



Nicola Sugg
Consultant Hydrogeologist
& Hydrologist

PB LEINER UK, SEVERN ROAD, PONTYPRIDD

LIQUID SODIUM HYDROXIDE SPILL - MONITORED NATURAL ATTENUATION

March 2024

Commissioned by:



Issue: V2

Project Reference: NS_0118_21/MNA

CONTENTS

EXECUTIVE SUMMARY	1
1.0 INTRODUCTION.....	2
1.1 Project Introduction and Aims	2
1.2 Background.....	2
1.3 NRW Recommendations and Response	3
1.4 Report Structure	4
2.0 HYDROGEOLOGICAL SITE SETTING	5
2.1 Site Location and Monitoring Network.....	5
2.2 Geology and Ground Conditions	6
2.3 Groundwater Levels and Flow	7
2.4 Aquifer Characteristics	9
2.5 Baseline Soils and Background Groundwater Quality.....	9
2.6 Hydrological Setting.....	9
3.0 HYDROGEOLOGICAL CONCEPTUAL SITE MODEL	10
3.1 Source Term Characteristics	10
3.2 Pathway	11
3.3 Receptor	16
3.4 Summary of the Hydrogeological Conceptual Site Model	16
4.0 SUMMARY AND RECOMMENDATIONS	18
5.0 CLOSURE.....	19

DRAWINGS

Drawing 1 Groundwater Levels and Inferred Groundwater Contours

APPENDICES

Appendix 1 Available Borehole Logs
Appendix 2 Groundwater Monitoring Data

EXECUTIVE SUMMARY

This report presents a review of Monitored Natural Attenuation for the liquid sodium hydroxide (NaOH) spill that occurred on 11th June 2020, at PB Leiner UK, Severn Road, Pontypridd, CF37 5SQ.

A series of ground investigations and site-specific monitoring were undertaken in July 2020 and December 2022, which identified elevated ammonium and manganese in groundwater as a result of the NaOH spill event and subsequent chemical interactions; these represent the contaminants of concern. Dedicated monthly groundwater quality monitoring has been undertaken between August 2023 and January 2024 to inform this report.

The recent data confirm that concentrations of ammoniacal-nitrogen and manganese in groundwater have declined to background levels within the spill area. Concentrations within down-gradient boreholes appear to have peaked and are generally following a declining trend, indicating that the plume has migrated down-gradient, as would be anticipated. The peak observed concentrations of ammoniacal-nitrogen and manganese reduce with distance along the flow path, indicative of natural attenuation, although the data are also influenced by wider anthropogenic impacts, variable groundwater levels and changing redox conditions.

The October 2023 Hydrogeological Conceptual Site Model report recommended the following review:

- If downward trends of ammoniacal-nitrogen (and continued downward trends of manganese) are evident at down-gradient WS202 and BH0 in January 2024 and peak concentrations at these boreholes are >10% lower than the peak concentration recorded at BH03 (source area), this will be considered acceptable evidence of natural attenuation. The requirement for continued monitoring of the down-gradient boreholes shall be reviewed.

The groundwater quality data for ammoniacal-nitrogen and manganese at WS202 and BH0 generally meet the above criteria, with the exception of a single elevated ammoniacal-nitrogen result at BH0.

The groundwater quality trends are masked by wider and historic anthropogenic impacts. However, the data indicate that the plume of contaminated groundwater has migrated down-gradient, towards the River Taff, with evidence of attenuation along the groundwater flow path as peak concentrations have generally reduced with distance from the spill area. The River Taff offers significant dilution potential for any residual contaminants within groundwater migrating from the spill area and there would be no discernible impact on river water quality.

Groundwater quality appears to have returned close to, or is already at, typical background levels within the site, and it is not therefore considered appropriate or necessary to continue monitoring groundwater quality or to undertake any further works.

1.0 INTRODUCTION

1.1 Project Introduction and Aims

ECL, on behalf of Veolia, has commissioned NSugg Ltd. to prepare a report detailing the Monitored Natural Attenuation (MNA) of a liquid sodium hydroxide (NaOH) spill at PB Leiner UK, Severn Road, Pontypridd, CF37 5SQ.

This report has been prepared to address comments raised by Natural Resources Wales (NRW) following their review of the Geo-Environmental Ground Investigation Assessment¹ (hereafter referred to as the 2023 Ground Investigation). NRW's comments are detailed below in Section 1.3.

The site's hydrogeological conceptual model is initially developed, based on a review of published data, previous ground investigations and recent surveying and monitoring. The potential source-pathway-receptor linkages are established and evidence of MNA is subsequently reviewed, based on site monitoring data.

MNA can be a viable, cost-effective remedial option for managing the risks posed by contaminated groundwater. Naturally occurring processes in the subsurface can reduce the toxicity, mobility or concentration of contaminants in groundwater. Such effects are the result of destructive mechanisms, including biodegradation, oxidation and hydrolysis, and non-destructive mechanisms such as sorption, dispersion and volatilisation, acting on contaminants².

1.2 Background

The following summary provides relevant background information regarding the NaOH spill event at PB Leiner (PB Gelatins) UK ('the site') and subsequent ground investigations; full details are provided within the 2023 Ground Investigation report and historic reports as referenced:

- On 11th June 2020, a spillage of approximately 20 tonnes of NaOH occurred at PB Leiner UK, covering an area of approximately 25m².
- Immediate measures were introduced by Veolia including isolation of the NaOH supply pipeline at its source (within PB Gelatins factory) and locking off the pipeline at the delivery point on the Veolia site. On the afternoon of 11th June 2020, the surface liquid was removed via vacuum tanker, by specialist contractor Egan Waste Services Ltd. The area was washed down, with the resulting washings also removed by vacuum tanker. All liquid wastes were disposed via PB Gelatins on-site trade effluent treatment plant.
- A preliminary site investigation was undertaken by ECL in July 2020³ which involved the installation of three boreholes (BH01 – BH03), with BH01 located up-gradient of the spill area, BH02 within the spill area and BH03 down-gradient (assuming groundwater flow direction towards the River Taff), although only BH03 was completed as a long-term monitoring borehole. The ground investigation included three hand-augered trial pits

¹ ECL, February 2023, Geo-Environmental Ground Investigation Assessment at PB Leiners (PB Gelatins), Cardiff, CF37 5SQ (ECL Reference: VEOL.01.02.GIR).

² Environment Agency, 2000, Guidance on the Assessment and Monitoring of Natural Attenuation of Contaminants in Groundwater.

³ ECL, August 2020, Geo-Environmental Ground Investigation Assessment at PB Leiners (PB Gelatins), Cardiff, CF37 5SQ (ECL Reference: ECL.095.01.01.GIR).

(HDP1 – HDP3) within the spill area. Soil samples were obtained for analysis and a single groundwater sample was obtained from BH03. The site investigation identified near surface soil material within the immediate spill area contaminated with elevated levels of sodium and increased pH values. However, the impact of the spill appeared constrained to the immediate spill location, with limited down-gradient migration.

- Repeat groundwater monitoring was undertaken in December 2021 (ECL report reference: VEOL.01.01.GE and identified potential down-gradient migration of contaminants due to a marginal increase in sodium levels since 2020. However, this evidence was based on a single monitoring event at BH03.
- The December 2022 site investigation (detailed within the 2023 Ground Investigation report) included the installation of two additional groundwater monitoring boreholes (WS201 within the spill area and WS202 down-gradient of the spill area). Repeat analysis of soil and groundwater samples was undertaken for comparison against 2020 data. The scope of the 2022 site investigation and the analytical suites were approved by NRW prior to works commencing, and the investigation aimed to assess the present (2022) land condition and extent of any natural attenuation. The report concluded that concentrations of sodium and pH (the marker compounds for the presence of NaOH) had significantly reduced in soils within the spill area compared to 2020 levels. However, elevated sodium concentrations were observed in groundwater down-gradient of the spill area, indicating potential migration of contaminants, although data were limited.

1.3 NRW Recommendations and Response

NRW reviewed the 2023 Ground Investigation report, and their key comments and recommendations can be summarised as follows:

1. Ammonium in groundwater exceeds relevant water quality standards at all monitoring points including down-gradient boreholes BH03 and WS202. Ammonium can be released from soils with the addition of NaOH and this is a known method of assessing the nitrogen content of soils. Ammonium does attenuate in soils and groundwater (ion exchange and oxidation) and may be dealt with by Monitored Natural Attenuation (MNA) at these concentrations, but this will require ongoing monitoring in down-gradient boreholes to ascertain this is occurring.

2. Manganese in groundwater also exceeds the water quality standard and should be monitored along with ammonium. Monitoring of dissolved oxygen, electrical conductivity, pH and ORP (oxidation-reduction potential) is also recommended. There are no concerns regarding sodium, iron or nickel concentrations at present.

3. The groundwater flow direction should be confirmed through appropriate surveying and monitoring, to confirm the presence of at least one down-gradient borehole located directly down-gradient of the centre of the plume.

4. An improved understanding of the contaminant pathways is required; monitoring boreholes must cover the depth(s) of potential pathways. The vertical extent of the plume should be delineated or at least the highest concentrations of potential contaminants should be within the monitored depths.

5. The presence of gravels indicates the potential for rapid movement of contaminants offsite to the river and concentrations are unlikely to be significant with respect to impact to the river. However, this should be confirmed with at least a simple source-pathway-receptor model. The groundwater gradient and estimated hydraulic conductivity is required.

In summary, it is recommended that the proper application of MNA be supported by a source-pathway-receptor model to assess risk to controlled waters. An additional option would be to remove the residual contaminants from the source zone by abstracting groundwater until concentrations are reduced below their respective water quality standards in the abstracted groundwater and nearby boreholes.

The down-gradient boreholes should continue to be monitored regularly.

The original proposal to remove the soil from the spill impacted area is no longer required, as the contaminants have migrated from this area. However, Veolia will now need to implement, as a minimum, a programme of monitored natural attenuation.

An initial Hydrogeological Conceptual Site Model report was prepared in October 2023⁴ to address the above comments and recommendations raised by NRA; the report developed the site's conceptual model and presented a review of initial monitoring data. NRW has requested that the Hydrogeological Conceptual Site Model report be updated as follows:

- 1. Review the report conclusions with respect to my main comment above, specifically, that the plume is not so much naturally attenuating but migrating relatively quickly towards the river and being effectively flushed from the site due to the high permeability of the underlying sands and gravels.*
- 2. Analyse the groundwater from the borehole with the highest concentrations of manganese and ammonium (WS202) for dissolved metals, especially those with low EQS, such as copper, and compare against the current EQS for surface waters, then redo the river-groundwater dilution calculations based on conservative (worst-case) approach. This is to help confirm that there is no risk to the receptor (receiving river) and support a request for cessation of the current investigation.*

This updated report aims to address the above comments and should be read in conjunction with the previous, referenced documents.

NRW identified the potential release of ammonium and manganese from the subsurface, as a result of the NaOH spill, with appropriate monitoring recommendations. A six-month programme of monthly groundwater monitoring was undertaken between August 2023 and January 2024, with the dataset reviewed within this report.

1.4 Report Structure

Section 2 of this report presents the site's hydrogeological setting, based on published data, the 2020 and 2022 ground investigations and recent surveying.

Section 3 develops the hydrogeological conceptual site model and reviews all available groundwater quality data for evidence of natural attenuation.

Section 4 presents a report summary and recommendations.

⁴ NSugg Ltd., October 2023, PB Leiner UK, Severn Road, Pontypridd, Hydrogeological Conceptual Site Model to support Monitored Natural Attenuation. Ref: NS_0118_21.

2.0 HYDROGEOLOGICAL SITE SETTING

This section of the report presents the hydrogeological site setting, to inform the conceptual site model.

2.1 Site Location and Monitoring Network

The NaOH spillage occurred on 11th June 2020 at the western end of the PB Leiner UK site; the approximate spillage location is indicated on Figure 1, with a more detailed site plan included as Figure 2.

