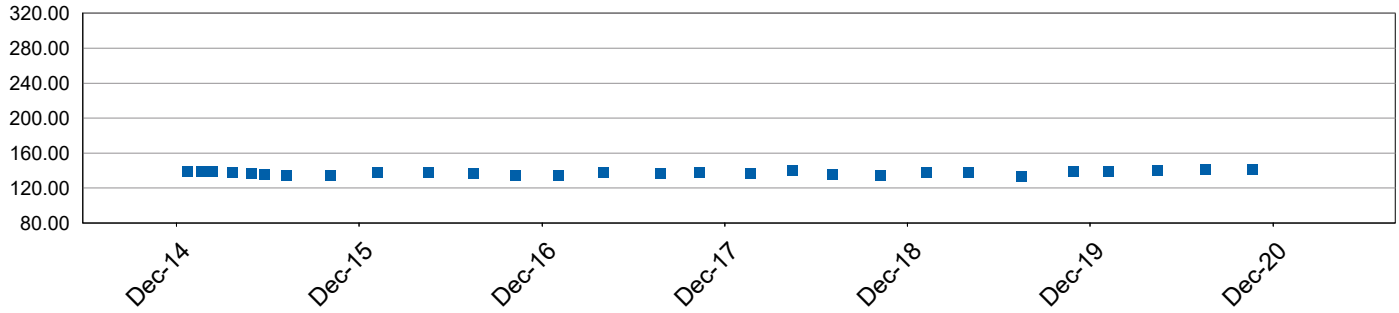
Whinney Hill - Whinney Hill P1 Groundwater Monitoring Points

