COMPREHENSIVE ENVIRONMENTAL SITE ASSESSMENT

Shell Whitemare Pool



29 September 2020

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EXECUTIVE SUMMARY

AECOM undertook a Phase 2 Environmental Site Assessment (ESA) of Shell Whitemare Pool, Whitemare Pool, Gateshead, Tyne & Wear, NE10 8YB. This report has been collated to support Shell UK Oil Products Limited (Shell) with its environmental asset management activities.

The site is currently an active petrol filling station located at a service station area adjacent to a dual carriageway, with a hotel and restaurants located adjacent to site. A substation is located within the north western area of the site.

There are six (6) active tanks with six (6) compartments in use at the site.

There is not known to have been any previous remediation.

In November 2019, nine (9) locations (MW101 – MW109) were drilled to a maximum depth of 15m below ground level (bgl) at the site. Six (6) of these locations were installed as groundwater monitoring wells (MW101 – MW103, MW105, MW106 and MW109). MW103 was installed to a depth of 2m bgl within superficial deposits, with the other wells installed to a deeper depth of between 6.6m and 9.5m bgl in the underlying bedrock. Three (3) vapour monitoring wells (VP101 – VP103) were also installed at to 1.0m bgl at the site. The investigation indicates:

- The geology beneath the site comprises Made Ground to a maximum depth of 1.7 metres (m) below ground level (bgl), underlain by superficial deposits of Pelaw Clay Member (Unproductive Strata) to a maximum depth of 3.4m bgl. The solid geology comprises strata of the Pennine Middle Coal Measures – Mudstone, Siltstone and Sandstone and Pennine Middle Coal Measures - Sandstone (Secondary A Aquifer) and was proved to a maximum drilled depth of 15.0m bgl. Boreholes in the south of the site (MW101 and MW106) were reported to predominantly comprise sandstone beneath the Pelaw Clay, underlain by mudstone proven to a maximum drilled depth of 10m bgl. Boreholes in the central – northern area of the site (MW103, MW105 and MW109) were identified to have interbedded horizons beneath the Pelaw Clay, with sandstone identified below this in MW105 and MW109. Bedrock in MW102 was reported to comprise sandstone between 2.8m and the maximum drilled depth of 10.0m bgl. Bedrock was encountered in all boreholes with the exception of MW107 which was not progressed following characterisation of the shallow geology. Perched water in the superficial deposits was encountered in two (2) locations in the east of the site during drilling (MW103 and MW108).
- Groundwater was encountered in all six (6) groundwater monitoring wells at elevations ranging from 40.105 metres Above Ordnance Datum (m AOD) to 49.12m AOD across four (4) gauging rounds undertaken between 10 December 2019 and 26 March 2020. The depth to shallow perched water ranged from 0.40m to 0.47m bgl in MW103, which is the only well installed within the superficial Pelaw Clay Member. Depth to groundwater within the Pennine Middle Coal Measures ranged from 4.18m bgl in MW101 located in the south west of the site, to 9.25m bgl in MW109 located in the north east of the site. The groundwater level in MW101 and MW106 was consistently reported to be higher in the south of the site, than in MW102 located in the east and MW105 and MW109 located in the north of the site. Monitoring well MW105 located on the northern side of the site was identified to contain limited or no groundwater during the last three (3) gauging rounds, with limited groundwater observed in MW109 in the February 2020 gauging round too. Based on four (4) rounds of groundwater gauging, it has not been possible to infer a groundwater flow direction due to observed variances in groundwater depths.
- The nearest surface water feature to the site is a surface water drain located approximately 68m west of site which possibly continues 30m from the site boundary to the north west (running north east to south west) based on the line of vegetation. It was not possible to confirm whether the drainage channel contained running water during the AECOM site visits, due to the presence of dense vegetation. Monkton Burn is situated 280m south east of site at its closest point but also to the east and north east, with ponds located 155m south west and 300m north east of site. Based on groundwater elevations within the Pennine Middle Coal Measures beneath the site, it is considered that the only surface water receptor that may be in hydraulic connectivity is the Monkton Burn.
- No visual or olfactory evidence of chemicals of potential concern (COPC) were identified in the soil samples collected during drilling, besides some black pockets of staining (possibly hydrocarbon) observed in the soil at MW106 at 4.95 – 5.0m and 5.7 – 6.6m bgl. A hydrocarbon odour was observed on the groundwater samples collected from MW102 south east of the forecourt area and MW106 located west of the tank farm (December round only).

A Stage 2 risk assessment was performed on the data collected during the intrusive works to assess potential risks to human health (on-site workers) and controlled waters (perched water in the superficial deposits, underlying Secondary A Aquifer, a drain located west of site and other surface water features). A Stage 3 risk assessment could not be performed to further assess potential risks to controlled waters (underlying Secondary A Aquifer and Monkton Burn located to the east of site) based on the current dataset, due to the complexity of the on-site geology and groundwater levels.

Asbestos was analysed for in seven Made Ground samples but was not identified.

The principal conclusions were as follows:

- Concentrations of COPC measured at the site were considered unlikely to represent an unacceptable risk to human health receptors.