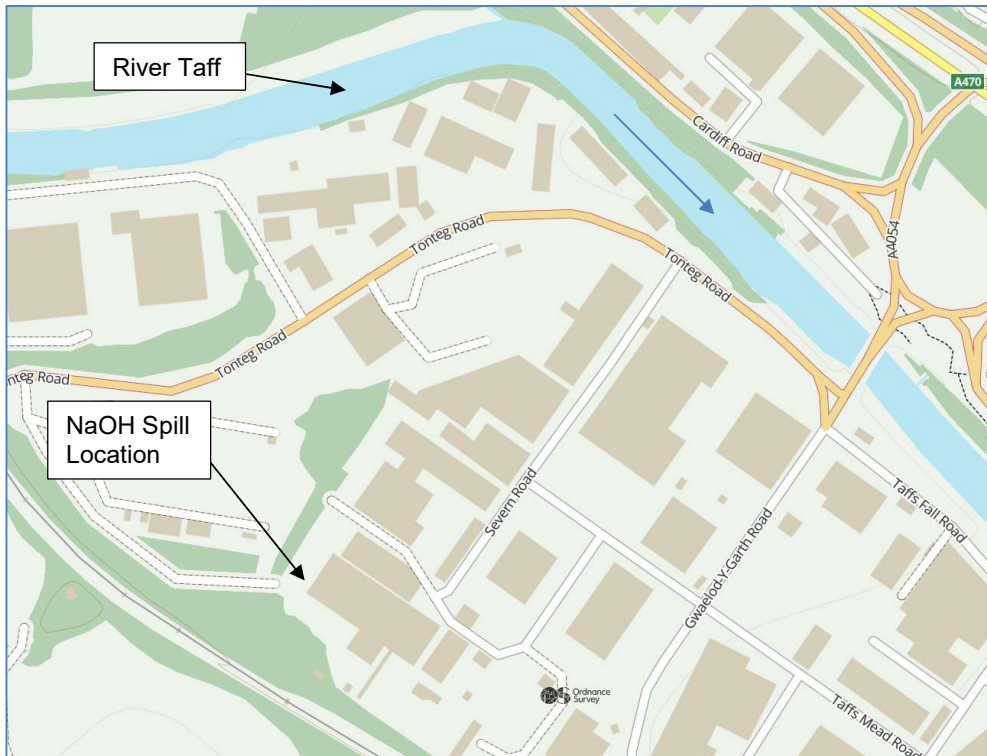


Figure 1. Site Location Plan

The approximate extent of the NaOH spillage is outlined in yellow on Figure 2. Figure 2 also presents the groundwater monitoring borehole locations, which are detailed in Sections 2.2 and 2.3.



Figure 2. Site Monitoring Plan (extracted from 2023 Ground Investigation report)

2.2 Geology and Ground Conditions

Review of the British Geological Survey's online published mapping confirms the following local ground conditions:

- Superficial Glacial Till (Diamicton – poorly sorted particles from clay to boulders within an unconsolidated matrix of clay, silt or sand) overlain locally by glaciofluvial deposits (sand and gravel). These glacial deposits are in turn overlain locally by River Terrace Deposits (sand and gravel) and Alluvium (clay, silt, sand and gravel) associated with the River Taff.
- These superficial deposits overlie the Brithdir Member (sandstone) of the Carboniferous Pennant Sandstone Formation.

Published geological logs from boreholes installed across the wider site in 1975 confirm the superficial deposits extend to at least 15m below ground level (mbgl) locally, and typically comprise compact to very compact sand and gravel with occasional cobbles and boulders (the published borehole log is included within Appendix 1).

Geological logs are also included within Appendix 1 for on-site monitoring boreholes WS201, WS202 and BH03, and for the 2020 ground investigation boreholes BH01 and BH02 which were subsequently backfilled. No log is available for historic borehole BH0.

Available geological logs, together with the findings of previous studies confirm the following site-specific ground conditions within the vicinity of the spill location; monitoring location descriptions assume a groundwater flow direction to the north or north-east, towards the River Taff:

Location	Boreholes	Ground Conditions	Presence of Groundwater
Approximately 25m south of spill (up-gradient)	BH01	0.0 to 1.4mbgl: Made Ground 1.4 to 3.6mbgl: slightly silty, slightly clayey sand with occasional gravel (refusal at 3.6mbgl)	Groundwater at 2.15mbgl
Spill Area	WS201 & BH02	0.0 to 1.4mbgl/1.6mbgl: Made Ground 1.4/1.6 to 3.2/3.6mbgl: silty sand with occasional gravel (refusal at 3.2/3.6mbgl)	Groundwater at 1.24mbgl
Approximately 40m north-east of spill (down-gradient)	BH03	0.0 to 1.7mbgl: Made Ground 1.7 to 2.3mbgl: slightly clayey, silty sand with occasional gravel 2.3 to 3.7mbgl: gravelly sand with occasional cobbles 3.7 to 4.7mbgl: gravel with coarse sand matrix (refusal at 4.7mbgl)	Groundwater at 1.89mbgl
Approximately 60m north-east of spill (down-gradient)	WS202 & BH0 (no log available)	0.0 to 2.6mbgl: Made Ground 2.6 to 3.3mbgl: gravelly sand with occasional cobbles (refusal at 3.3mbgl)	Groundwater at 1.76mbgl

The borehole logs confirm variable thickness of made ground, with up to 2.6m recorded at WS202. The made ground includes evidence of the site’s historic land uses, which included a metal alloy works, with the presence of brick, slag and ash/clinker noted, together with occasional evidence of hydrocarbons.

The published borehole logs from the wider site confirm the superficial deposits extend to at least 15mbgl locally; therefore, the borehole refusals noted above are assumed to relate to the presence of large cobbles/boulders within the superficial deposits. The superficial deposits predominantly comprise sand and gravel and are inferred as glaciofluvial deposits.

Groundwater was recorded at a shallow depth (1.24mbgl to 2.15mbgl) within the made ground / superficial deposits. The borehole log for BH03 notes the presence of wet, saturated ground at 2.2mbgl to 2.3mbgl (silty sand) but a more significant groundwater strike within the underlying gravels at between 2.6mbgl and 3.2mbgl, rising to 1.9mbgl.

2.3 Groundwater Levels and Flow

As noted above, the site-specific borehole logs (Appendix 1) confirm the presence of shallow groundwater within the made ground and/or superficial deposits beneath the site.

Groundwater monitoring boreholes BH0, BH3, WS201 and WS202 were surveyed on 17th August 2023 and available groundwater level data are presented in Table 1.

Table 1: Groundwater Level Monitoring Data

Borehole	Screened Depth & Horizon Monitored	Groundwater Level (mAOD)						
		16/12/2022	17/08/2023	19/09/2023	16/10/2023	14/11/2023	12/12/2023	09/01/2024
WS201 spill area	1.1mbgl to 3.1mbgl (39.89mAOD to 37.89mAOD) Made ground and superficial deposits (silty sand)	39.75	39.89	39.89	40.21	40.63	40.57	39.31
WS202	1.15mbgl to 3.15mbgl (39.46mAOD to 37.46mAOD) Made ground and superficial deposits (gravelly sand)	38.85	38.92	38.60	39.02	39.45	39.44	39.27
BH0	Unknown, no borehole log available. Borehole depth: 3.6mbgl. Assume screened in made ground and superficial deposits	-	39.02	38.65	39.14	39.76	39.62	39.44
BH03	1.0mbgl to 4.0mbgl (40.09mbgl to 37.09mbgl) Made ground and superficial deposits (silty sand, gravelly sand, gravel)	39.20	39.48	39.52	39.58	40.13	39.91	39.69

Figure 1 presents groundwater hydrographs for the monitoring boreholes and Drawing 1 presents the groundwater levels recorded on 19th September 2023 together with inferred groundwater contours.

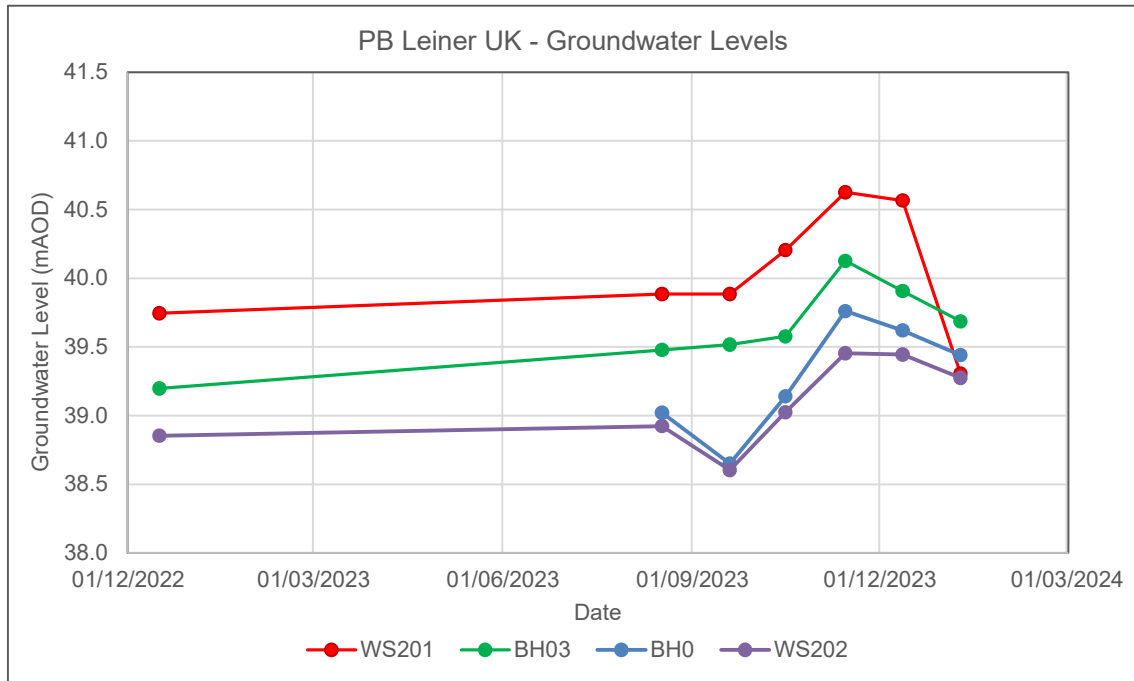


Figure 1. Groundwater Hydrographs (result for WS201, January 2024, is out of trend)

The data confirm that groundwater is shallow, typically 0.5m to 2.0m below ground level, with the highest groundwater levels recorded at borehole WS201 within the spill area.

Drawing 1 confirms a local groundwater flow direction to the north-east, towards the River Taff, as anticipated. The average hydraulic gradient beneath the site is approximately 0.025 but ranges from approximately 0.01 in the vicinity of the spill to approximately 0.05 down-gradient of the spill area, based on the September 2023 data.

The inferred groundwater velocity and flow rate are discussed in Section 3.

2.4 Aquifer Characteristics

Review of the British Geological Survey online mapping confirms that the local superficial deposits (glaciofluvial deposits, river terrace deposits and alluvium) are classified as Secondary A aquifers. The presence of glacial till has not been proven beneath the site; however, this is classified as a Secondary aquifer (undifferentiated). The underlying bedrock is also classified as a Secondary A aquifer.

Shallow groundwater is present within the made ground and superficial glaciofluvial deposits; these comprise unconsolidated materials with intergranular groundwater flow. Groundwater is typically less than 2mbgl and is therefore vulnerable to any surface contamination sources.

2.5 Baseline Soils and Background Groundwater Quality

The 2020 Geo-Environmental Ground Investigation Assessment identified a number of contaminants including metals, PAHs and hydrocarbons within up-gradient soils and made ground (borehole BH01), associated with the site's historic industrial land uses. No up-gradient groundwater quality data are available.

Groundwater quality and soils data from the NaOH spill area and from down-gradient boreholes are discussed in Section 3, where the hydrogeological conceptual site model and evidence of natural attenuation are reviewed.

2.6 Hydrological Setting

The site is located within the surface water catchment of the River Taff, which flows in a south-south-easterly direction through Pontypridd, passing approximately 350m north of the spillage location at its closest point.

The closest NRW river monitoring station is located on the River Taff at Pontypridd (grid reference: ST 07941 89726), approximately 3.5km upstream of the site. Review of the UK Centre of Ecology & Hydrology's National River Flow Archive confirms a mean flow of 21.04m³/s, and a low flow (Q₉₅ with 95% exceedance) of 3.63m³/s, based on the 1970 – 2022 data record.

Review of Ordnance Survey mapping indicates a river bank height in the vicinity of the site, of between 39mAOD and 40mAOD, with a typical water level of 36mAOD to 37mAOD. The shallow groundwater beneath the site has been recorded in the range 38.60mAOD to 39.89mAOD and is therefore assumed to be in hydraulic continuity with the River Taff and contributing baseflow to the watercourse; this is reviewed further within Section 3.

3.0 HYDROGEOLOGICAL CONCEPTUAL SITE MODEL

This section of the report develops the hydrogeological conceptual site model of the source, pathway and receptor terms, focussing on evidence of natural attenuation within the subsurface.

3.1 Source Term Characteristics

Sodium hydroxide (NaOH), also known as caustic soda, disassociates in groundwater into sodium ions and hydroxide ions. This strongly alkaline solution will produce a local change in pH, the extent and duration of which is dependent on the soil buffering capacity. A temporary increase in sodium concentrations may also be observed, although this in turn may release other cations into solution via cation exchange. Other secondary groundwater quality impacts may also be observed, depending on the nature of the ground conditions; changes to contaminant concentrations and pH can release a previously stable contaminant.