01/01/2015 to 25/02/2021

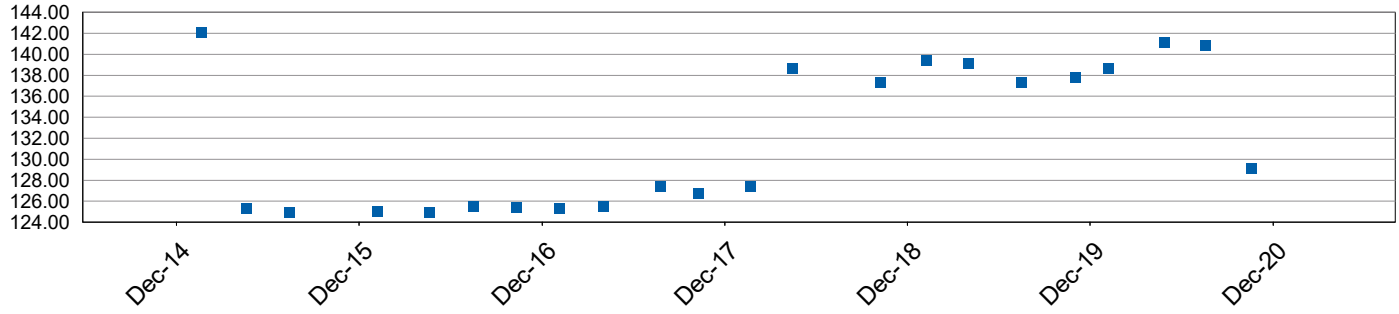
Groundwater Level (mAOD)
WH/0421AM



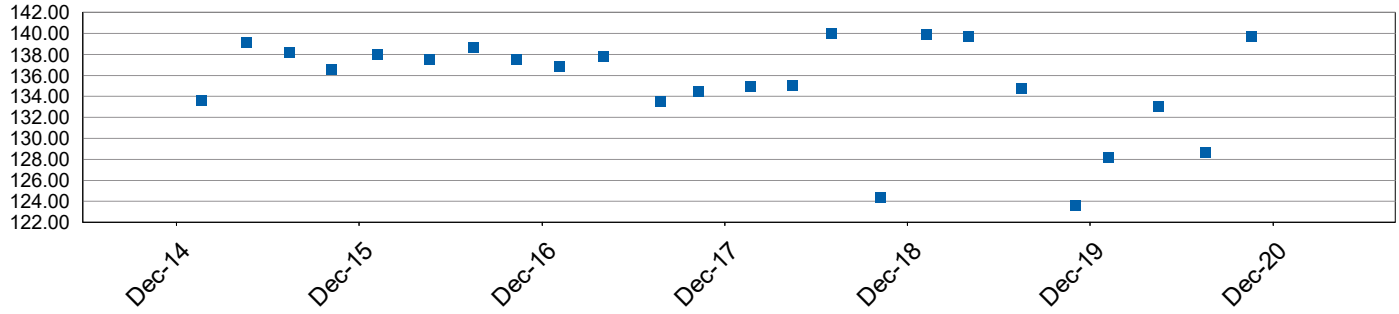
Groundwater Level (mAOD)
WH/0422DKF



Groundwater Level (mAOD)
WH/0206AM



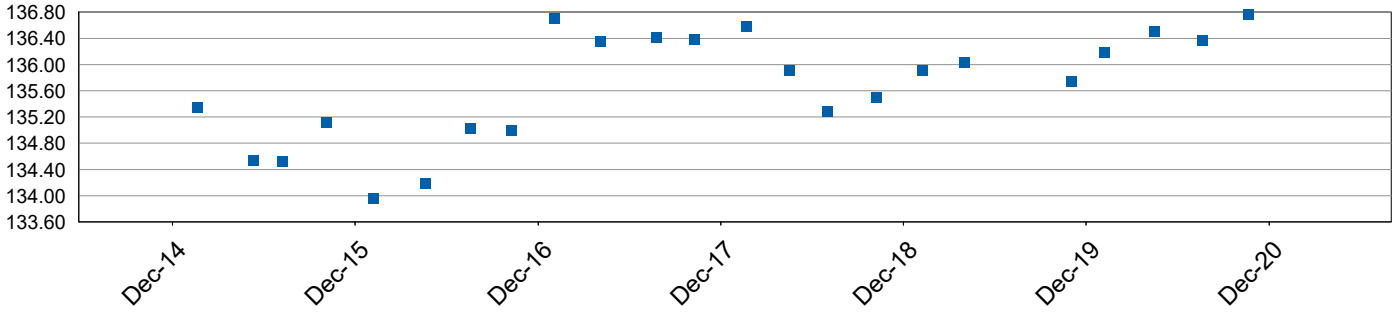
Groundwater Level (mAOD)
WH/0206DKF



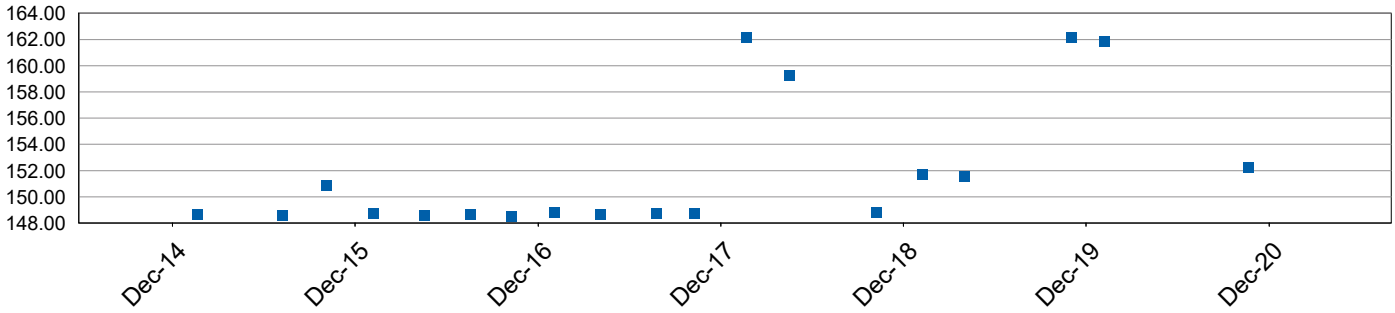
Whinney Hill - Whinney Hill P1 Groundwater Monitoring Points