- Potentially unacceptable risks to the groundwater may be present from reported groundwater concentrations of BTEX in one monitoring well (MW102) located in the east of the site.
- It is noted that groundwater may possibly be in hydraulic connectivity with Monkton Burn located to the east of the site (280m south east at its closest point); however, given the distance it is considered unlikely that concentrations of COPC would represent a potentially unacceptable risk to the surface water.

1. INTRODUCTION

AECOM was requested by Shell UK Oil Products (Shell) to undertake a Phase 2 Environmental Site Assessment (ESA) at Shell Whitemare Pool located at Whitemare Pool, Gateshead, Tyne & Wear, NE10 8YB.

Table A – Site Information	
Site Name	Shell Whitemare Pool
Site Operation	The site is currently an active petroleum filling station.
GSAP ID Number	10019383
Site Address	The site is located at Whitemare Pool, Gateshead, Tyne & Wear, NE10 8YB (**Figure 1)**.
Grid Reference (easting and northing)	431200, 561570
Reported Site Area	Approximately 4,600 square metres (m^2)
Freehold/Leasehold	Freehold. AECOM understands that the site is owned by Shell. A Right of Way is present across the site for access and egress to the adjacent hotel on the service station area. AECOM understands that a section of the road (Roman Road) adjacent to the west of the petrol filling station forms part of the wider site boundary and that a Public Right of Way is present along this section.

1.1 Objectives

This report has been collated to support Shell with its environmental asset management activities.

The objective of the Phase 2 Investigation detailed herein was to refine the preliminary Conceptual Model (CM) for the site developed in the Phase 1 (Ref. 1).

This was undertaken by:

- Evaluation of the likelihood of occurrence, nature and potential magnitude of impacted ground at the site.
- Evaluation of potential transport mechanisms and migration pathways by which chemicals of potential concern (COPC) could migrate off-site.
- Estimation of the potential effects of impacted ground on the subject property and surrounding areas.

1.2 Scope of Work

- Completion of a Phase 2 site investigation between November and December 2019 including the installation and sampling of groundwater monitoring wells and vapour monitoring wells.
- Completion of an additional groundwater monitoring event between 4 and 7 February 2020, with two additional groundwater gauging rounds undertaken in March 2020.
- Assessment of the magnitude, type and extent of COPC present through the performance of laboratory and/or on-site analysis of soil, groundwater and soil vapour for various chemical indicators associated with operation as a petrol filling station.
- Screening of analytical results against appropriate Generic Assessment Criteria (GAC) to determine the requirement for a Detailed Quantitative Risk Assessment (DQRA).
- Completion and submission of this Comprehensive ESA Report.

1.3 Sustainability

In implementing the scope of works outlined above, AECOM made the following considerations of sustainability:

- Waste was field screened, analysed, and segregated to reduce requirement for soil treatment.
- Borehole surveying was conducted concurrent with groundwater and vapour monitoring to reduce travel impact.
- Field staff stayed in a local hotel during field work to reduce travel impact.

2. BACKGROUND INFORMATION AND PRELIMARY RISK ASSESSMENT

2.1 Background Information

A summary of the information about the site setting, site use and development is provided in Tables B, C and D below. Full details are provided in the Phase 1 (Ref 1).

Table B – Environmental Setting	
Surrounding Land Use	North: The site is immediately bound by Roman Road and dense vegetation, within which is a potential drainage ditch approximately 30m north west of site. It was not possible to assess the presence of any ditch during the AECOM site visits due to the vegetation. The land approximately 115m north east of site is currently part of Red Barns Quarry, which extracts brick shale. South: The site is bounded by the A194 dual carriageway (Leam Lane) and a landscaped vegetated area. A roundabout and the A184 (Newcastle Road) are located approximately 135m south of site. East: The site is bound by the A194 dual carriageway (Leam Lane) to the east of site (5m), beyond which are agricultural fields (approximately 30m from the site boundary). West: The site is bound by commercial buildings which include a service station and Travelodge, with the nearest hotel buildings 24m south west of site. Food outlets (Subway and Burger King) situated 68m south west.
Elevation	The site is located at an approximate elevation of 50m Above Ordnance Datum (AOD).
Topography	The topography of the surrounding area is a similar elevation to site. In the wider area, the topography slopes to the north and north east,
Surface Water Features	The nearest surface water feature is an unnamed drain approximately 68m west of the site. It was not possible to ascertain whether the drain contained surface water during the AECOM site visit, due to the presence of dense vegetation. However, the line of the vegetation suggested that the drain may extend to approximately 30m north west of the site boundary, running north east to south west. Monkton Burn is located approximately 280m south east of site at its closest point and runs to the east and north east of the site, flowing in a north easterly direction. There is also a small pond situated approximately 155m south west of site and another pond situated in the quarry workings 300m north east of site at Red Barn quarry.
Geology	It is anticipated that Made Ground may be present associated with the site's development. GeoDelft identified Made Ground to a maximum depth of 1.0m bgl during intrusive investigation in 1999 (Ref. 2). GeoDelft reported peaty/sandy/gravelly/silty clay to depths between 2.5m bgl and the maximum drilled depth of 3.0m bgl in two of the boreholes drilled on site in 1999 (Ref. 2). GeoDelft recorded weathered siltstone was reported in three (3) of the five (5) boreholes drilled and was reported between 2.5m and 2.7m bgl to the maximum drilled depth of 3.0m bgl. Available British Geological Survey (BGS) geological maps indicate the site to be underlain by superficial deposits of the Pelaw Clay Member overlying bedrock. The bedrock comprises the Pennine Middle Coal Measures Formation, anticipated to comprise sandstone across the majority of the site and mudstone, siltstone and sandstone in the northernmost section of the site. The maps also show the Claxheugh Fault, running east/west through the northern part of site.