The locally increased pH may have resulted in increased solubility of certain metals. NaOH has reported use as a soil washing reagent, to wash soils contaminated by arsenic and lead, with the high pH conditions preventing reabsorption⁵. The presence of hydroxide ions can also convert ammonium to ammonia, with use of NaOH a known method for measuring the concentration of ammonium in solution.

The 2023 Ground Investigation Report presents the results of soils and groundwater analysis from the NaOH spill area undertaken in 2020 and 2022. In 2020, the pH of soils within the spill area ranged from pH9.7 to pH10.6; by 2022 the soils pH had reduced to the range pH8.3 to pH10.5. In 2020, the sodium concentrations within soils of the spill area ranged from 750mg/kg to 14,000mg/kg; by 2022 the sodium concentrations had reduced significantly, with all results less than 420mg/kg.

The source term concentrations, based on the 2020 soils analysis, reduced significantly with depth, indicating that the contamination was largely contained within the surface 0.5m thickness of made ground at that time.

No groundwater quality data are available from the NaOH spill area from the 2020 ground investigation; recent data are reviewed in detail within Section 3.2.2. The 2023 Ground Investigation report records the presence of elevated concentrations of manganese and ammonium in groundwater, which appear to have been mobilised from the subsurface following the NaOH spill event. These have been identified as the contaminants of concern and their down-gradient migration and attenuation is reviewed in Section 3.2.2.

Sorption and redox reactions are generally considered the dominant mechanisms for reducing the mobility, toxicity or bioavailability of inorganic contaminants such as manganese and ammonium. Ammonium may also be subject to aerobic biodegradation. Evidence of these attenuation mechanisms is reviewed in the following sections. It is noted that ammonium concentrations in groundwater are monitored and reported as ammoniacal-nitrogen (as N).

⁵ Zhang H et al, 2022, Washing Reagents for Remediating Heavy-Metal-Contaminated Soil: A Review. *Front. Earth Sci.* 10:901570. doi: 10.3389/feart.2022.901570.

3.2 Pathway

3.2.1 Groundwater Flow Pathway and Travel Times

Section 2 of this report confirms the presence of shallow groundwater within the made ground and superficial deposits beneath the site, with groundwater flow towards the north-east, discharging into the River Taff approximately 375m to the north-east. Groundwater levels beneath the site fall towards the River Taff from approximately 39.9mAOD to 38.6mAOD, with typical river water levels in the range 36mAOD to 37mAOD.

Intergranular shallow groundwater flow will occur via these unconsolidated deposits, with opportunities for natural attenuation of contaminants, predominantly via dispersion, diffusion, cation exchange, sorption and biodegradation.

Once the contaminants enter groundwater, they are transported with groundwater flow, but the extent of the contamination will spread across a larger area through the processes of diffusion and dispersion. The density of the liquid NaOH infiltrating to the groundwater table would have been comparable to the density of groundwater, thus restricting the initial vertical mixing within the aquifer. Vertical dispersion of the contaminants down-gradient is generally assumed to be limited to 0.1% of the pathway length⁶. Therefore, based on a groundwater flow pathway of approximately 60m from the spill location to the down-gradient boreholes WS202 and BH0, a vertical dispersion of approximately 0.06m would be anticipated.

Review of Drawing 1 confirms that borehole WS201 is located within the spill area and boreholes BH03, BH0 and WS202 are all located at various distances down-gradient of the spill. These boreholes are constructed with screened response zones typically between 1.1mbgl and 3.1mbgl. Due to the shallow depth of groundwater and relatively permeable intergranular aquifer, this screened horizon is inferred to include the zone of highest groundwater contaminant concentrations associated with the NaOH spill.

The velocity of groundwater flow, and unretarded conservative contaminant migration within groundwater, can be calculated using Darcy's Law as:

$$V = KI$$

Where: V is the groundwater velocity
K is the aquifer hydraulic conductivity
I is the hydraulic gradient

Assuming an average hydraulic gradient of 0.025 (refer to Section 2.4) and a typical hydraulic conductivity range for coarse gravelly sand of 1.0×10^{-5} m/s to 1.0×10^{-3} m/s, a groundwater velocity of between 2.5×10^{-7} m/s and 2.5×10^{-5} m/s is inferred. This is equivalent to between 8m/year and 788m/year.

The rate of groundwater flow through the spill area can also be estimated using Darcy's Law:

$$Q = AKI$$

Where: Q is the groundwater flow rate
A is the cross-sectional area of groundwater flow
K is the aquifer hydraulic conductivity

⁶ Environment Agency, January 2001, Guidance on the Assessment and Interrogation of Subsurface Analytical Contaminant Fate and Transport Models.

I is the hydraulic gradient

As above, an average hydraulic gradient of 0.025 can be inferred, and a hydraulic conductivity range of between $1.0 \times 10^{-5} \text{m/s}$ and $1.0 \times 10^{-3} \text{m/s}$ is considered appropriate for the ground conditions. The width of the assumed spill area, perpendicular to the direction of groundwater flow, is approximately 20m and an assumed worse-case vertical mixing zone of 5m gives a cross-sectional area of groundwater flow of 100m^2 . Therefore, the approximate rate of groundwater flow through the spill area is calculated as between $2.5 \times 10^{-5} \text{m}^3/\text{s}$ and $2.5 \times 10^{-3} \text{m}^3/\text{s}$. This is equivalent to between 0.03l/s and 2.5l/s and is discussed further in Section 3.3.

The hydraulic gradient is shown to vary across the site and preferential flow pathways may occur where the aquifer is naturally more permeable and/or the presence of relatively low permeability made ground is limited. It is not considered appropriate to undertake borehole pumping tests to determine site-specific hydraulic conductivity data, due to the spatial variability in hydraulic conductivity and the potential to disrupt the local groundwater flow regime and mobilise contaminated groundwater into the area, thus influencing the groundwater quality monitoring datasets and potential for MNA discussed below.

3.3.2 Groundwater Quality Monitoring Data

NRW's recommendations are summarised in Section 1.3 and include routine groundwater quality monitoring for evidence of natural attenuation of the contaminants of concern. Routine groundwater quality monitoring commenced in August 2023 as detailed in Table 2.

Table 2: 2023 Groundwater Monitoring Schedule

Boreholes	Frequency	Parameters
WS201 (spill area)	Monthly	Manganese (dissolved)
BH03 (approximately 40m down-gradient of spill area)		Electrical Conductivity
BH0 & BH202 (approximately 60m down-gradient of spill area)		pH
		Dissolved Oxygen
		Redox Potential
		Ammoniacal-Nitrogen (as N)
		Nitrate (as NO_3)

Borehole WS201 is located within the spill area and boreholes BH03, BH0 and WS202 are located down-gradient, within the groundwater flow pathway to the River Taff.

Groundwater quality monitoring has been undertaken monthly between August 2023 and January 2024 inclusive, providing a six-month dataset. All available groundwater quality data from this period, together with historic monitoring events, are presented in Appendix 2; this includes raw datasets and graphs to confirm groundwater quality trends.

Table 3 presents the most recent groundwater quality data, from 9th January 2024 monitoring event, compared against the relevant water quality standards, to provide a review of the present-day situation.

Table 3: January 2024 Groundwater Quality Data

Parameter (units)	Concentration				Water Quality Standard
	WS201 (spill area)	BH03	BH0	WS202	
Manganese, dissolved (µg/l)	980	1600	1500	1800	50 ^a
Electrical Conductivity (µS/cm)	594	681	416	704	2500 ^a
pH (units)	7.4	6.9	6.8	7.2	<6 or >9
Dissolved Oxygen (mg/l)	4.5	4.3	7.1	5.1	n/a
Redox Potential (mV)	180	190	210	180	n/a
Ammoniacal-Nitrogen as N (mg/l)	0.16	3.6	1.1	6.9	0.39 ^a
Nitrate as NO ₃ (mg/l)	2.1	2	1.3	0.23	50 ^a

Notes: Water Quality Standards are based on freshwater Environmental Quality Standards where available. (a) UK Drinking Water Standards.

The January 2024 data presented in Table 1, confirms that the groundwater quality at WS201, located within the original spill area, is relatively good with near-neutral pH and an ammoniacal-nitrogen concentration below the UK Drinking Water Standard (DWS). Groundwater quality within the down-gradient boreholes is variable but the concentrations of the contaminants of concern (manganese and ammoniacal-nitrogen) remain slightly elevated compared to residual concentrations within the spill area (boreholes WS201).

Appendix 2 includes time-series graphs of the monitored parameters; these include trend lines but the actual variation in concentrations between monitoring events is unknown. Graphs of the contaminants of concern, ammoniacal-nitrogen and manganese are included below. Review of the available groundwater quality data indicates the following:

- Manganese (dissolved) concentrations in groundwater are presented within Figure 2. Monitoring within the spill area (WS201) commenced in December 2022, approximately 18 months after the spill event. Concentrations at WS201 have remained relatively low and are considered representative of background groundwater, with no residual impact from the NaOH spill evident. A longer data record is available for borehole BH03, located 40m down-gradient of the spill area; this borehole reports gradually declining manganese concentrations from 3400µg/l in July 2020, one month after the spill event, to 160µg/l in September 2023 as the plume of contaminated groundwater appears to have migrated down-gradient and attenuated. Recent concentrations at BH03 (October 2023 to January 2024) are variable and often elevated (maximum: 2300µg/l), potentially reflecting seasonally elevated groundwater levels interacting with the in-situ made ground. The boreholes are all installed within made ground, within an active industrial estate and historic coal mining area; therefore, background anthropogenic groundwater quality influences would be anticipated. Manganese concentrations within all boreholes are consistently, and often significantly elevated, above the 50µg/l UK Drinking Water Standard. Data from boreholes BH0 and WS202 located approximately 60m down-gradient of the spill, report similar manganese concentrations to BH03, indicating that any peak manganese concentrations associated with the spill event have passed.

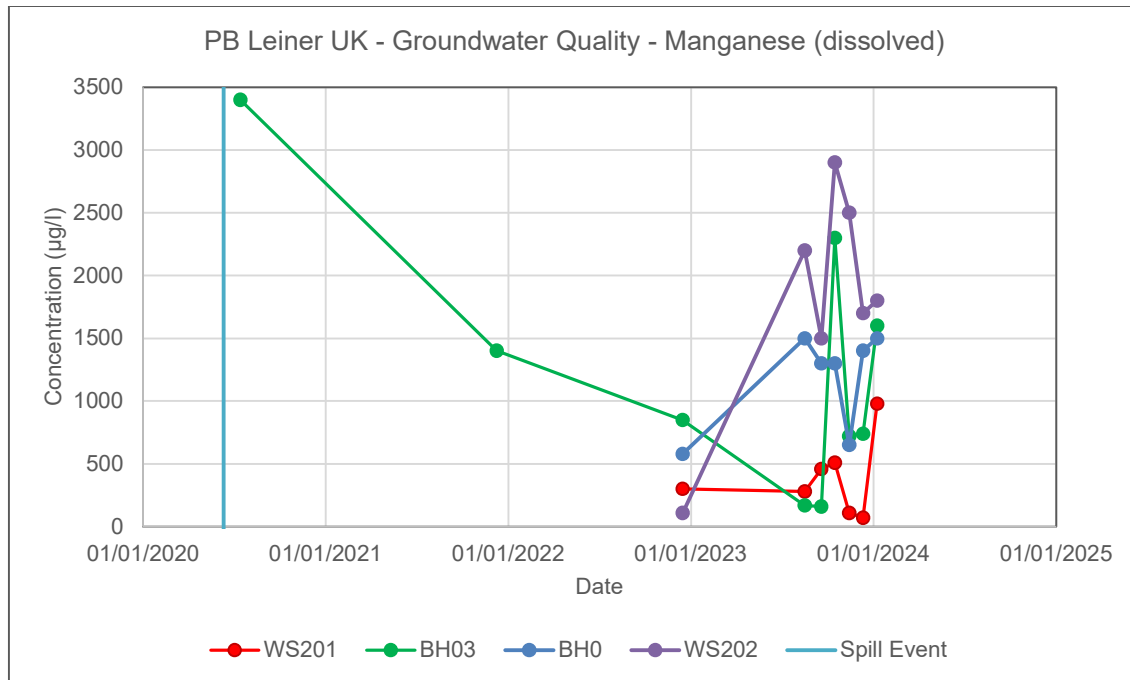


Figure 2. Manganese Concentrations in Groundwater

- Ammoniacal-nitrogen concentrations in groundwater are presented below within Figure 3. Concentrations within the spill area (WS201) have declined to below the UK DWS also indicating that the plume of contaminated groundwater has migrated down-gradient, with residual concentrations attenuated to acceptable levels. Concentrations at BH03, located 40m down-gradient of the spill increased to a maximum of 36.4mg/l in December 2021 and have subsequently declined, remaining below 10mg/l since September 2023. Concentrations at BH0 and WS202, located approximately 60m down-gradient of the spill area, are more variable with concentrations often exceeding 10mg/l during 2023. The peak concentration of 40mg/l at BH0 has been confirmed by the laboratory but appears to be an isolated outlier. Ignoring this single elevated result, concentrations at BH0 and WS202 have followed a general declining trend since September 2023, with the most recent results (January 2024) remaining below 7mg/l at all boreholes.
- The most recent data report slightly elevated concentrations of both manganese and ammoniacal-nitrogen in groundwater at the down-gradient boreholes, compared to concentrations within the spill area. This may reflect the residual impact of the plume of contaminated groundwater and/or the spatial variation in made ground or other potential anthropogenic influences on groundwater quality within the area.