01/01/2015 to 25/02/2021

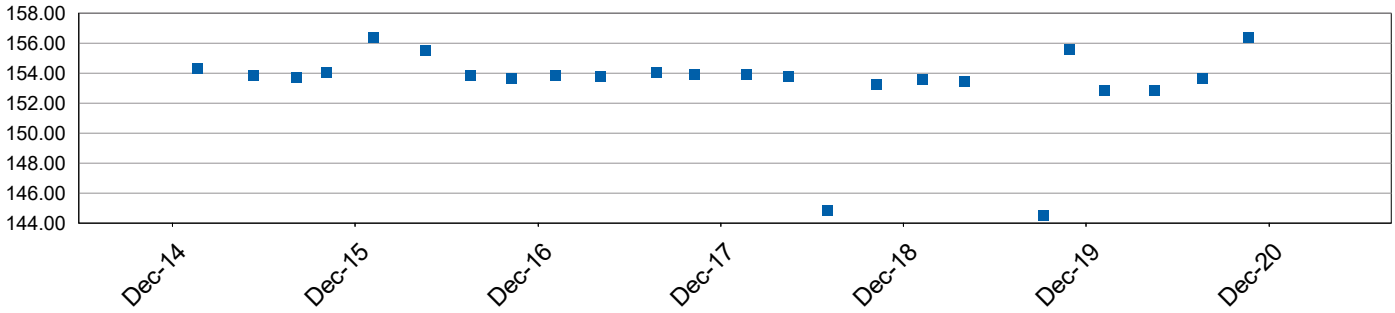
Groundwater Level (mAOD)
WH/0209DKFR



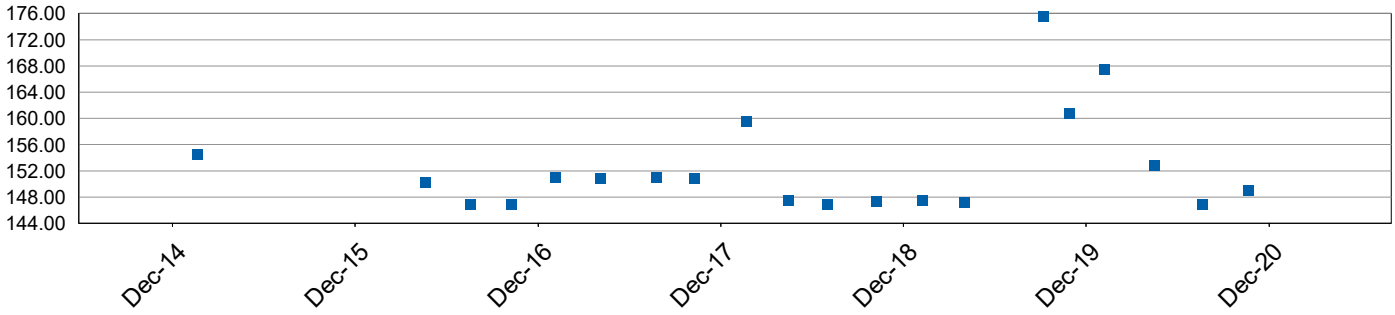
Groundwater Level (mAOD)
WH/0211DKFR



Groundwater Level (mAOD)
WH/BH09



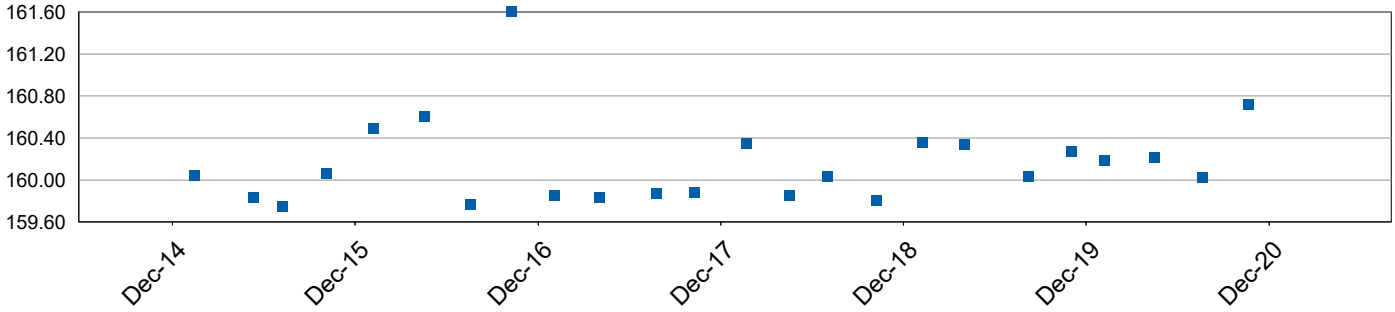
Groundwater Level (mAOD)
WH/BH11



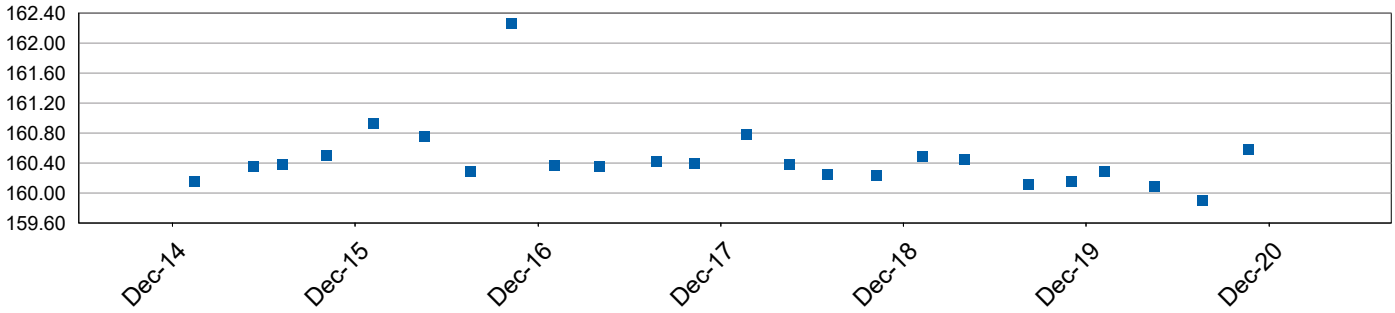
Whinney Hill - Whinney Hill P1 Groundwater Monitoring Points

01/01/2015 to 25/02/2021

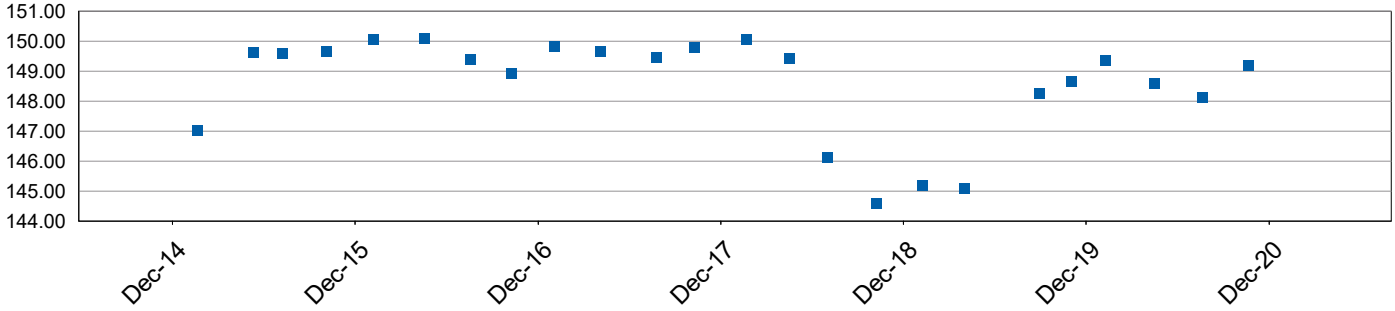
Groundwater Level (mAOD)
WH/BH15AM



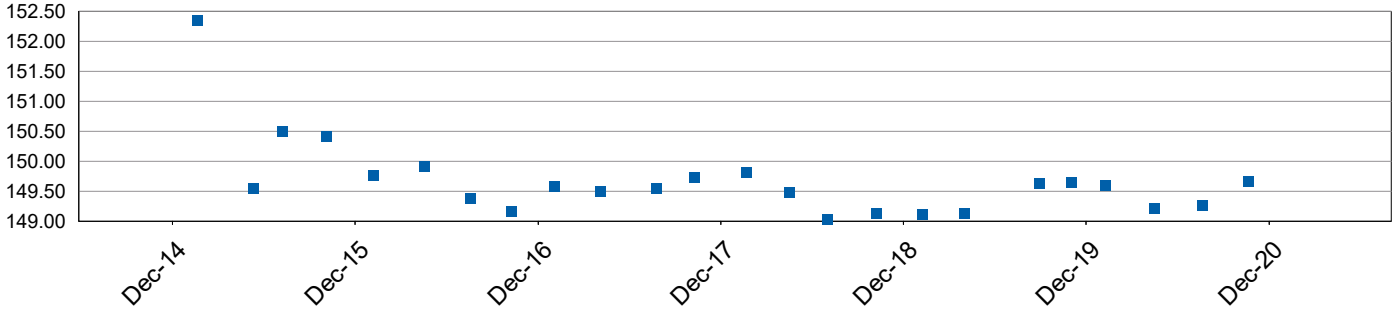
Groundwater Level (mAOD)
WH/BH15DKF



Groundwater Level (mAOD)
WH/BH34



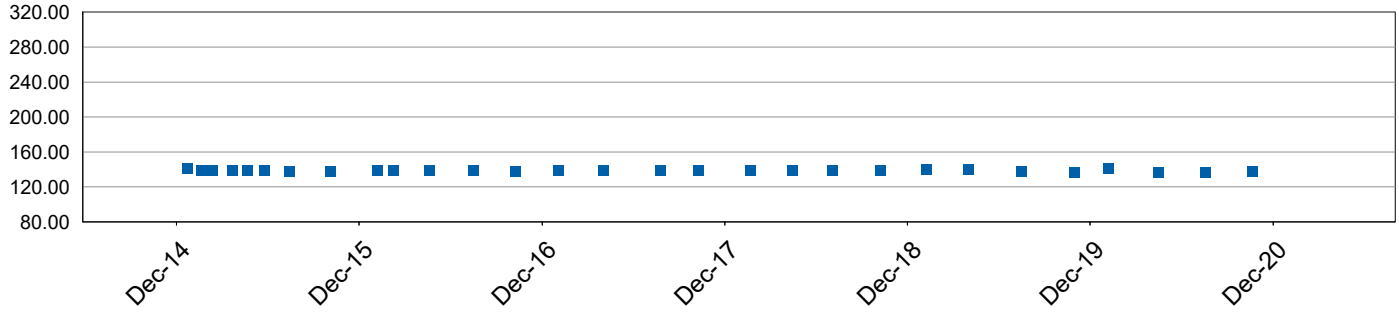
Groundwater Level (mAOD)
WH/BH35



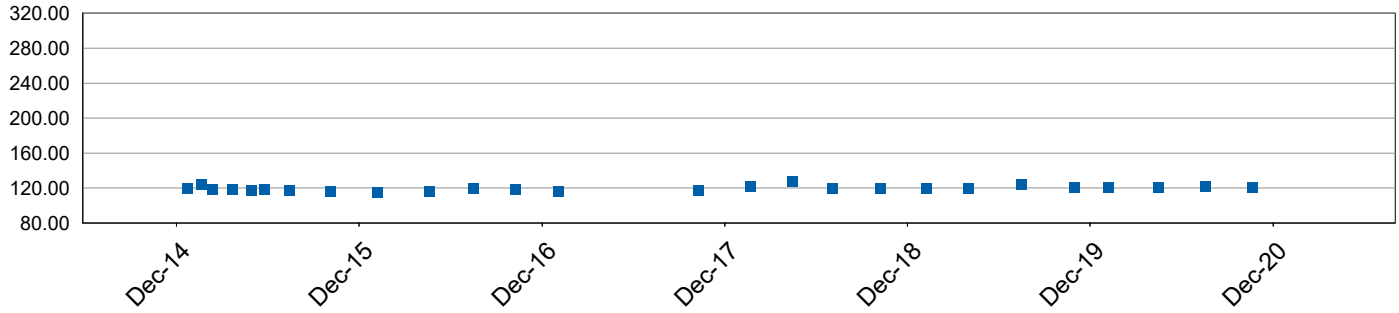
Whinney Hill - Whinney Hill P2 Groundwater Points