Table B – Environmental Setting	
Hydrogeology	The Environment Agency (EA) classifies the Pelaw Clay Member as Unproductive Strata and the Pennine Middle Coal Measures – Sandstone and Sandstone, Siltstone and Mudstone as a Secondary A Aquifer.
Groundwater Abstractions and SPZs	No licensed records of groundwater abstractions were identified within 2km of the site. South Tyneside Council confirmed that the council does not have any records of private groundwater abstraction within 1km radius of the site. The 1km radius also falls within the boundary of Gateshead Metropolitan Borough Council, who also confirmed that there are no private groundwater abstractions within 1km radius of the site. The site is not located within an EA defined source protection zone (SPZ).
Potential Vapour Receptors	USEPA Guidance (Ref. 3) has been used to determine potential vapour intrusion receptors that require assessment. The site sales building has been assessed primarily as a vapour receptor for potential acute risks, however chronic risks to site workers have also been considered. No factors that preclude the use of the USEPA guidance (Ref. 3) have been identified and vegetated land is present in all directions. Off-site workers and visitors to commercial properties located adjacent to the south west of the site, with the nearest building a hotel 24m south west, have not been PVI screened in given their distance.

Table C – Site use and Development	
Current Use	The site is currently an active petrol filling station located at a service station area adjacent to a dual carriageway, with a hotel and restaurants located adjacent to site. A substation is located within the north western area of the site. There are currently six (6) vessels with six (6) tank compartments in operation at the site and no above ground tanks.
Site History	Information provided by Shell indicated that five (5) vessels with seven (7) tank compartments were installed on-site in 1987 and one more single compartment tank was installed in 1990. Historical mapping indicated that the site first operated as a garage c.1992. Information from Shell indicates that tanks were first installed at the site in 1987. There are currently six (6) vessels with six (6) tank compartments in operation at the site.
Dates of accidental release or known source of COPC	The PO report indicates there have been no accidental releases on site. Tank and line testing provided in the PO report indicates that the line between tank 2 and pump 5/6 failed testing on 31 May 1995 and 9 June 1995, with the same line passing testing later in June 1995. The lines between tank 5 and pumps 5/6 and 7/8 were also tested in June 1995 and passed. Further reports of tank and line testing undertaken in 1996 and 1997 indicated that all tanks and lines passed testing. Fairbanks Environmental have been monitoring wetstock records on behalf of Shell since November 2012. According to information received from Fairbanks on 1 July 2019, there have been no historical or current concerns regarding wetstock variance at Shell Whitemare Pool.

Table C – Site use and Development	
Dates of closure, tank removal, soil removal etc	Information provided in the PO report indicates that Stage 1B and Stage 2 vapour recovery was installed on site in approximately 1997, with new fuel lines installed from pump islands 3/4 and 5/6. Based on records provided, overfill protection was fitted on four (4) tanks in 2003. Information provided by RSK (Ref. 4) indicated that the site underwent a re-pump in 2008 with associated pipework and the interceptor removed and replaced at the same time. The Soil Verification Report also indicates that two (2) dual compartment tanks had the baffles removed at this time, for future operation as single compartment tanks. As such, there are currently six (6) vessels with six (6) tank compartments in operation at the site.
Previous site investigations	<u>GeoDelft, Tier 1 Soil Gas Survey, Report Ref. C928.SG356.8975, dated April 1998 (Ref. 5)</u> GeoDelft undertook a soil gas survey on site in 1998 and identified a Volatile Organic Compound (VOC) plume around the pumps and forecourt, with VOC readings recorded as more than 100ppm) in this area. The report does not list any accidental releases in the site history.
	<u>GeoDelft, Tier 2 Environmental Survey, Report Ref. C1443.SG356, dated September 1999 (Ref. 2)</u> GeoDelft drilled five (5) boreholes on the site to a maximum depth of 3.0m below ground level (bgl) in 1999. The geology encountered was reported to comprise Made Ground to a maximum depth of 1.0m bgl. Beneath the Made Ground, sand or silt was encountered, underlain by peaty/sandy/gravelly/silty clay to the maximum drilled depth. Weathered siltstone was reported in three of the boreholes, encountered between 2.5m and 2.7m bgl and reported to the maximum drilled depth of 3.0m bgl. Groundwater was identified in two boreholes, with a strike identified at 2.0m bgl in SS01 and resting water level reported to be 2.3m bgl. A strike was encountered at 1.65m bgl in SS02, with resting water level reported as 0.75m bgl. The boreholes were not installed with monitoring wells and were backfilled with bentonite.
	<u>RSK, Soil Verification Report, Report Ref. 310714- R1(01), dated April 2009 (Ref.4)</u> RSK undertook soil verification sampling during site redevelopment in May 2008, which comprised the reconfiguration of the underground storage tanks, and removal and replacement of the forecourt interceptor, fuel islands and associated pipework. Fourteen (14) soil samples were collected for laboratory analysis, with samples collected to a maximum depth of 1.0m bgl. Samples were collected from the shallow excavations created to reconfigure the tanks, the sides of the interceptor excavation and from beneath two of the fuel pumps. Visual and olfactory observations of hydrocarbon impact were noted on one side wall of the interceptor excavation, close to a drainage gulley and an olfactory observation was reported for the soil sample collected from beneath pump 4. As part of the redevelopment works, approximately 400 tonnes of inert material from the excavations was removed from site and disposed of at a suitable licensed waste facility. Samples were screened against Generic Assessment Criteria (GAC) with benzo(a)pyrene and naphthalene concentrations reported to exceed the GAC in soil samples collected from the interceptor excavation. Further risk assessment was undertaken and naphthalene concentrations were assessed via Detailed Quantitative Risk Assessment. The site was considered suitable for its current use.
Historical Site Boreholes	No historical boreholes were identified on site during the AECOM site visits.
Historical Remedial Activities	There is not known to have been any previous remediation undertaken at the site.