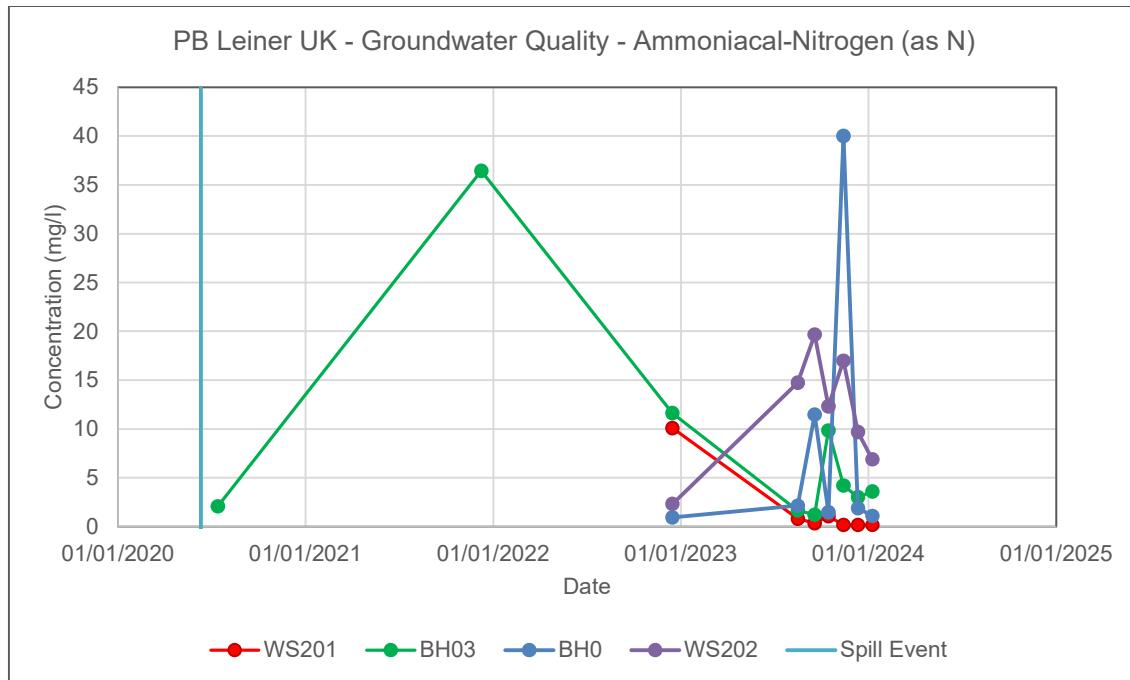


Figure 3. Ammoniacal-Nitrogen Concentrations in Groundwater

- The dissolved oxygen content and redox potential of groundwater samples have been included in the monthly monitoring suite since August 2023. The dissolved oxygen content of the groundwater samples confirms aerobic conditions, although the oxygen content is occasionally reduced at down-gradient BH0 relative to the other monitoring locations. Aerobic biodegradation of organic contaminants generally occurs under a redox potential greater than 150mV². The monitoring data confirm a redox potential generally in the range 100mV to 250mV for groundwater beneath the site, which may limit aerobic biodegradation. The redox potential of groundwater at down-gradient borehole BH0 was significantly lower in September 2023 (33mV) and November 2023 (-110mV). It is noted that these periods of low redox potential and reducing conditions coincide with peak ammoniacal-nitrogen concentrations at BH0. No borehole log is available for BH0, but the presence of reducing conditions in shallow groundwater indicates low permeability ground conditions with relatively limited groundwater through flow.
- In summary, the data confirm no significant residual impact for the contaminants of concern within groundwater at the source area of the NaOH spill. Concentrations at BH03, approximately 40m down-gradient of the spill area, are comparable to background levels, with occasional groundwater quality impacts considered indicative of wider anthropogenic land uses. Any potential residual impacts of the NaOH spill on groundwater quality at BH0 and WS202, located approximately 60m down-gradient, are considered limited, indicative of the 3 ½ years that have elapsed since the spill event. Groundwater beneath the site is shallow and within the made ground; therefore, the groundwater quality is influenced by the nature of the made ground and any wider anthropogenic inputs associated with the site’s industrial setting. Spatial and temporal variations in groundwater levels and redox conditions will alter the mobility of substances in groundwater and redox reactions including nitrification, hence influencing local groundwater quality. However, the data indicate no significant residual impact of the NaOH spill in groundwater within the site. The plume has migrated down-gradient, and the reduction in peak concentrations with distance down-gradient indicates natural attenuation via sorption, cation exchange and/or biodegradation.

- NRW's comments on the October 2023 Conceptual Site Model report are detailed in Section 1.3 and included a recommendation to analyse groundwater quality at WS202 for dissolved metals with a low freshwater EQS, such as copper. However, no historic groundwater quality data are available for metals, thus preventing trend analysis. The six-month groundwater quality monitoring schedule was agreed with NRW and targets the primary contaminants of concern. Groundwater is present within the shallow made ground, with the area subject to a long industrial land use. Therefore, metals are likely to be present in groundwater, due to historic anthropogenic impacts as observed for manganese, with their mobility largely dependent on pH and redox conditions. The groundwater quality monitoring data (Appendix 2) confirm no significant change in the pH of groundwater following the spill event. Redox conditions are spatially and temporally variable as discussed above, but no trends associated with the spill event are evident. Therefore, it is concluded that any potential impacts of the NaOH spill on the mobility of metals would not be discernible from historic, anthropogenic concentrations and the focus of the monitoring and this report has remained on the primary contaminants of concern: manganese and ammoniacal-nitrogen.

3.3 Receptor

The potential receptor for groundwater contamination migrating down-gradient from the spill area is the River Taff located approximately 375m down-gradient. Section 2.7 confirms a mean river flow for the River Taff at Pontypridd (approximately 3.5km upstream of the site) of 21.04m³/s, and a low flow (Q₉₅ with 95% exceedance) of 3.63m³/s, based on the 1970 – 2022 data record.

The approximate rate of groundwater flow through the spill area is calculated in Section 3.2 as between 2.5x10⁻⁵m³/s and 2.5x10⁻³m³/s. This is equivalent to between 0.0001% and 0.012% of the mean river flow, and equivalent to between 0.0007% and 0.07% of the Q₉₅ flow rate. Therefore, the River Taff offers significant dilution potential for any contaminants within groundwater migrating from the spill area and there would be no discernible impact on river water quality.

3.4 Summary of the Hydrogeological Conceptual Site Model

The hydrogeological conceptual site model can be summarised as follows:

Source	The NaOH spill event occurred in June 2020 and data indicate the presence of elevated manganese, sodium, ammoniacal-nitrogen and pH within groundwater beneath the spill area and immediately down-gradient in 2020. Recent data (September 2023) confirms that concentrations of these key contaminants in groundwater beneath the spill area have declined to background levels.
Pathway	Groundwater flows in a north-easterly direction towards the River Taff. Groundwater levels are relatively shallow beneath the site, with a groundwater flow pathway within the permeable sands and gravels of the superficial deposits. The groundwater flow pathway to the River Taff is approximately 375m, with an estimated unretarded groundwater velocity of between 8m/year and 788m/year. The groundwater quality data also indicate a groundwater velocity within this range, based on the breakthrough curves. Monitoring boreholes BH03, BH0 and WS202 are located on the groundwater flow pathway between the spill area and the river. The groundwater quality data indicate that the contaminants of concern have migrated down-gradient with groundwater flow. Reduced peak concentrations are observed at down-

gradient boreholes due to the effects of sorption, cation exchange, diffusion, dispersion and the potential biodegradation of ammoniacal-nitrogen.

Receptors The primary receptor for groundwater contaminants is the River Taff. However, any potential impact on river water quality would be negligible, with the groundwater throughflow from the spill area representing just 0.0001% to 0.012% of the mean river flow.

4.0 SUMMARY AND RECOMMENDATIONS

This report presents a review of Monitored Natural Attenuation of the June 2020 NaOH spill event at PB Leiner UK, Pontypridd and is based on a review of previous ground investigations and recent site monitoring data.

Shallow groundwater flow occurs within the made ground and superficial deposits beneath the site, with groundwater discharging to the River Taff approximately 375m down-gradient of the spill area. Recent groundwater level monitoring data confirm that existing boreholes BH03, BH0 and WS202 are located hydraulically down-gradient of the spill location, between the source and the receptor (the River Taff) and are therefore appropriate for monitoring groundwater quality impacts and trends.

Previous studies identified elevated ammonium and manganese in groundwater, which had been released from the subsurface as a result of the NaOH spill event and subsequent chemical interactions; these represent the contaminants of concern. Monthly groundwater quality monitoring has been undertaken between August 2023 and January 2024, with recent data compared against previous (2020 and 2022) datasets. Source term concentrations of ammoniacal-nitrogen and manganese have declined to background levels within the spill area. Concentrations within down-gradient boreholes appear to have peaked and are generally following a declining trend, indicating that the plume has migrated down-gradient, as would be anticipated. The peak observed concentrations of ammoniacal-nitrogen and manganese reduce with distance along the flow path, indicative of natural attenuation, although the data are also influenced by wider anthropogenic impacts, variable groundwater levels and changing redox conditions.

The six-month period of monthly groundwater monitoring ceased in January 2024, approximately 3 ½ years after the spill event. The October 2023 Hydrogeological Conceptual Site Model report⁴ recommended the following review:

- If downward trends of ammoniacal-nitrogen (and continued downward trends of manganese) are evident at WS202 and BH0 in January 2024 and peak concentrations at these boreholes are >10% lower than the peak concentration recorded at BH03, this will be considered acceptable evidence of natural attenuation. The requirement for continued monitoring of the down-gradient boreholes shall be reviewed.

The groundwater quality data for ammoniacal-nitrogen and manganese at WS202 and BH0 generally meet the above criteria, with the exception of a single elevated ammoniacal-nitrogen result at BH0. The groundwater quality trends are masked by wider and historic anthropogenic impacts, but the data indicate that the plume of contaminated groundwater has migrated down-gradient, towards the River Taff, with evidence of attenuation along the groundwater flow path. Section 3.3 of this report indicates that the approximate rate of groundwater flow through the spill area is equivalent to between 0.0001% and 0.012% of the mean river flow. Therefore, the River Taff offers significant dilution potential for any residual contaminants within groundwater migrating from the spill area and there would be no discernible impact on river water quality.