01/01/2015 to 25/02/2021

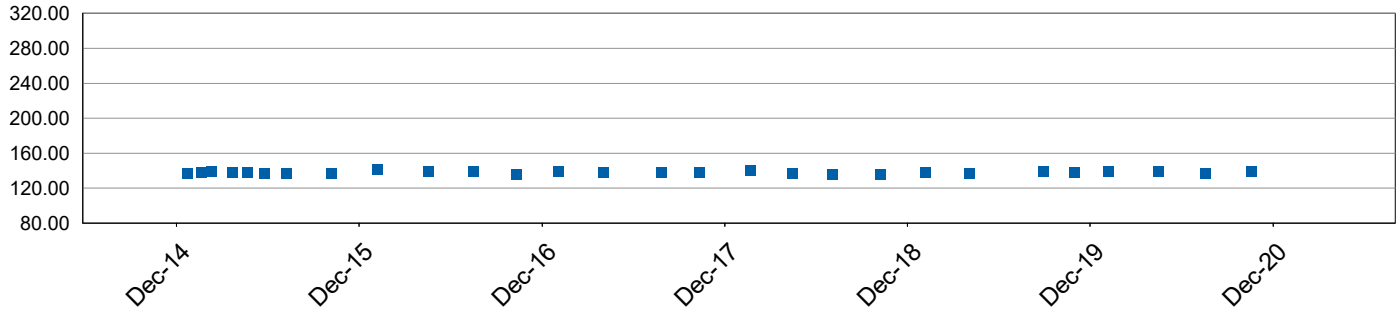
Groundwater Level (mAOD)
WH/0202AMR



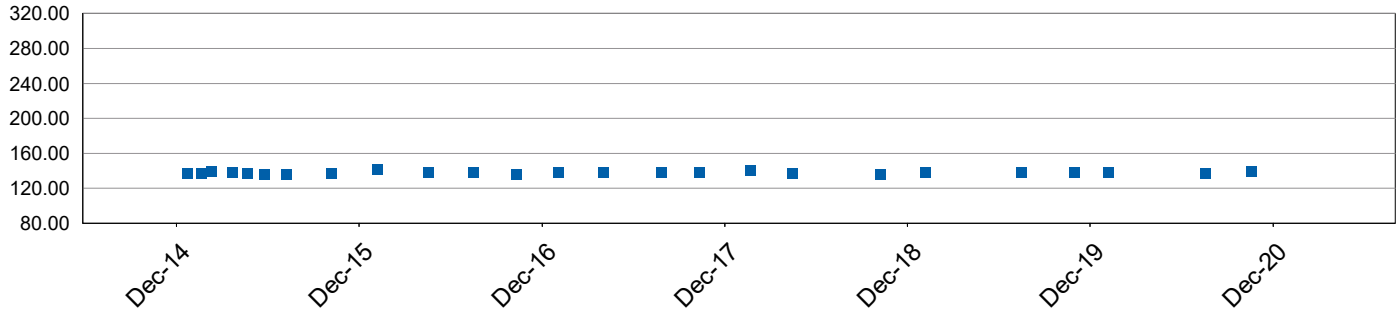
Groundwater Level (mAOD)
WH/0202DKF(R)



Groundwater Level (mAOD)
WH/0203AM(R)



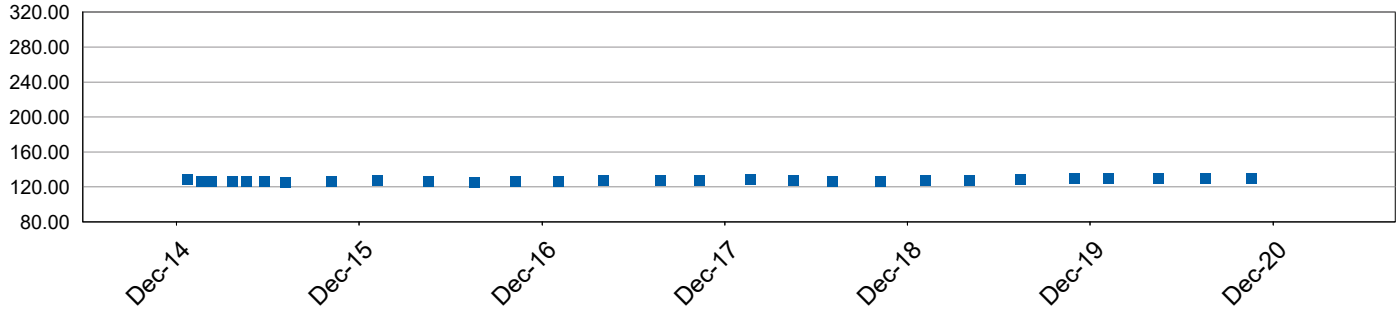
Groundwater Level (mAOD)
WH/0203DKF(R)



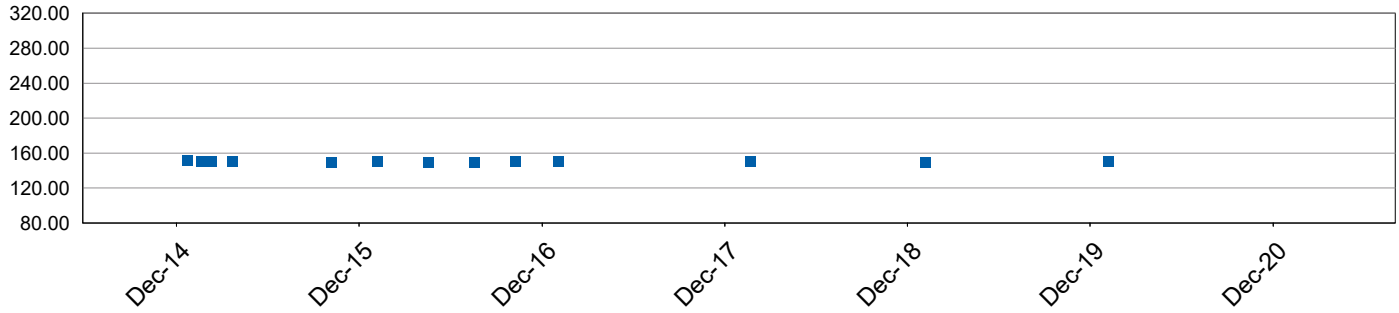
Whinney Hill - Whinney Hill P2 Groundwater Points