Table D – Summary of On-site Fuel Tank / Compartments			
Vessel number or ID	**Vessel 1**	**Vessel 2**	**Vessel 3**
Tank Compartment number or ID	**Tank Compartment 1**	**Tank Compartment 2**	**Tank Compartment 3**
Tank type(1)	Single Walled Steel	Single Walled Steel	Single Walled Steel
Tank compartment size (litres) (2)	34,580	21,660	12,920
Product stored(2)	Unleaded	Diesel	VP-Unleaded
Status(2,3)	Active	Active	Active
Date of installation(1)	1987	1987	1987
Removal date or abandonment date	Not Applicable	Not Applicable	Not Applicable
Relative level (RL) of tank base	Assumed to be 4.5m bgl	Assumed to be 4.5m bgl	Assumed to be 4.5m bgl
Vessel number or ID	**Vessel 4**	**Vessel 5**	**Vessel 6**
Tank Compartment number or ID	**Tank Compartment 4**	**Tank Compartment 5**	**Tank Compartment 6**
Tank type(1)	Single Walled Steel	Single Walled Steel	Single Walled Steel
Tank compartment size (litres) (2)	24,700	21,660	12,920
Product stored(2)	Diesel	Diesel	VP-Diesel
Status(2,3)	Active	Active	Active
Date of installation(1)	1987	1987	1990
Removal date or abandonment date	Not Applicable	Not Applicable	Not Applicable
Relative level (RL) of tank base	Assumed to be 4.5m bgl	Assumed to be 4.5m bgl	Assumed to be 4.5m bgl

NOTES:

1 – Based on information provided by Shell

2 – Tank gauge print out obtained 09 July 2019 during site walkover

3 – Petroleum officer response dated 09 July 2019

2.2 Preliminary Conceptual Model

Following review of the available data regarding site history, environmental setting, and continued oil use, a preliminary conceptual model (CM) was developed, as presented in Table E below. For a risk from a given source to be considered plausible, a 'pathway' must be present by which COPC can reach a given receptor. Such complete Source ⇨ Pathway ⇨ Receptor (SPR) exposure mechanisms are commonly termed 'pollutant linkages'. The CM illustrates the potentially viable source-pathway-receptor linkages which have been identified.

Table E – Preliminary Conceptual Model

Source	Pathway	Receptor
Human Health		
• Impacted soils • Soil vapour • Impacted groundwater	• Lateral and vertical vapour migration and subsequent inhalation. • Particulate – Ingestion, inhalation, dermal contact, with soil particulates. • Permeation – Migration of hydrocarbon substances through plastic potable water supply pipes.	• On-site shop staff, visiting staff and general public. • Visiting contractors excavating ground.*
Controlled Waters		
• Impacted soils • Impacted groundwater	• Partitioning between soil and pore water. • Leaching of impacted soils. • Lateral migration of impacted groundwater.	• Surface water (Unnamed drain approximately 68m west of site but potentially as close as 30m north west of site, Monkton Burn 280m south east at its closest point and ponds 155m south west and 300m north east of site). • Perched groundwater within the Pelaw Clay Member (Unproductive Strata) and Pennine Middle Coal Measures Formation (Secondary A Aquifer).

* Potential risks to visiting contractors undertaking intrusive works should be managed by appropriate PPE, risk assessment and method statements. Risks to visiting contractors excavating the ground have therefore not been further assessed.

Off-site workers and visitors in adjacent commercial properties (nearest building 24m south west) have not been screened in for vapour assessment.