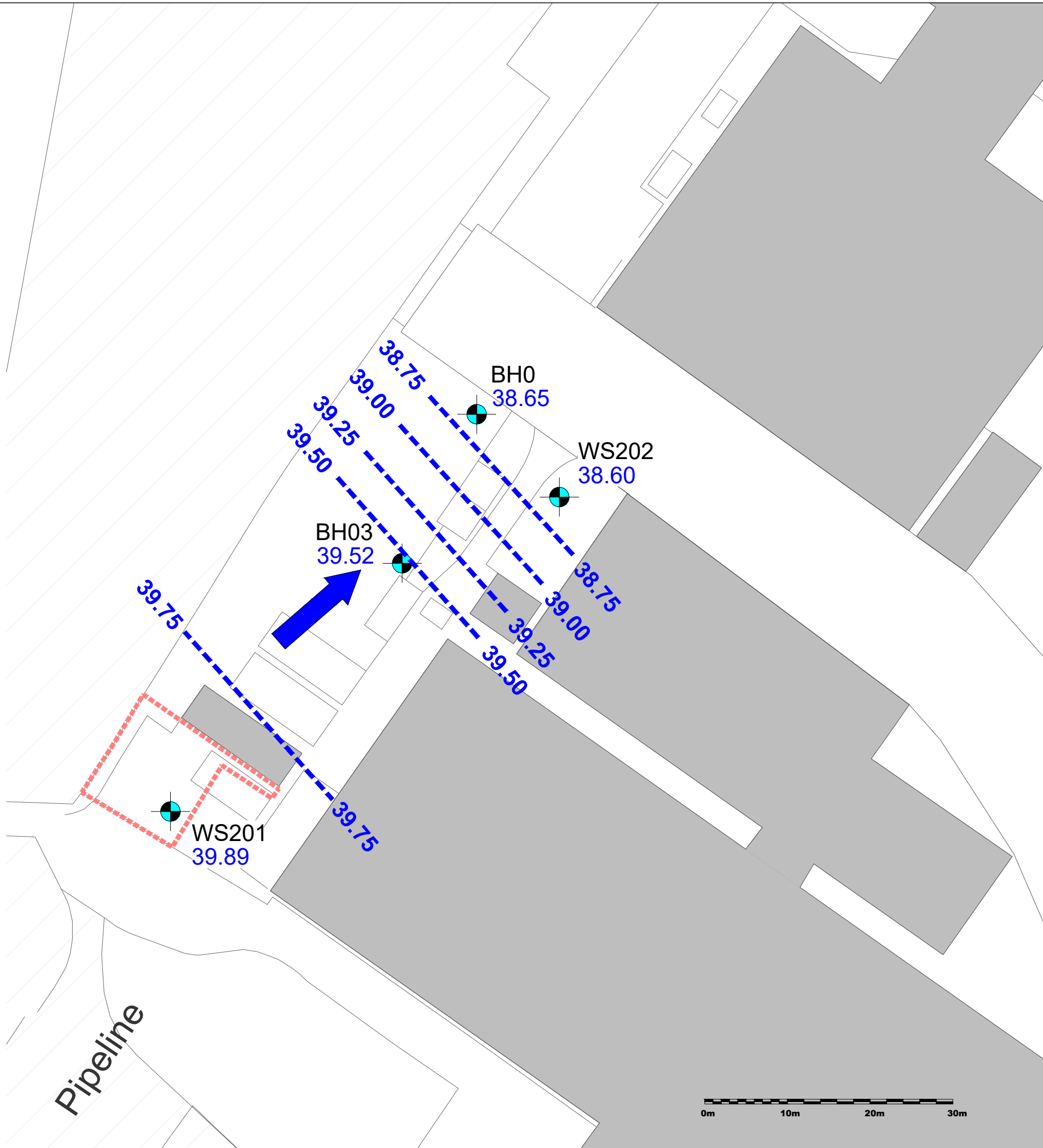
Groundwater quality appears to have returned close to, or is already at, typical background levels within the site, and it is not therefore considered appropriate or necessary to continue monitoring groundwater quality or to undertake any further works.

5.0 CLOSURE

This report has been prepared by Nicola Sugg (trading style of NSugg Limited) with all reasonable skill and care, and in accordance with the services agreed with ECL. Relevant information provided by ECL has been accepted in good faith as being accurate and valid. This report is based on the relevant guidance and legislation in force at the date of the report and should be reviewed if such guidance and legislation are amended or superseded.






This report is for the exclusive use of ECL and Veolia; no warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without prior written consent from Nicola Sugg.

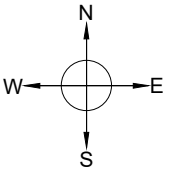
DRAWINGS



NOTES

Reference:
 Environmental Compliance Ltd. Intrusive Investigation
 Locations Plan, PBGE.01.06-01, 24.10.2022.

- LEGEND**
-  Groundwater Monitoring Boreholes
 -  Groundwater Level (mAOD) 19th September 2023
 -  Inferred Groundwater Contours within the Made Ground and Superficial Deposits
 -  Inferred Direction of Groundwater Flow within the Made Ground and Superficial Deposits
 -  Approximate Extent of NaOH Spillage, June 2020



SITE
 PB Leiner, Pontypridd

PROJECT
 Hydrogeological Conceptual Site Model

DRAWING TITLE
 Groundwater Levels and Inferred Groundwater Contours

DRAWING NUMBER 001	REVISION 0
SCALE 1:500 @ A3	DATE 09.10.2023

Nicola Sugg
 Consultant Hydrogeologist & Hydrologist
 T: 07866 374158 www.n sugg.co.uk



APPENDIX 1



STRATA SURVEYS LTD

Bristol Office

JOB P. Leiner & Sons Ltd TREForest

Job No. B51008

METHOD 150mm S&A

(Pantypidd)

DATE 14 December 75

Scale 1 : 50

BOREHOLE LOG
ST18NW/158A
B.H. No. 1
1012
8682

John

Depth m	Sampling details	Penet. Tests	Boring details	Ground Water	Depth m	Borehole Findings		Level m
						Legend	Description	
0					0		TARMAC	
0.5	P1	SPT N=33			0.5		Fill of clay and gravel	
2	B1	CPT N=66	2h chisel		2		Brown SAND and GRAVEL	
2.5			Aborted		2.5		BOULDER (not penetrated)	
3					3			
4					4			

SYMBOLS D = Disturbed sample U = Undisturbed 100 mm sample W = Water sample
B = Bulk disturbed sample SPT = Standard Penetration Test CPT = Cone ditto
P = SPT spoon sample N = 300 mm blow count N = ditto extrapolated
NR = No recovery ∇ = Depth cased ▼ = transient water level ▽ = standing ditto

REMARKS Hole aborted at 2.5 m. Moved to BH 1A adjacent.



ST18NW/158A

STRATA SURVEYS LTD

Bristol Office

BOREHOLE LOG

JOB P. Leiner & Sons Ltd TREForest
METHOD 150 mm S & A
DATE 15-16 December 75

Job No. B51008
Scale 1 : 50

B.H. No. 1A sht 1 of 2
10128682

Depth m	Sampling details	Penet. Tests	Boring details	Ground Water	Depth m	Borehole Findings		Level m
						Legend	Description	
0					0		TARMAC	
1	P1	SPT N=33			1		FILL of clay and gravel	
2	B1	CPT N=60			2		Very compact coarse brown SAND and GRAVEL with cobbles	
3		CPT N=62			3			
4					4			
5	B2 ▲W1	CPT N=53		Struck & Standing	5			
6					6			
7		CPT N=44	15 Dec		7		Compact medium/compact brown SAND, with occasional gravel and cobbles	
8	B3	CPT N=40			8			
9					9			
10		CPT N=36			10		Compact coarse brown SAND and GRAVEL, with occasional cobbles and boulders (cont.)	
11					11			

SYMBOLS D = Disturbed sample U = Undisturbed 100 mm sample W = Water sample
B = Bulk disturbed sample SPT = Standard Penetration Test CPT = Cone ditto
P = SPT spoon sample N = 300 mm blow count N̄ = ditto extrapolated
NR = No recovery ∇ = Depth cased ▼ = transient water level ▽ = standing ditto

REMARKS



ST18NW/158A

STRATA SURVEYS LTD

Bristol Office

JOB P. Leiner & Sons Ltd TREForest

Job No. BS1008

METHOD 150 mm S & A

DATE 15-16 December 75

Scale 1 : 50

BOREHOLE LOG
1012 8682
B.H. No. 1A skt. 2 of 2

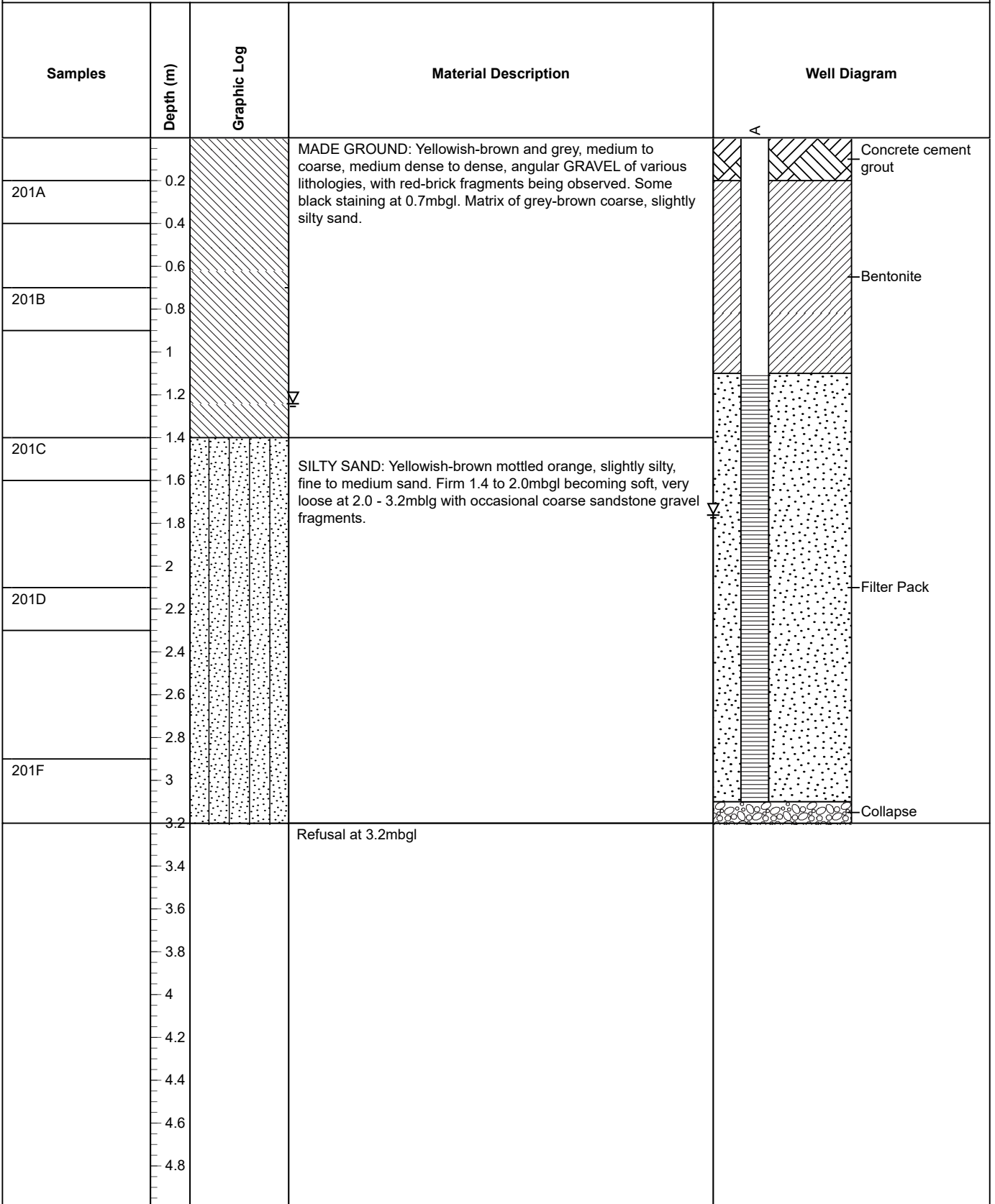
Depth m	Sampling details	Penet. Tests	Boring details	Ground Water	Depth m	Borehole Findings		Level m
						Legend	Description	
11	• B4	CPT N=44			11		Compact Coarse brown SAND and GRAVEL, with occasional cobbles and boulders	
12		CPT N=50			12			
13					13			
14		CPT N=53			14			
15	• B5				15			
16					16			

SYMBOLS D = Disturbed sample U = Undisturbed 100 mm sample W = Water sample
B = Bulk disturbed sample SPT = Standard Penetration Test CPT = Cone ditto
P = SPT spoon sample N = 300 mm blow count N = ditto extrapolated
NR = No recovery ◁ = Depth cased ▽ = transient water level ▼ = standing ditto

REMARKS

PROJECT NUMBER VEOL.01.02	DRILLING DATE 16/12/2022	COORDINATES (X,Y) 310058, 186843
PROJECT NAME Veolia NaOH SI	TOTAL DEPTH 3.2mbgl	
CLIENT Veolia	INSTALL DEPTH 3.10mbgl	
ADDRESS CF37 5SQ	SCREEN 1.1m Plain and 2m (50mm) Slotted Pipe	
	GROUNDWATER 1.24mbgl	

COMMENTS Groundwater monitoring borehole - spill area	LOGGED BY FT
	CHECKED BY SB



PROJECT NUMBER VEOI.01.02	DRILLING DATE 16/12/2022	COORDINATES (X,Y) 310112, 186883
PROJECT NAME Veolia NaOH SI	TOTAL DEPTH 3.3mbgl	
CLIENT Veolia	INSTALL DEPTH 3.15mbgl	
ADDRESS CF37 5SQ	SCREEN 1.15m Plain and 2m (50mm) Slotted Pipe	
	GROUNDWATER 1.76mbgl	

COMMENTS Downgradient, groundwater monitoring borehole	LOGGED BY FT
	CHECKED BY SB