01/01/2015 to 25/02/2021

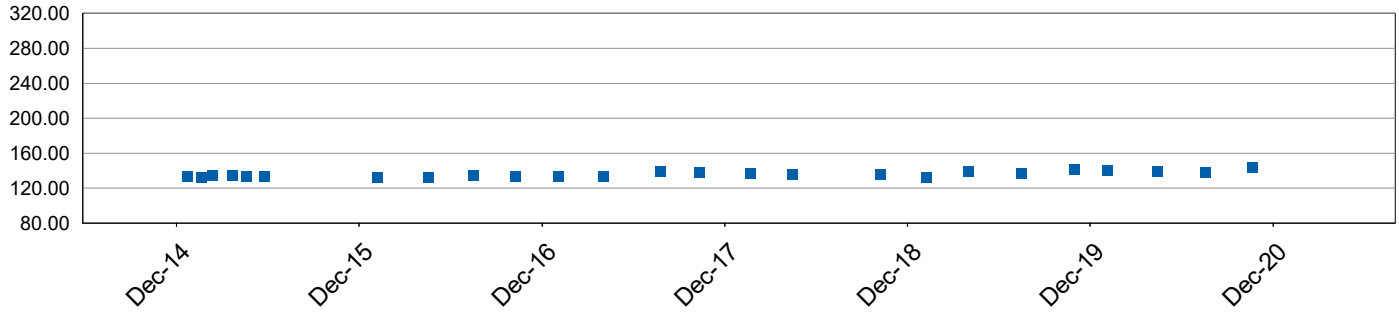
Groundwater Level (mAOD)
WH/0401DKF



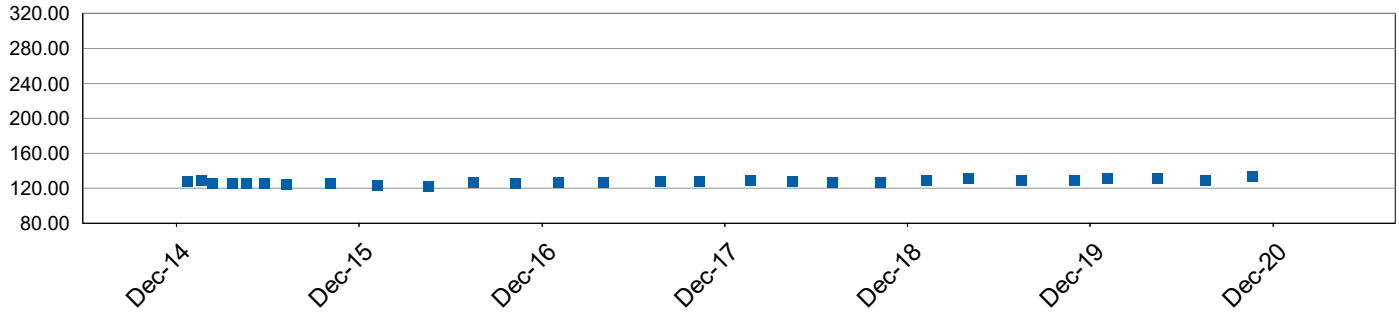
Groundwater Level (mAOD)
WH/0402AM



Groundwater Level (mAOD)
WH/0419AM



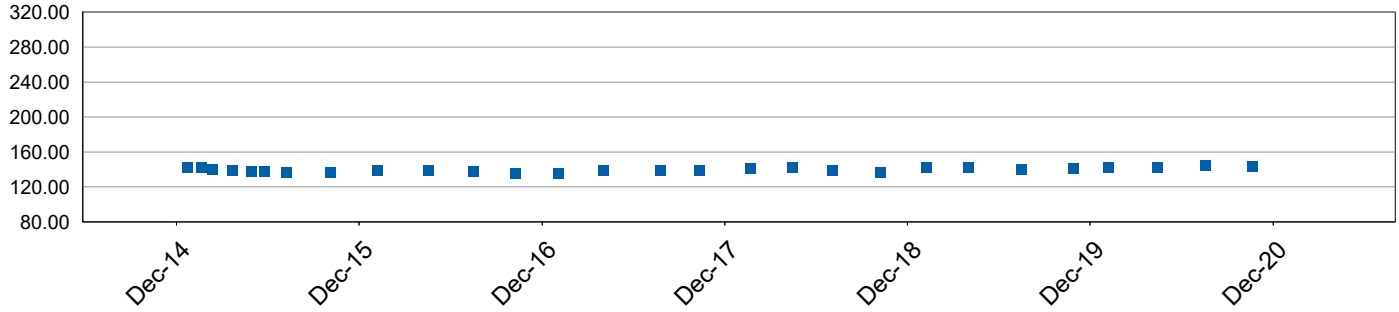
Groundwater Level (mAOD)
WH/0420DKF



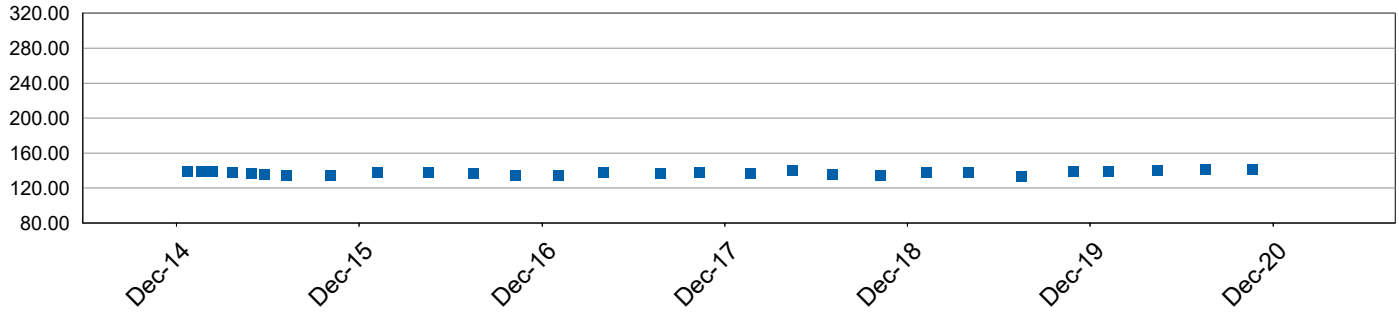
Whinney Hill - Whinney Hill P2 Groundwater Points