3. FIELD WORK

3.1 Summary of Field Work

Table F – Summary of Field Work	
Date of Field Work	Site investigation work was completed between 15 October 2019 and 26 March 2020.
Site Activities	Initial field works undertaken between October and December 2019 included the following key tasks: • Service clearance and initial site walkover with AECOM's nominated subcontractor to undertake on-site robust sub-scan of the site. • Geophysics survey undertaken by AECOM to undertake a ground penetrating radar (GPR) survey. • Clearance of ten (10) locations by vacuum excavation to a depth of 1.2 metres (m) below ground level (bgl) and two (2) locations to a depth of 1.6m bgl at 150% diameter of the proposed borehole. • Further advancement of eight (8) of the cleared holes to total depths of between 2.7m and 15.0m bgl. • Installation of six (6) groundwater monitoring wells (MW101to MW103, MW105, MW106 and MW109) and three (3) vapour monitoring wells (VP101 – VP103). • Borehole elevation survey of all nine (9) installed monitoring wells. • Collection of soil samples from targeted locations to evaluate the presence of potential impact and assess geotechnical conditions. • Groundwater level gauging of six (6) groundwater monitoring wells (MW101 to MW103, MW106 and MW109). • Purging and groundwater sample collection from six (6) groundwater monitoring wells, and collection of field measurements of groundwater quality (pH, conductivity, temperature, redox potential and dissolved oxygen). • Completion of ground gas monitoring of three (3) vapour monitoring wells (VP101 to VP103). • Purging and vapour sample collection from three (3) vapour monitoring wells (VP101 to VP103). • Hydraulic conductivity testing of three (3) groundwater monitoring wells (MW101, MW102, and MW109). • Collection of passive and active water samples from the potable supply line in the shop. Further field works undertaken between February and March 2020 comprised: • A further groundwater monitoring round with purging and groundwater sample collection from four (4) groundwater monitoring wells gauged to have sufficient water to sample. • Hydraulic conductivity testing of three (3) groundwater monitoring wells (MW101, MW102 and MW106). • Groundwater level gauging of five (5) groundwater monitoring wells (MW101 to MW103, MW105 and MW109) during two (2) visits in March 2020. It was not possible to gauge MW106 due to the presence of equipment (inert falling head test slug and transponder) stuck down the monitoring well.

Table F – Summary of Field Work	
Service Clearance	Prior to commencing works all excavation locations were pre-cleared for the potential presence of subsurface utilities by ADP Ltd. Utility and as-built plans were reviewed and a site-wide robust underground utilities subscan was conducted on 15 and 16 October 2019, utilising a cable avoidance tool with generator (CAT & genny) and Ground Penetrating Radar (GPR). Between 11 and 13 November 2019, each borehole location was cleared by AECOM subcontractor Geotron using vacuum excavation to 150% of the drilling diameter and to a depth of no less than 1.2m bgl prior to mechanical drilling.
Geophysics	Between 15 and 16 October 2019, a full GPR survey was conducted at the site using AECOM's geophysics team. The results of this are reported in a separate report (Ref. 6 and provided in **Appendix I**). The location of all the six operational tanks was confirmed and it was also noted that no other features were observed that could be directly interpreted as underground storage tanks. Several areas of buried obstructions or disturbed ground were reported beneath the site, associated with known fuel infrastructure and the interceptor as well as other areas consistent with buried services.
Borehole Drilling Methodology	Between 19 November and 3 December 2019, boreholes were completed by Geotron UK Ltd using a Commachio 205 drill rig, utilising a window sample technique (MW101 – MW106, MW108 and MW109) and rotary follow on (MW101 to MW103, MW105, MW106, and MW109). Eight (8) boreholes (MW101 – MW106, MW108 and MW109) were drilled to a maximum depth of 15.0m bgl. AECOM personnel logged and screened soil arisings during excavation. Borehole MW103 was the first location drilled and therefore drilled to 5.0m bgl to investigate the extent of the superficial Pelaw Clay Member, the nature of the shallow bedrock and the presence of any perched water within the superficial clay. Following further characterisation of the extent of the superficial clay, MW104 and MW108 were drilled to depths between 2.7m and 3.4m bgl to investigate the presence of perched water in the superficial Pelaw Clay Member. Perched water was only identified in MW103 and MW108 in the east of the site. Boreholes MW101, MW102, MW105, MW106 and MW109 were advanced to depths between 8.4m and 15.0m bgl. Borehole MW107 was not progressed following vacuum excavation, as no perched groundwater was encountered in the adjacent borehole (MW106). The borehole logs are presented in **Appendix B**. Soil samples were collected during the site investigation programme on the basis of volatile organic compounds headspace results using a Photoionision Detector (PID), and visual and olfactory evidence of the potential presence of COPC for environmental testing. Additional soil samples were collected for geotechnical assessment and Waste Acceptance Criteria (WAC) testing. The location and depth of each soil sample is highlighted on the drilling logs provided in **Appendix B.**
Well Installation Methodology	Six (6) groundwater monitoring wells (MW101 – MW103, MW105 – MW106 and MW109) were installed within the drilled boreholes to total depths of between 2.0m and 9.5m bgl using 50 millimetre (mm) diameter, 0.5mm slotted, flush-threaded high-density polyethylene (HDPE) well screen and finished with a sufficient length of compatible HDPE riser. Three (3) of the vacuum excavated boreholes were installed as vapour wells (VP101 – VP103) also using a 50mm diameter, 0.5mm slotted, flush threaded HDPE well screen. The annulus surrounding each well was filled with a filter pack comprising clean, washed 1-2mm gravel selected given the published geology of sand, to a minimum of 0.2m (groundwater monitoring wells) or 0.15m (vapour wells) above the top of the screened interval, and topped with a layer of activated bentonite to act as a seal. Each well was finished in a protective well vault placed flush to surface and set in a concrete pad.