Samples	Depth (m)	Graphic Log	Material Description	Well Diagram
	0.0		Concrete	
202A	0.2		MADE GROUND: Brown/black medium to coarse medium dense angular GRAVEL of limestone and anthropogenic materials (observed brick, metal, plastic). Matrix of brownish-black coarse sand.	
	0.4			
202B	0.8			
	1.0			
202C	1.2			
	1.4			
202D	1.6		Filter Pack	
	1.8			
202F	2.4			
	2.6			
202E	3.0		GRAVELLY SAND: Yellowish-brown, loose to medium-dense, slightly silty coarse sand with frequent fine to medium gravel and occasional cobble sized fragments of sandstone. [Superficial deposits].	
	3.2			
	3.4		Refusal at 3.3mbgl	
	3.6			
	3.8			
	4.0			
	4.2			
	4.4			
	4.6			
	4.8			

PROJECT NUMBER 095.01.01	DRILLING DATE 14/07/2020	COORDINATES (X,Y) 310088,186873
PROJECT NAME PB Leiner	TOTAL DEPTH 4.7mbgl	
CLIENT Veolia	INSTALL DEPTH 4.0mbgl	
ADDRESS CF37 5SQ	SCREEN 1m Plain and 3m (50mm) Slotted Pipe	
	GROUNDWATER 1.89mbgl	

COMMENTS Downgradient, groundwater monitoring borehole	LOGGED BY FT
	CHECKED BY SB

Samples	pH (field measurement)	Sample Type	Depth (m)	Graphic Log	Material Description	Additional Observations	Well Diagram
BH03a		S	0.2		MADE GROUND: Brown/black medium to coarse medium dense angular GRAVEL of limestone, some coal, occasional wood fragments and anthropogenic materials (observed brick, metal, plastic). Matrix of brownish-black coarse sand.		
			0.4				
			0.6				
			0.8				
			1				
BH03		GW	1.8		SILTY SAND: Brown, slightly clayey, silty, medium sand (stiff, loose), occasional fine gravel of sandstone. [Superficial deposits]	Very wet, water saturated, between 2.2-2.3mbgl, very soft, very loose. Very mild hydrocarbon odour at 2.2mbgl.	
			2				
BH03b	6.47	S	2.2		GRAVELLY SAND: Yellowish-brown, mottled black at 2.8mbgl, soft to firm, loose to medium-dense, slightly silty coarse sand with frequent fine to medium gravel and occasional cobbles of sandstone. [Superficial deposits].	Groundwater strike within Gravel between 2.6 and 3.2mbgl, rising to 1.9mbgl following completion of drilling.	
			2.4				
	6.48		2.6				
			2.8				
			3				
			3.2				
			3.4		GRAVEL: Greyish-brown becoming yellowish brown, medium to coarse, loose, sub-angular to sub-rounded gravel, becoming increasingly coarse to base, with coarse sand matrix.		
			3.6				
			3.8				
			4				
			4.2				
			4.4				
			4.6				
			4.8				
			5		Refusal at 4.7mbgl		
			5.2				



Up-gradient, Background - BH01 095.01.01

PROJECT NUMBER 095.01.01	DRILLING DATE 14/07/2020	COORDINATES (X,Y) 310061, 166819
PROJECT NAME PB Leiner	TOTAL DEPTH 3.6mbgl	
CLIENT Veolia	INSTALL DEPTH -	
ADDRESS CF37 5SQ	SCREEN -	
	GROUNDWATER 2.15mbgl	

COMMENTS Upgradient, background location. Drilled first prior to works in main spill area.	LOGGED BY FT
	CHECKED BY SB

Samples	Sample Type	Depth (m)	Graphic Log	Material Description	Additional Observations
		0.2		MADE GROUND: Yellowish-brown and grey, medium to coarse medium dense angular GRAVEL of limestone with occasional anthropogenic materials observed (brick fragments, some coal). Matrix of brownish-black coarse sand.	
BH01a	Soil	0.4			
		0.6			
		0.8			
		1.0		Becomes dark grey-black, loose, soft, silty sand with medium gravel of mudstone, coal, ash/clinker at 0.8mbgl - 1.4mbgl	Assumed waste materials/spoil from historic boiler house.
		1.2			
		1.4		SILTY SAND: Greyish-brown, soft, firming towards base, stiff at 3.5mbgl, slightly silty, slightly clayey fine to medium sand with occasional medium to coarse gravel of sandstone.	
		1.6			
		1.8			
		2.0			
		2.2			
BH01b	Soil	2.4			
		2.6			
		2.8			
		3.0			
		3.2			
		3.4		Recovered materials were saturated, soft to firm, (perched water).	
		3.6		Refusal at 3.6mbgl	
		3.8			
		4.0			
		4.2			
		4.4			
		4.6			
		4.8			



Main Spill Area- BH02 095.01.01

PROJECT NUMBER 095.01.01	DRILLING DATE 14/07/2020	COORDINATES (X,Y) 310060,188843
PROJECT NAME PB Leiner	TOTAL DEPTH 3.6mbgl	
CLIENT Veolia	INSTALL DEPTH -	
ADDRESS CF37 59Q	SCREEN -	
	GROUNDWATER borehole collapse to 1.4mbgl	

COMMENTS Main spill area. NaOH impacted soils.	LOGGED BY FT
	CHECKED BY SB

Samples	Sample Type	Depth (m)	Graphic Log	Material Description	Additional Observations		
		0.2		MADE GROUND: Yellowish-brown and grey, medium to coarse medium dense angular GRAVEL of limestone with anthropogenic materials observed (fragments of brick and slag). Matrix of brownish-black coarse sand.			
BH02a	Soil	0.4					
BH02e	Leachate	0.6				Black, thick/heavy oil, strong hydrocarbon odour.	
BH02b	Soil	0.8					
		1.0					
		1.2					
BH02c	Soil +Leachate	1.4				Borehole collapse to 1.4mbgl following completion of drilling, no groundwater level measurement possible.	
		1.6				SILTY SAND: Reddish-brown mottled orange, slightly silty, fine to medium sand (soft, very loose), occasional fine gravel of sandstone. [Superficial deposits]	
		1.8					
		2.0					
BH02f	Leachate	2.4		Very saturated (wet), very soft (material extrudes between fingers)			
BH02d	Soil	2.6					
		2.8		SILTY SAND: Greyish-brown, soft, firming towards base. Very stiff at 3.55mbgl, slightly silty, fine to medium sand.			
		3.0					
		3.2		Refusal at 3.6mbgl			
		3.4					
		3.6					
		3.8					
		4.0					
		4.2					
		4.4					
		4.6					
		4.8					

APPENDIX 2

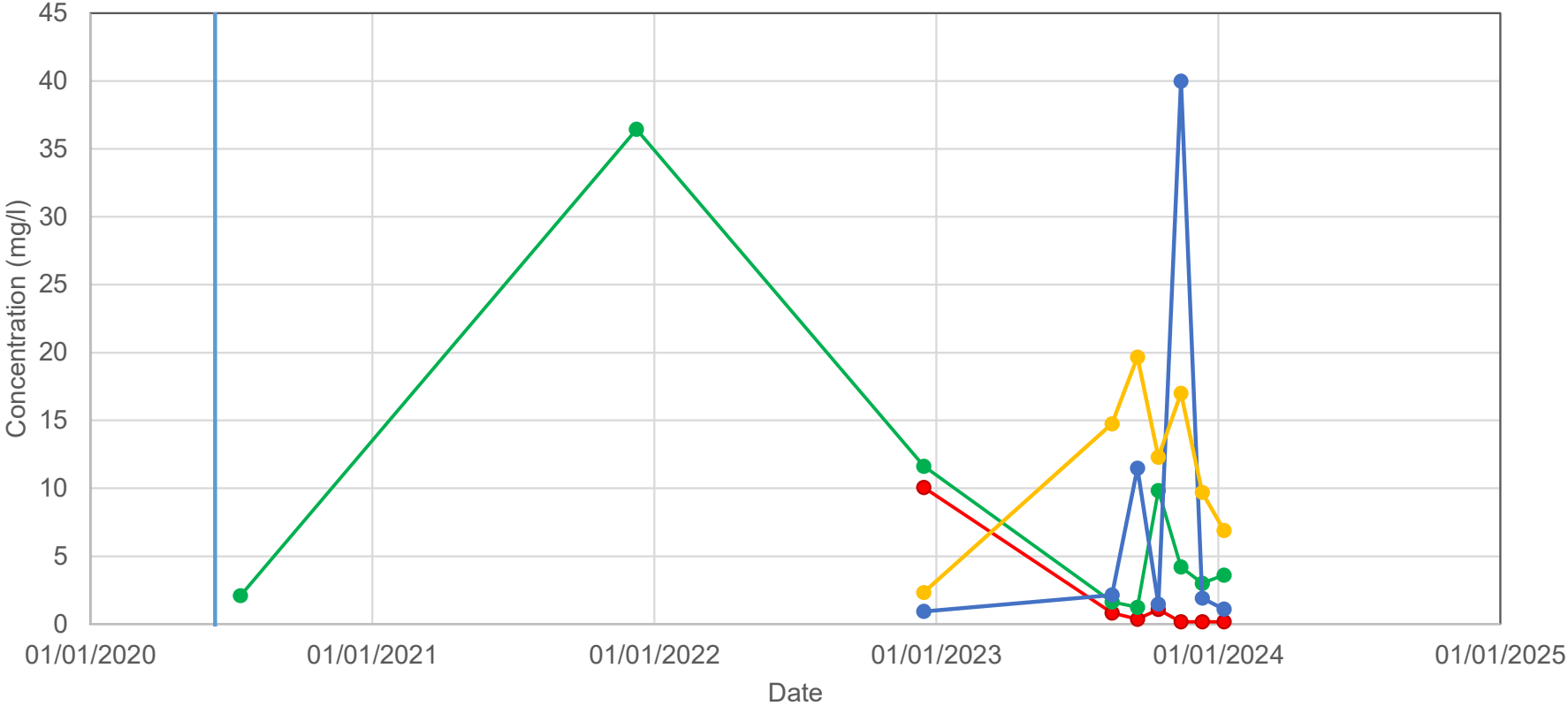
Parameter	Units	BH03	BH03	WS201	WS202	BH0	BH3	
		14/07/2020	09/12/2021	16/12/2022				
Easting	x	310088.8483	310088.8483	310060.3064	310107.6088	310097.2686	310088.8483	
	Northing	y	186873.7580	186873.7580	186843.2468	186881.5166	186891.8915	186873.7580
mAOD	m	41.0869	41.0869	40.9851	40.6146	40.9605	41.0869	
Sample Depth	m							
Groundwater Level (mAOD)	m			39.7451	38.8546	40.9605	39.1969	
Dip to Groundwater	m			1.24	1.76		1.89	
Bottom Well Depth	m			3.10	3.15		4.00	
Well diameter	m							
Well volume	m ³							
3 well volumes	litres							
Amount purged	litres							
Laboratory	Manganese, Dissolved	µg/l	3400	1400	300	110	580	850
	Conductivity	uS/cm		760	1200	1300	440	1200
	pH	pH units	7.1	7.1	8.3	8.4	7.5	7.3
	Dissolved Oxygen	mg/l						
	Redox Potential	mV						
	Ammoniacal Nitrogen as N	mg/l	2.1	36.4	10.1	2.3	0.9	11.6
	Nitrate as NO ₃	mg/l		38.9	0.42	2.86	4.21	0.1
Nitrate as N	mg/l	0.091	8.78	0.09	0.65	0.95	0.02	

Parameter	Units	WS201	WS202	BH0	BH3	WS201	WS202	BH0	BH3
		17th August 2023				19th September 2023			
mAOD	m	40.9851	40.6146	40.9605	41.0869	40.9851	40.6146	40.9605	41.0869
Sample Depth	m	2.85	1.74	1.94	1.61	2.9	2.0100	3.3100	1.5700
Groundwater Level (mAOD)	m	39.8851	38.9246	39.0205	39.4769	39.8851	38.6046	38.6505	39.5169
Dip to Groundwater	m	1.1	1.69	1.94	1.61	1.1	2.01	2.31	1.57
Bottom Well Depth	m	3.03	3.07	3.6	3.62	3.01	3.09	3.66	3.65
Well diameter	m	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Well volume	m ³	0.0038	0.0027	0.0033	0.0039	0.00375	0.0029206	0.0026507	0.004084
3 well volumes	litres	11.37	8.13	9.78	11.84	11.25	6.362	7.952	12.252
Amount purged	litres	11.5	10	11	12	10	8	9	13
Colour		brown	dark brown	grey	yellow - light brown	yellow - medium brown	dark brown / black	greyish / black	yellow - pale brown
Turbidity		high	very high	medium	medium - high	medium	very high	medium - high	medium
Sheen		none apparent	none apparent	none apparent	none apparent	none apparent	none apparent	none apparent	none apparent
Odour		none apparent	heavy oil / diesel	damp/mould	damp/earthy	very slight oily smell	heavy oil / diesel	mild heavy oil	damp/earthy
Temperature	°C	16.4	15.2	15.3	17.2	17.6	15.4	14.9	17.7
Laboratory	Manganese, Dissolved	µg/l	280	2200	1500	170	460	1500	160
	Conductivity	uS/cm	687	1550	588	928	795	2040	1040
	pH	pH units	7.5	7.2	7	6.9	7.4	7.4	7.0
	Dissolved Oxygen	mg/l	9	7.7	7.6	8.1	10.1	9.3	5.7
	Redox Potential	mV	140	150	150	150	150	94	33
	Ammoniacal Nitrogen as N	mg/l	0.8	14.8	2.1	1.6	0.35	19.67	11.48
	Nitrate as NO ₃	mg/l	5.4		1.3	15	0.57	0.19	<0.10
Nitrate as N	mg/l		0.16						