01/01/2015 to 25/02/2021

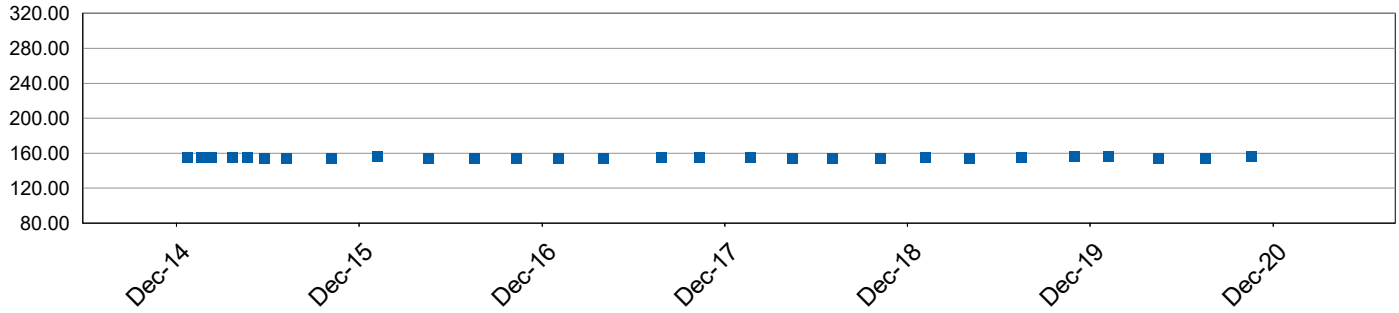
Groundwater Level (mAOD)
WH/0421AM



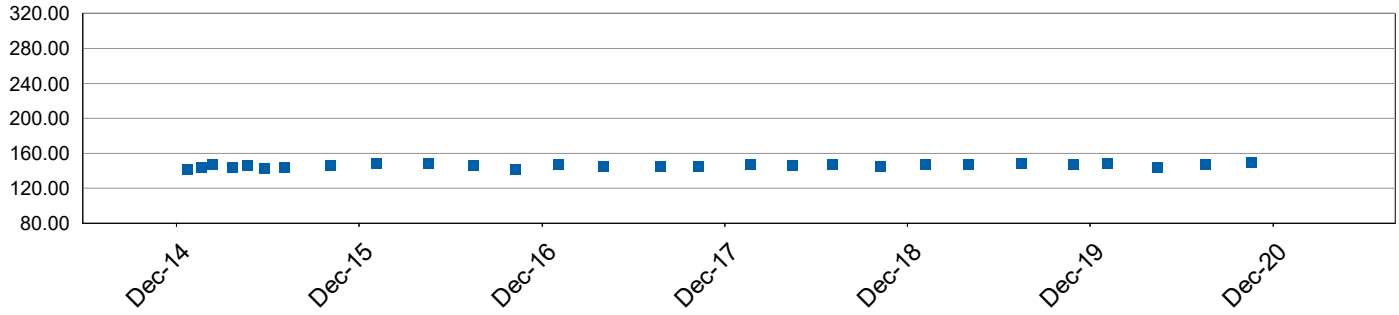
Groundwater Level (mAOD)
WH/0422DKF



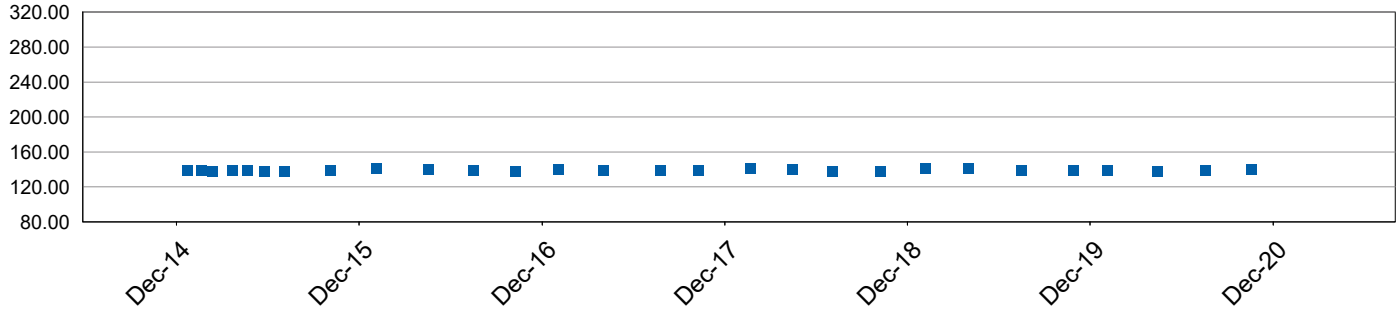
Groundwater Level (mAOD)
WH/BH0203OLR



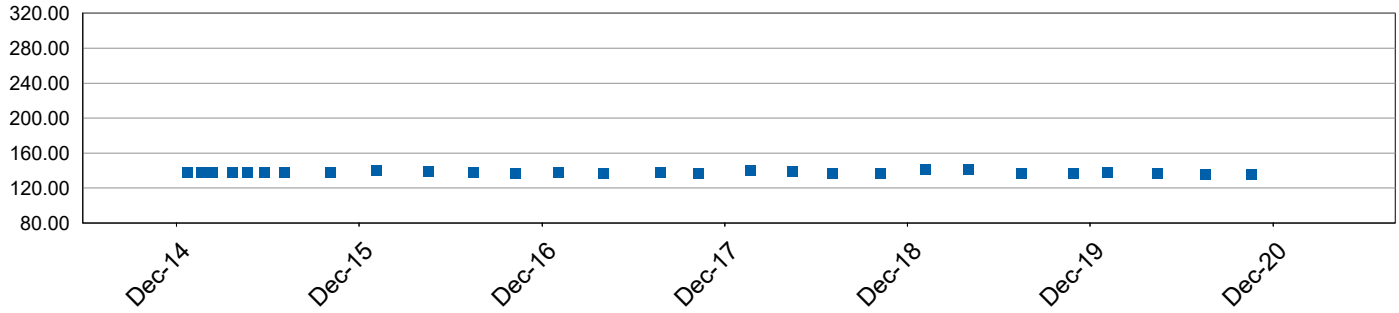
Groundwater Level (mAOD)
WH/BH87AM(A)