Table F – Summary of Field Work

Borehole Location Rationale

Drilling locations were designed to evaluate the soil, soil vapour and / or groundwater conditions associated with the target locations described below. A borehole location plan is provided as **Figure 2.** MW105 was initially attempted at an alternative location; however, this borehole was relocated due to a refusal at the initial location (MW105A).

Borehole ID	Target Location	Actual location	Completion Depth (m bgl)	Monitoring Well (Y/N)
MW101	South west of site close to southern site boundary.	As target	10.0	Y
MW102	Close to eastern site boundary and forecourt area.	As target	10.0	Y
MW103	East of shop building and close to the forecourt area.	As target	5.0	Y
MW104	North east corner of site adjacent to cess pit.	As target	3.4	N
MW105A	Close to northern site boundary, within the HGV fuel lane and on-site substation.	As target	0.6 – refusal on obstructions	N
MW105	Close to northern site boundary, the HGV fuel lane and on-site substation.	As target but moved on to grass away from obstructions	8.4	Y
MW106	Western area of site, adjacent to tank farm and near vent pipes / off-set fill points.	As target	9.0	Y
MW107	Western area of site, adjacent to tank farm and near vent pipes / off-set fill points.	As target	1.2	N
MW108	Close to eastern site boundary and forecourt area.	As target	2.7	N
MW109	North east corner of site adjacent to cess pit.	As target	15.0	Y
VP101	South west of site close to southern site boundary and commercial properties to south of site.	As target	1.2	Y
VP102	Close to eastern site boundary and forecourt area.	As target	1.2	Y
VP103	East of shop building	As target	1.2	Y

Table F – Summary of Field Work	
Surveying	The elevations of groundwater and vapour monitoring well standpipes installed by AECOM were surveyed to Ordnance Survey National Grid coordinates and m AOD by Greenhatch Ltd, under the supervision of AECOM on 12 December 2019.
Well Development	Following installation of monitoring wells MW101 to MW109, the following volumes of water were removed by pumping and/or bailing: MW101 1,177l, MW102 212l, MW103 55l, MW105 75l, MW106 241l and MW109 200l to remove sediment and facilitate groundwater flow into the well.
Groundwater gauging and sampling	Groundwater level gauging and sampling was undertaken between 10 and 12 December 2019. Prior to sampling, the depth to groundwater and light non aqueous phase liquids (LNAPL) (if present) was gauged using a portable oil / water interface probe. Groundwater gauging results are presented in **Table 1** in **Appendix C**. Between 10 and 12 December 2019, groundwater wells MW101 to MW103, MW105, MW106 and MW109 were purged and sampled using low-flow sampling (MW101 to MW103 and MW106) or dewatering and sampling following recovery (MW105 and MW109) utilising a peristaltic pump incorporating a flow through cell and dedicated tubing. During well purging activities, water was periodically monitored for temperature, pH, conductivity, dissolved oxygen (DO), and oxidation/reduction potential (ORP or Redox) using a water quality meter to determine when representative formation waters were being encountered. **Table 2** in **Appendix C** provides details of the purging, and indicates if any wells did not recharge sufficiently to allow low flow sampling, and a sample was taken once water recharged. All groundwater samples were collected into laboratory supplied containers, labelled and placed on ice. A second site visit was conducted between 4th and 7th February 2020 to undertake groundwater level gauging, sampling and hydraulic conductivity testing on MW101, MW102 and MW106. Groundwater gauging results prior to sampling are presented in **Table 1** in **Appendix C**. During the gauging round, monitoring wells MW105 and MW109 had an insufficient water column to monitor and sample, with MW105 reported to be dry. As such, groundwater wells MW101, MW102, MW103 and MW106 were purged and sampled using low-flow sampling utilising a peristaltic pump incorporating a flow through cell and dedicated tubing. During well purging activities, water was periodically monitored for temperature, Ph, conductivity, dissolved oxygen (DO), and oxidation/reduction potential (ORP or Redox) using a water quality meter to determine when representative formation waters were being encountered. A bailer was used to attempt to grab sample groundwater in MW109; however only limited turbid silty water was encountered. **Table 3** in **Appendix C** provides details of the purging and low flow sampling and indicates which wells could not be sampled. All groundwater samples were collected into laboratory supplied containers, labelled and placed on ice. Groundwater gauging results for the visits completed on 20 March and 26 March 2020 are also presented in **Table 1** in **Appendix C**.
Potable water sampling	Two (2) samples of potable water were collected from the staff kitchen within the retail shop on 10 December 2019. One (1) 'static' potable sample was collected immediately after the tap was open and one (1) 'active' potable sample was collected after water was left to run for five minutes to represent water being sourced from pipe-work off-site.
Ground gas monitoring	Ground gas monitoring of VP101 to VP103 was conducted on 11 and 12 December 2019 using a portable infrared ground gas monitor (GFM435 Infrared Gas Analyser). Monitoring results are presented in **Table 4** in **Appendix C**.