Parameter	Units	WS201	WS202	BH0	BH3	WS201	WS202	BH0	BH3	
		16th October 2023				14th November 2023				
In-situ	mAOD	m	40.9851	40.6146	40.9605	41.0869	40.9851	40.6146	40.9605	41.0869
	Sample Depth	m	2.6200	1.6400	1.8200	1.5100	2.3700	1.1600	1.2000	0.9500
	Groundwater Level (mAOD)	m	40.2051	39.0246	39.1405	39.5769	40.6251	39.4546	39.7605	40.1269
	Dip to Groundwater	m	0.78	1.59	1.82	1.51	0.36	1.16	1.2	0.96
	Bottom Well Depth	m	3.11	3.13	3.64	3.66	3.11	3.13	3.67	3.66
	Well diameter	m	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Well volume	m ³	0.004575	0.003024	0.0035736	0.0042215	0.0054	0.003868	0.00485	0.005301
	3 well volumes	litres	13.725	9.071	10.72	12.665	16.2	11.604	14.55	15.9
	Amount purged	litres	10	10	11	13	12 (emptied)	12	15/16	16
	Colour		pale yellow - very light br	dark brown	very pale yellow	clear - very light yellow	yellow/ light brown	dark brown	brown (med)	light grey
	Turbidity		low - medium	high	low	low	low	high	medium	low
	Sheen		none apparent	none apparent	none apparent	none apparent	none apparent	none apparent	none apparent	none apparent
	Odour		very slight oily smell	ld heavy oil / diesel odd	damp / earthy	damp / earthy	none apparent	slight heavy oil	fishy	none apparent
	Temperature	°C	13.9	13.3	13.1	15.4	10.8	12	11.2	11.6
Laboratory	Manganese, Dissolved	µg/l	510	2900	1300	2300	110	2500	650	720
	Conductivity	uS/cm	793	2240	495	1270	577	1760	722	1090
	pH	pH units	7.7	7.3	6.8	6.9	7.3	7.3	6.9	7
	Dissolved Oxygen	mg/l	8.2	5.7	6	6.7	10.1	8.3	1.7	9.2
	Redox Potential	mV	250	170	250	230	180	110	-110	140
	Ammoniacal Nitrogen as N	mg/l	1.07	12.30	1.48	9.84	0.16	17	40	4.2
	Nitrate as NO ₃	mg/l	<1.0	<0.1	<1.0	11	2.5		< 0.10	2.6
	Nitrate as N	mg/l						< 0.10		

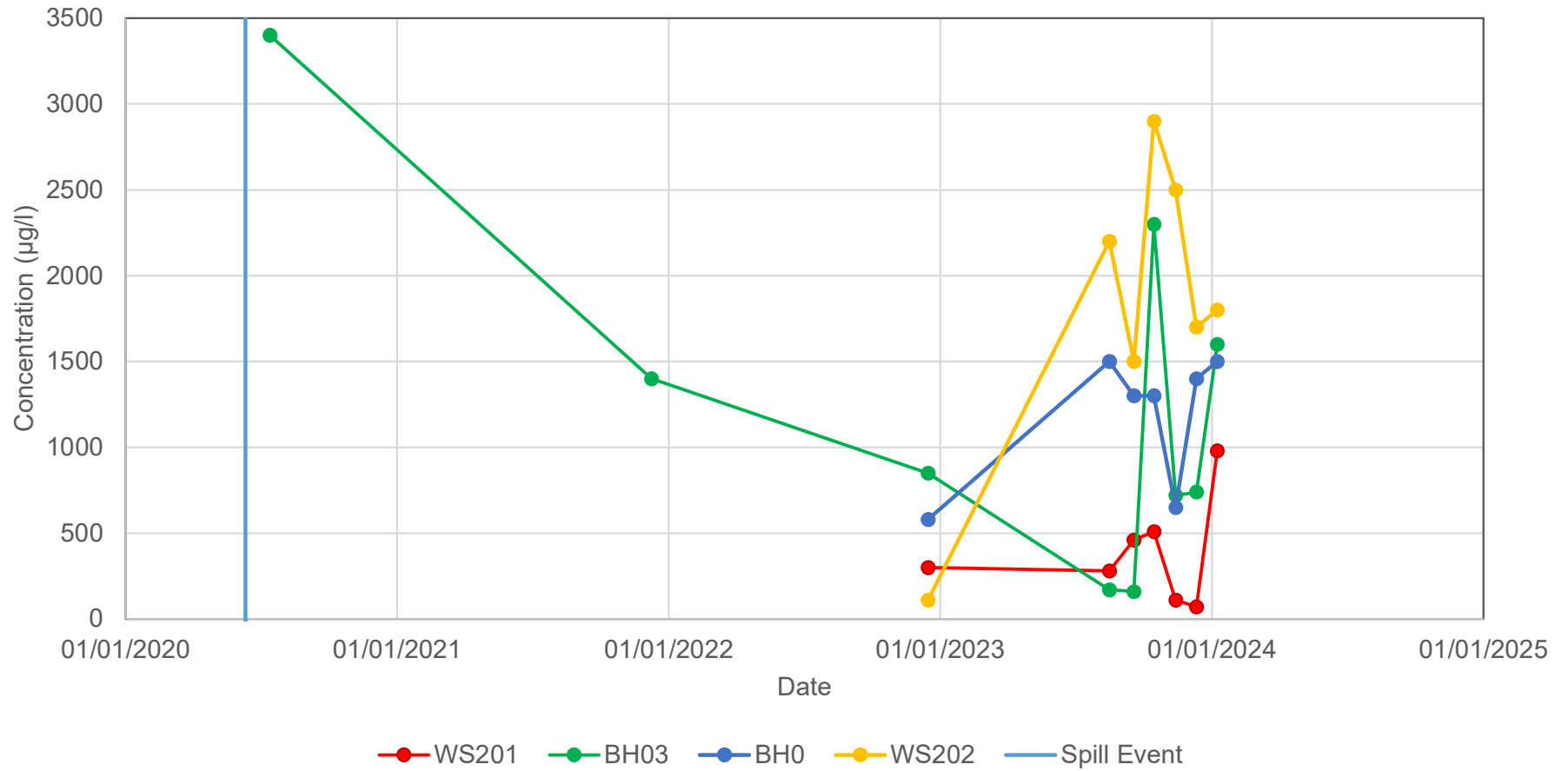
Parameter	Units	WS201	WS202	BH0	BH3	WS201	WS202	BH0	BH3	
		12th December 2023				9th January 2024				
In-situ	mAOD	m	40.9851	40.6146	40.9605	41.0869	40.9851	40.6146	40.9605	41.0869
	Sample Depth	m	0.7800	1.3400	1.3600	1.1800	2.6100	1.4200	1.5400	1.4100
	Groundwater Level (mAOD)	m	40.5651	40.4446	39.6205	39.9069	39.3051	39.2746	39.4405	39.6869
	Dip to Groundwater	m	0.42	0.17	1.34	1.18	1.68	1.34	1.52	1.4
	Bottom Well Depth	m	3.1	3.12	3.56	3.66	3.11	3.51	3.53	3.65
	Well diameter	m	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Well volume	m ³	0.005263667	0.003833333	0.004333333	0.004866667	0.002807667	0.004260667	0.003946667	0.004418
	3 well volumes	litres	15.791	11.5	13	14.6	8.423	12.782	11.84	13.254
	Amount purged	litres	16	12	13	15	9	13	12	14
	Colour		dark brown/grey	dark brown	opaque/grey	light brown	dark brown	dark brown	clear / very pale yellow	light / medium brown
	Turbidity		med-high	v. high	low-med	low-med	high	high	low	medium
	Sheen		N/A	N/A	N/A	N/A	none apparent	none apparent	none apparent	none apparent
	Odour		slight oil	slight oil	damp/oil	damp	oil / diesel	diesel	sulphur / oily	rthy / slight sulphur sm
	Temperature	°C	12.40	13.50	13.50	13.00	10.10	10.80	10.80	10.10
Laboratory	Manganese, Dissolved	µg/l	71	1700	1400	740	980	1800	1500	1600
	Conductivity	uS/cm	548	1210	483	1010	594	704	416	681
	pH	pH units	7.3	7.3	6.7	6.8	7.4	7.2	6.8	6.9
	Dissolved Oxygen	mg/l	10	6.5	6.8	8.3	4.5	5.1	7.1	4.3
	Redox Potential	mV	240	140	220	230	180	180	210	190
	Ammoniacal Nitrogen as N	mg/l	0.18	9.7	1.9	3	0.16	6.9	1.1	3.6
	Nitrate as NO ₃	mg/l	1.8		< 0.10		2.1	0.23	1.3	2
Nitrate as N	mg/l		0.24		0.49					

PB Leiner UK - Groundwater Quality - Ammoniacal-Nitrogen (as N)