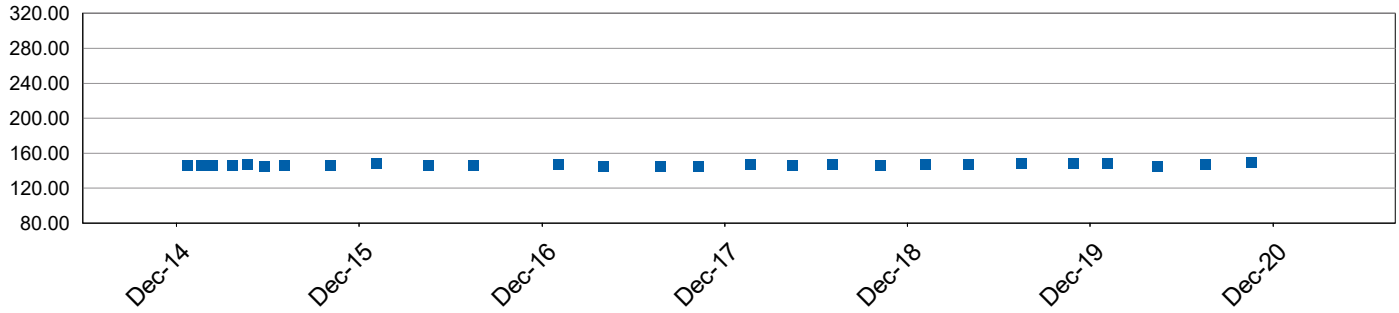
Groundwater Level (mAOD)
WH/BH87AM(B)



Groundwater Level (mAOD)
WH/BH87DKF



Groundwater Level (mAOD)
WH/BH87OLR



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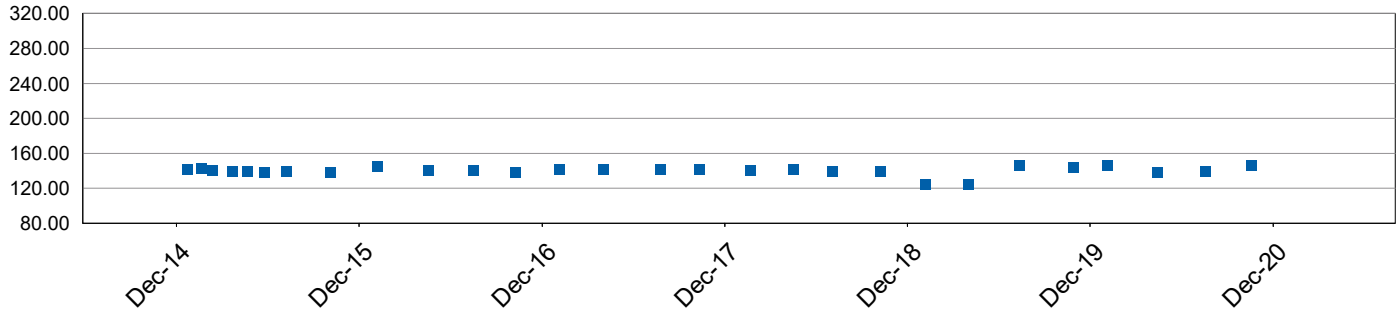
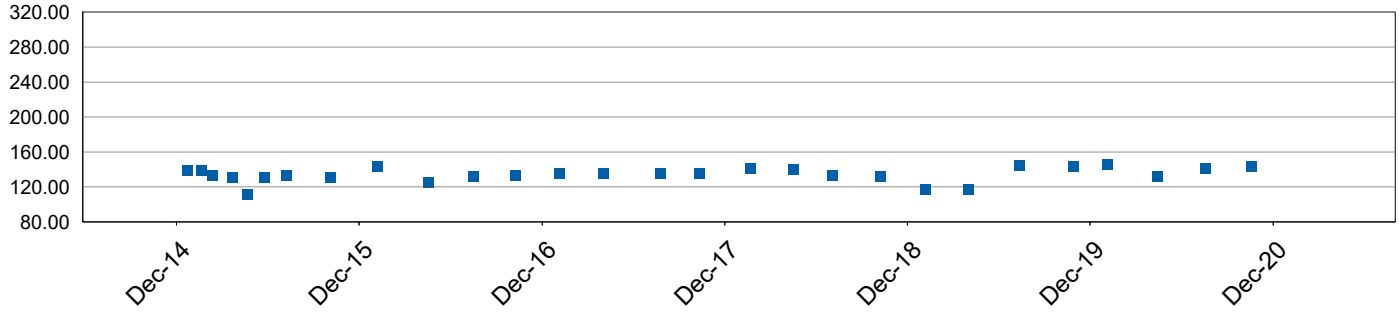
WH/BH88AM



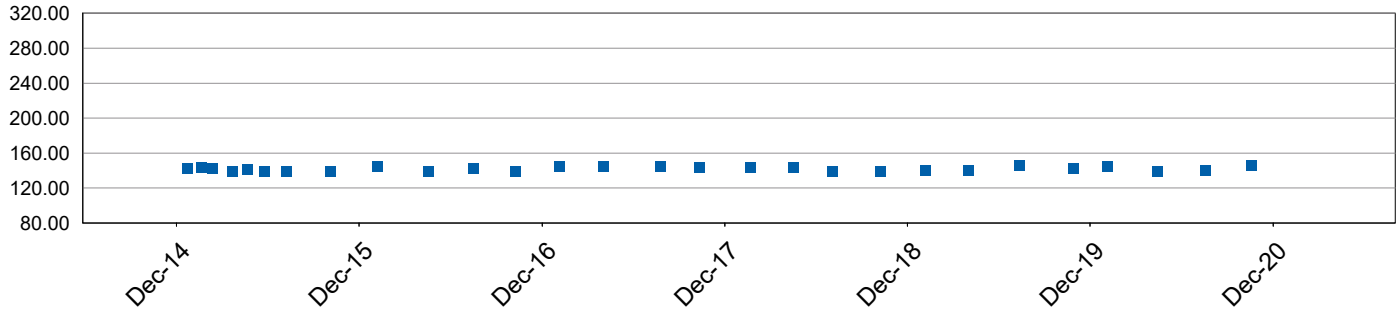
Whinney Hill - Whinney Hill P2 Groundwater Points