Table F – Summary of Field Work	
Soil vapour monitoring	Prior to soil vapour sample collection each well was purged of one (1) well pipe volume using an air pump to remove standing ambient air from the well. Leak checks were then completed to ensure that ambient air was not being drawn into the sample train. The oxygen content of the soil gas was confirmed to be reduced compared to ambient air, and a vacuum was applied to the sample train and held without significant loss of vacuum. The vapour monitoring samples were then collected in absorbent tubes. During and after purging, measurements of Volatile Organic Compounds (VOCs) were taken using a photo ionisation detector (PID) equipped with a 10.6 electron-volt (Ev) lamp. Vapour samples were recovered from vapour wells VP101 to VP103 in December 2019 using Carbopack B sorbent tubes and a low flow pump.
Field quality control sampling	The following field quality control samples were collected as part of this CESA: • Groundwater: one (1) duplicate sample, one (1) trip blank, and one (1) equipment blank. • Potable water: one (1) duplicate. During the February 2020 GME the following field quality control samples were collected: • Groundwater: one (1) duplicate sample, one (1) trip blank, and one (1) equipment blank.

3.2 Field Screening Results / Observations

Table G – Field Screening

Observations	During excavation and drilling of the boreholes, soil vapour screening of arisings was undertaken using a PID. Full details of visual and olfactory observations and PID readings are presented in the borehole logs provided in **Appendix B.** Key observations which are considered relevant to the CSM are summarised as follows;
Light Non-Aqueous Phase Liquid (LNAPL)	No measurable thickness of LNAPL was encountered in any of the monitoring wells on site during all four (4) groundwater gauging rounds. No potential indicators of residual LNAPL were reported during either groundwater monitoring event.
Field Groundwater Quality Parameters	Groundwater parameter data, i.e. redox, electrical conductivity, groundwater temperature, dissolved oxygen and pH were collected following purging in December 2019 and February 2020 and are presented in **Table 2** and **Table 3** in **Appendix C** respectively.

Borehole ID	Maximum PID	Depth (m bgl)	Soil Visual Olfactory Observations	Groundwater Visual Olfactory Observations
MW102	<0.1	-	-	Hydrocarbon odour encountered during both groundwater monitoring events. Maximum PID reading of 178.2ppm.
MW106	4.8	4.95 – 5.0 and 5.7 – 6.6	Some black staining (possibly hydrocarbon)	Hydrocarbon odour only encountered during the December 2019 groundwater monitoring event. Maximum PID reading of 66.2ppm.

3.3 Geological/Hydrogeological Information

Table H – Hydrogeological Information

Summary of Site Geology

The geological sequence encountered on-site is summarised below based on review of the findings of the intrusive investigation:

Unit	Description	Range of Depth to Top of Unit (m bgl)	Range of Thicknesses (m)
Topsoil	Grass and topsoil	Surface	0.1 – 0.3
Made Ground	Concrete / Asphalt	Surface	0.14 – 0.26
Made Ground	Reworked dark brown slightly sandy gravelly clay.	0.1 – 0.26	0.4 – 1.7
Pelaw Clay Member	Firm brown sandy gravelly clay.	0.3 – 1.7	1.3 – 3.1
Pennine Middle Coal Measures Formation (north and central area of site, potentially north of Claxheugh Fault)	Predominantly brown or grey interbedded horizons of sandstone, siltstone, grey mudstone and shale (MW103, MW105 and MW109 only).	2.7 – 3.2	2.3 – 4.6
	Grey / grey brown SANDSTONE with some coal inclusions (MW105 and MW109 only, MW103 only advanced to 5.0m bgl).	5.2 - 7.8	3.2 – 7.2 (base not proved)
	Grey / yellow brown SANDSTONE (MW102 only) with some gravel inclusions.	2.8	7.2
Pennine Middle Coal Measures Formation (south west of site, potentially south of Claxheugh Fault)	Brown SANDSTONE, often weathered or fractured with some gravel inclusions or black striations (MW101 and MW106)	2.8 – 3.0	3.6 – 4.5
	Grey MUDSTONE with thin sandstone horizons identified underlying sandstone in MW101 and MW106 only	6.6 - 7.3	2.4 – >2.7 (base not proved)

Depth to Groundwater

Groundwater level data is presented in **Table 1** in **Appendix C** and is summarised below:

- In December 2019, groundwater was recorded within six (6) monitoring wells, at depths ranging from 0.43m bgl (MW103 installed in the superficial clay deposits) and between 4.18m and 6.70m bgl (MW101 and MW109 respectively, installed in the Pennine

Table H – Hydrogeological Information

Middle Coal Measures aquifer). Groundwater elevations ranged from 42.65m AOD to 45.69m AOD in the bedrock and was 49.10m AOD in MW103.