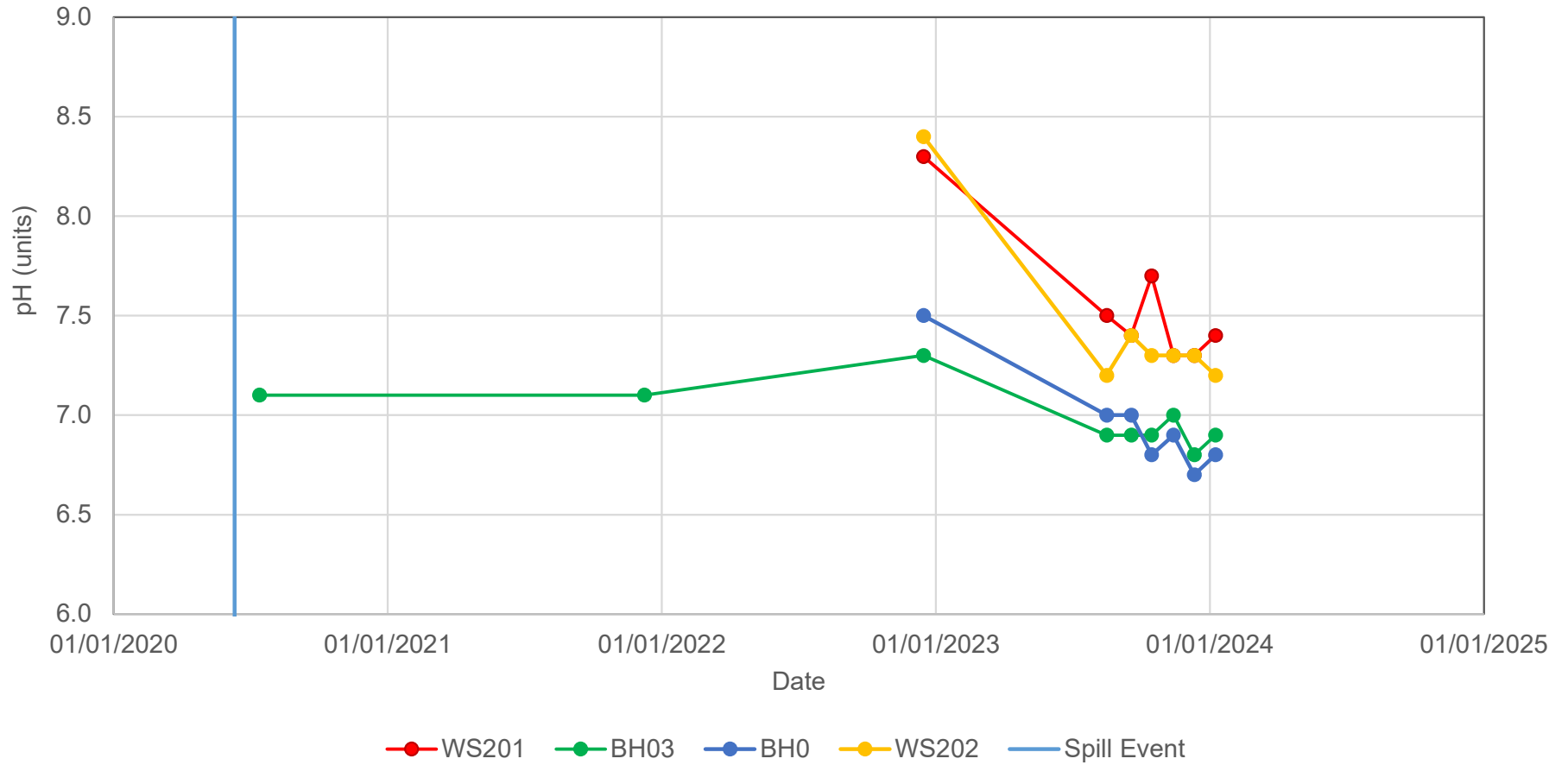


● WS201 ● BH03 ● BH0 ● WS202 — Spill Event

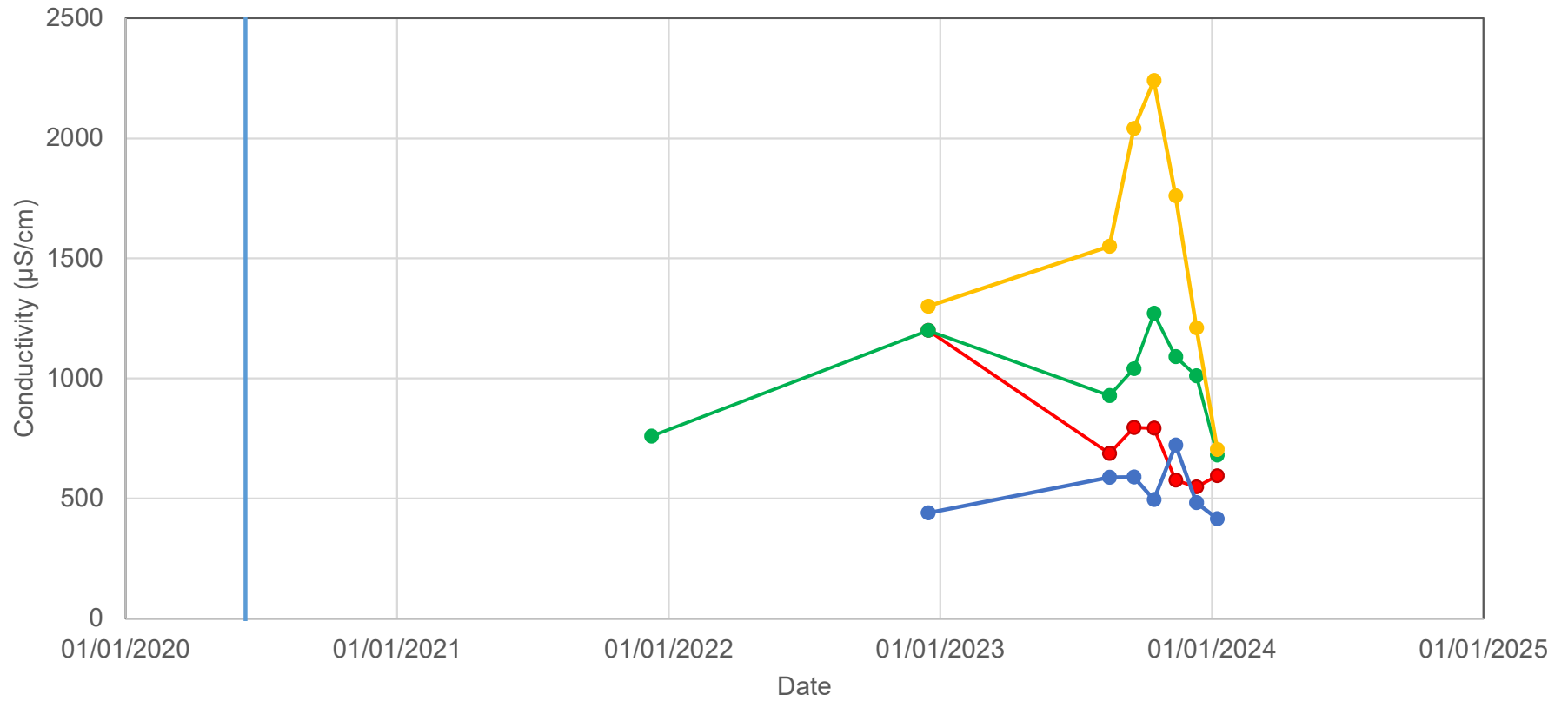
PB Leiner UK - Groundwater Quality - Manganese (dissolved)



PB Leiner UK - Groundwater Quality - pH

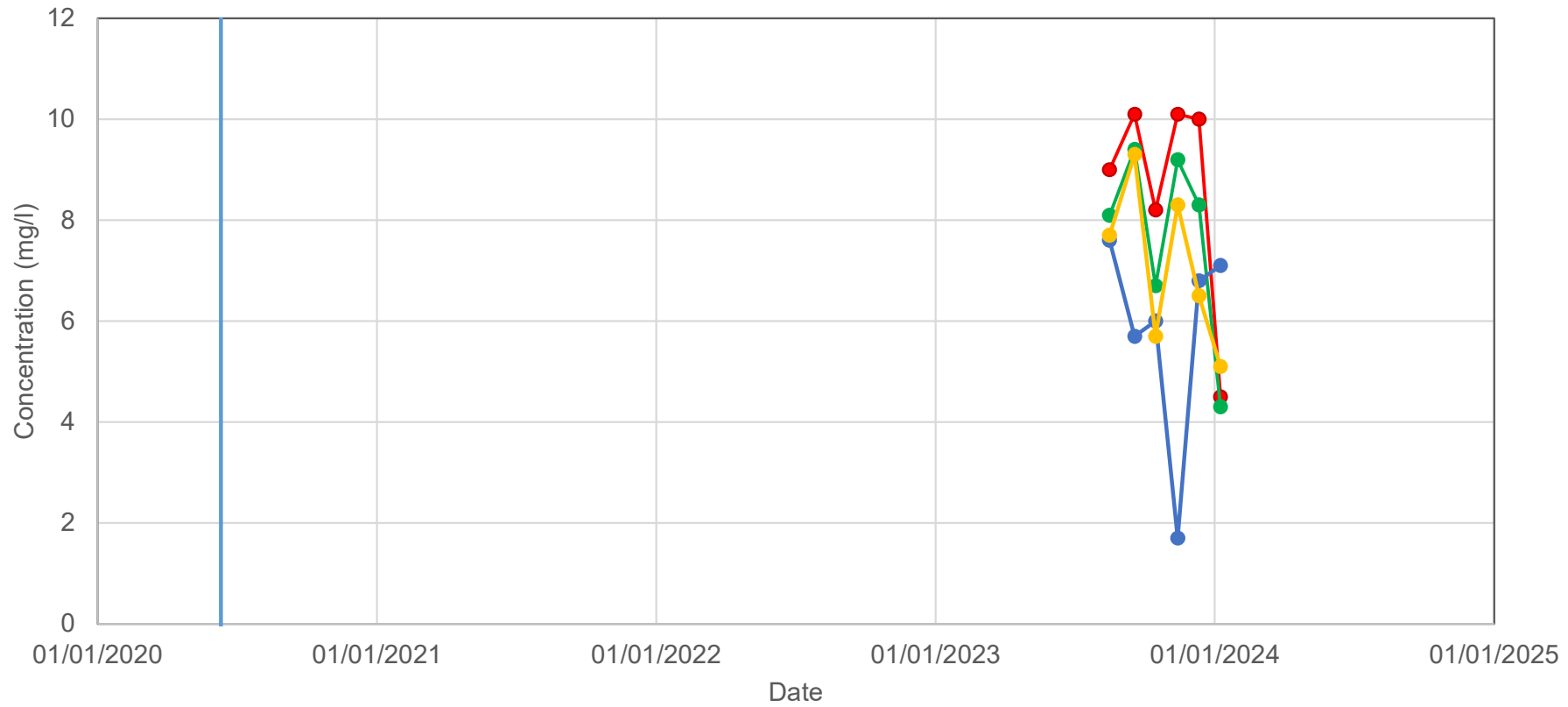


PB Leiner UK - Groundwater Quality - Electrical Conductivity



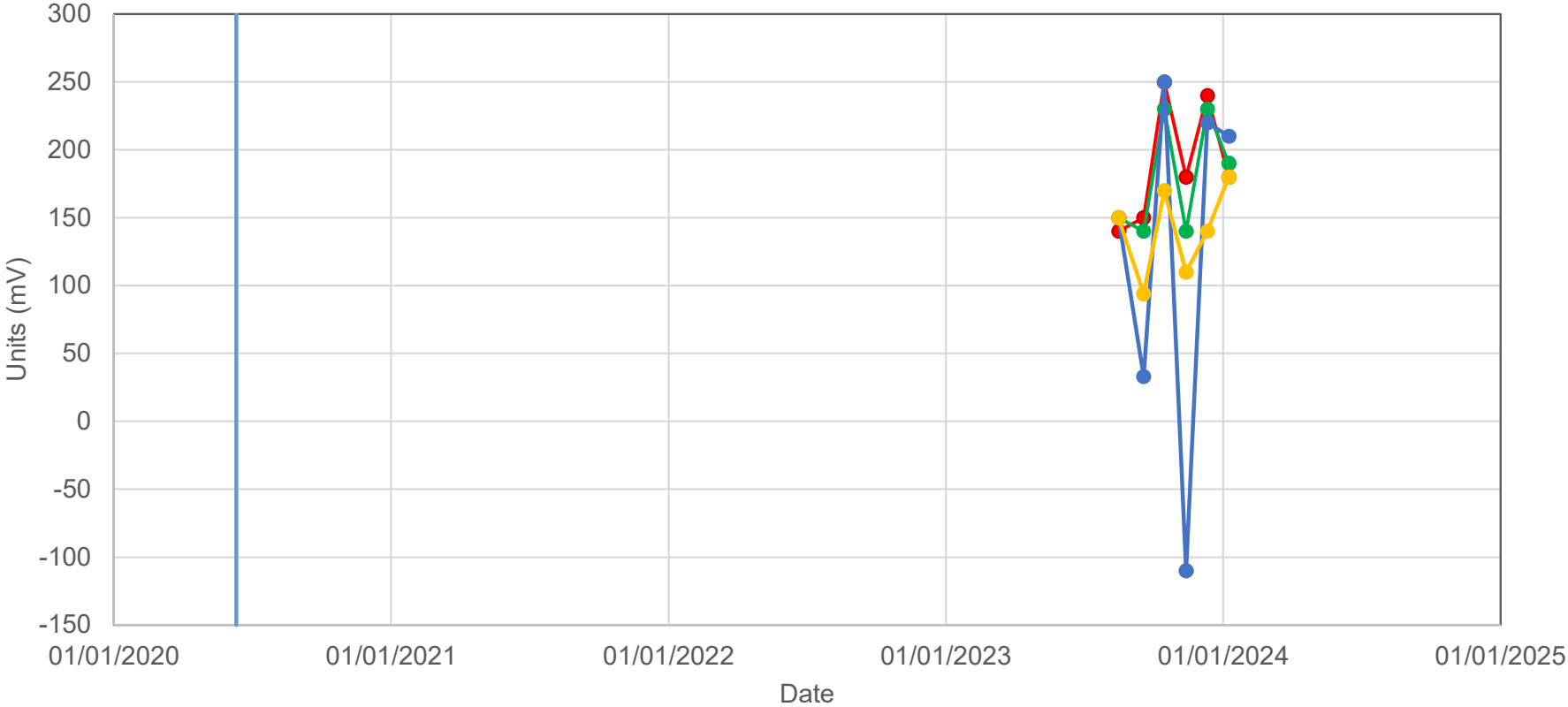
● WS201 ● BH03 ● BH0 ● WS202 — Spill Event

PB Leiner UK - Groundwater Quality - Dissolved Oxygen



● WS201 ● BH03 ● BH0 ● WS202 — Spill Event

PB Leiner UK - Groundwater Quality - Redox Potential



● WS201 ● BH03 ● BH0 ● WS202 — Spill Event



Nicola Sugg
Consultant Hydrogeologist
& Hydrologist

nicola@nsugg.co.uk

www.nsugg.co.uk

07866 374158

Nicola Sugg trading style of NSugg Limited (company number: 08043774)
Registered Office: Grove Hill House, Martinstown, Dorchester, Dorset DT2 9JP