01/01/2015 to 25/02/2021

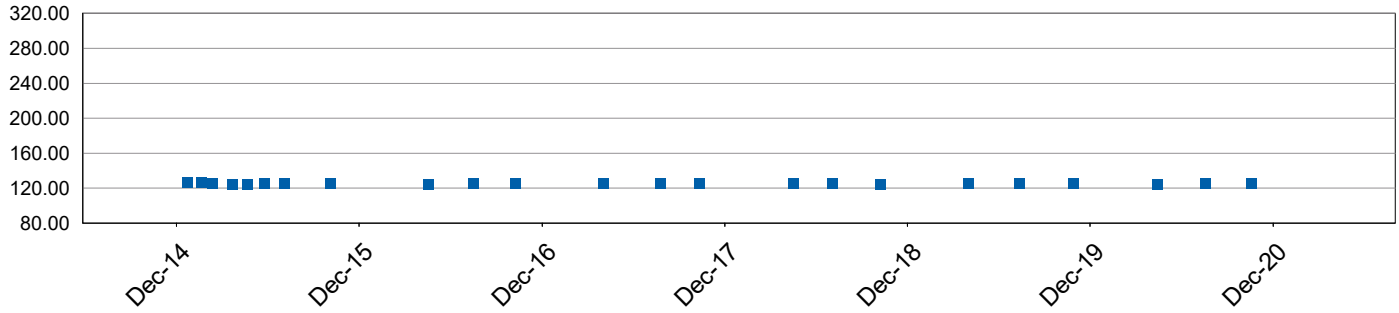
Groundwater Level (mAOD)
WH/BH88DKF



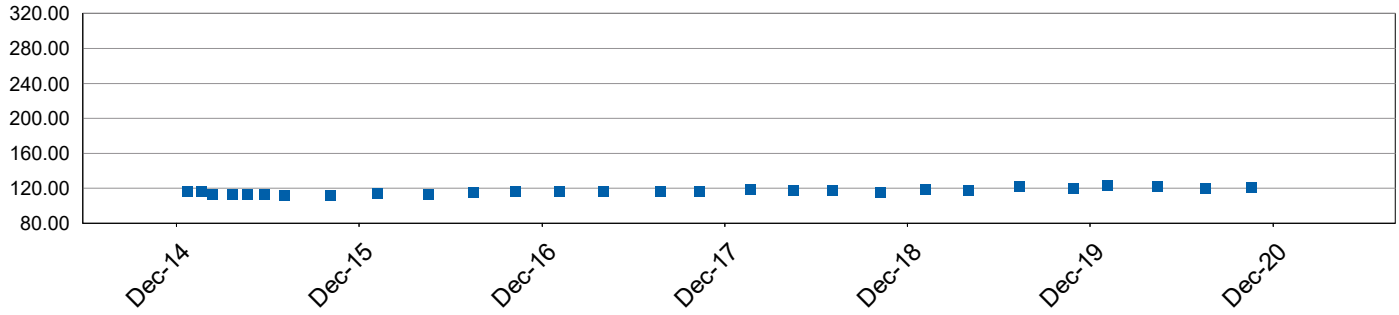
Groundwater Level (mAOD)
WH/BH88OLR



Groundwater Level (mAOD)
WH/BH89AM



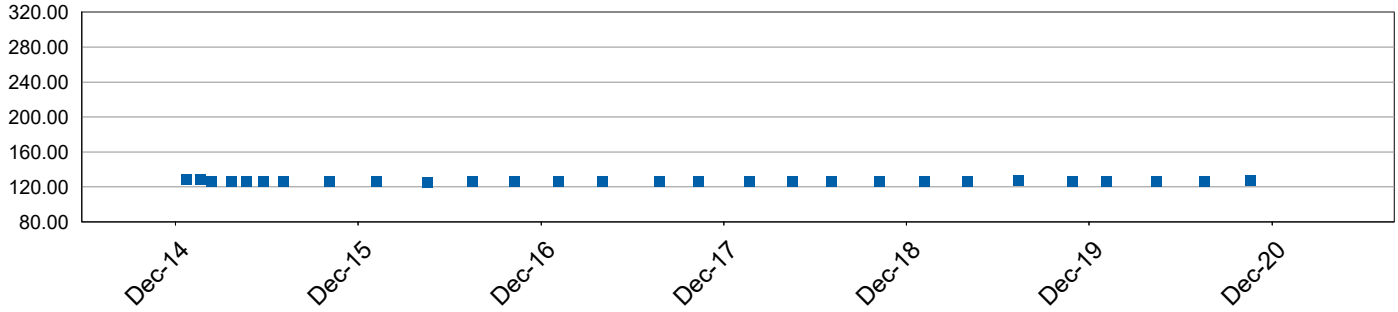
Groundwater Level (mAOD)
WH/BH89DKF



Whinney Hill - Whinney Hill P2 Groundwater Points

01/01/2015 to 25/02/2021

Groundwater Level (mAOD)
WH/BH89OLR



Appendix C. Phase 1 Carbon Dioxide Action Level Calculations

(appended as a separate spreadsheet file)

Appendix D. Phase 2 Carbon Dioxide Action Level Calculations

(appended as a separate spreadsheet file)

Appendix E. Comparison of Current and Proposed CO_2 Action Levels

Phase Number	Borehole Number	Current Action Level	Proposed Action Level	Change in Action Level
1	WH/BH34	20.3	22.6	2.3
	WH/BH35	1.9	3	1.1
	WH/BH49/1	13	7.7	-5.3
	WH/BH49/2	6.9	9.2	2.3
	WH/BH49/3	7	5.5	-1.5
	WH/BH51/1	14.9	9.6	-5.3
	WH/BH51/2	15.8	9	-6.8
	WH/BH51/3	10.9	8.5	-2.4
	WH/BH52/1	11.2	7.1	-4.1
	WH/BH52/2	8.4	5.9	-2.5
	WH/BH52/3	7.7	7.8	0.1
	WH/BH53/1	6.7	5.5	-1.2
	WH/BH53/2	12.6	4.7	-7.9
	WH/BH53/3	2.3	3.5	1.2
	WH/BH53/4	2.3	3.7	1.4
2	WH/BH65	6.3	7.2	0.9
	WH/BH66	4.1	3.8	-0.3
	WH/BH67	7.9	9.9	2
	WH/BH68A	1.5	2.2	0.7
	WH/BH68B	1.5	2.6	1.1
	WH/BH69	4.7	7.1	2.4
	WH/BH70	3.6	4.6	1
	WH/BH71	5	7.1	2.1
	WH/BH72	5.5	10.5	5
	WH/BH73	5.3	7	1.7
	WH/BH74	3.1	4.9	1.8
	WH/BH75	12	14.7	2.7