- In February 2020, groundwater was recorded in four (4) of the six (6) wells at depths ranging from 0.47m bgl (MW103) and between 4.37m bgl (MW101) and 9.25m bgl (MW109) in the bedrock. MW105 was reported to contain no groundwater. Groundwater elevations ranged from 40.10m AOD to 45.50m AOD in the bedrock and was 49.06m AOD in MW103.
- On 20 March 2020, groundwater was recorded in five (5) of the five (5) monitoring wells gauged at depths ranging from 0.40m bgl (MW103) and between 4.36m bgl (MW101) and 8.75m bgl (MW109) in the bedrock. Groundwater elevations ranged from 40.59m AOD to 45.51m AOD in the bedrock and was 49.12m AOD in MW103.
- On 26 March 2020, groundwater was recorded in five (5) of the five (5) monitoring wells gauged at depths ranging from 0.46m bgl (MW103) and between 4.41m bgl (MW101) and 8.96m bgl (MW109) in the bedrock. Groundwater elevations ranged from 40.39m AOD to 45.46m AOD in the bedrock and was 49.07m AOD in MW103.

Groundwater elevations for the monitoring wells installed in the bedrock aquifer are presented on the below graph:

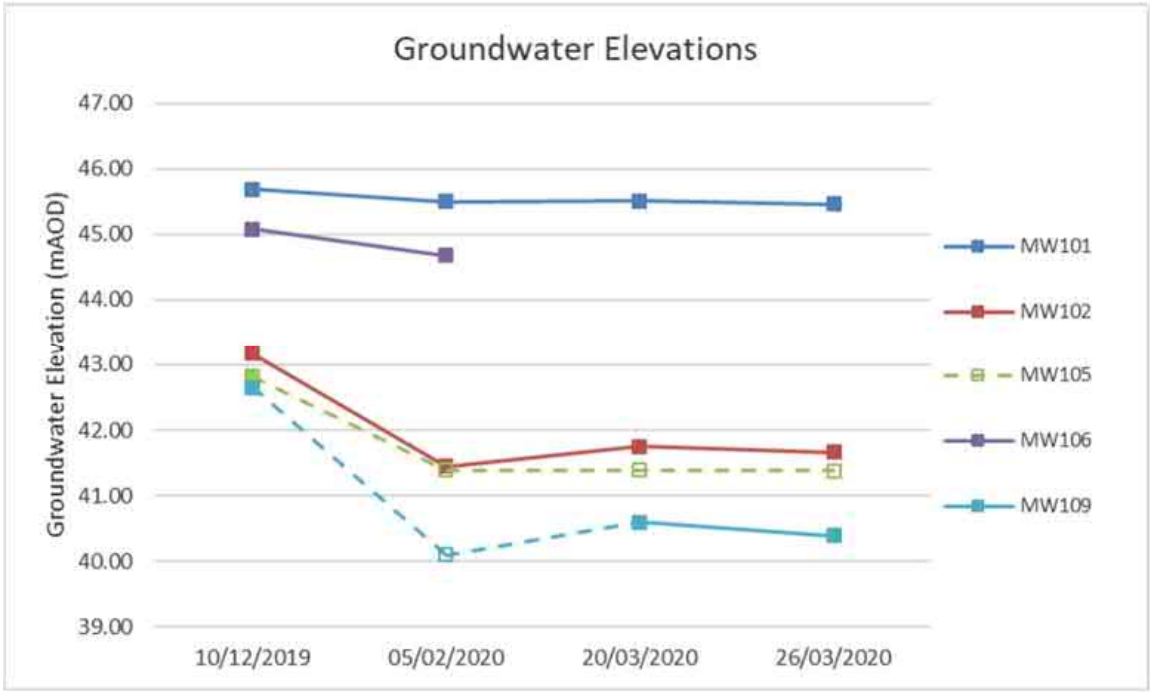


Table H – Hydrogeological Information	
	Note: Monitoring well MW105 located on the northern side of the site is represented as a dashed line as the well was identified to contain limited or no groundwater during the last three (3) gauging rounds and may not be indicative of resting water level in the wider aquifer, with limited groundwater observed in MW109 in the February 2020 gauging round too. During drilling, perched water was only identified in MW103 located in the eastern area of the site and in MW108 located in the south east of the site. However, perched water was not identified in MW102, located adjacent to the north of MW108. Perched water was subsequently encountered in vapour monitoring wells VP101 to VP103, with depth to water reported to range as follows: VP101 - 0.80m (26 March 2020) and 0.99m bgl (20 March 2020). VP102 - 0.67m (December 2019 and 20 March 2020) and 0.7m bgl (26 March 2020). VP103 – 0.44m (December 2019) and 0.58m bgl (February 2020). Groundwater elevations in the three vapour monitoring wells and MW103 ranged between 48.79m AOD and 49.12m AOD.

Table H – Hydrogeological Information	
Inferred Groundwater Flow	Groundwater elevations are presented on **Figures 3 to 6**. It has not been possible to infer a groundwater flow or hydraulic gradient within the Pennine Middle Coal Measures underlying the site based on the following: • During the well development and gauging rounds, depth to groundwater was consistently reported to be higher in MW101, and in MW106 in the south-west of the site during the first two rounds where gauging was possible. The difference in depth between MW101 and MW106 and the other wells (MW102, MW105 and MW109) was approximately 2m in December 2019 and approximately 3.5 – 4m between February and March 2020. • Between the December 2019 and February 2020 gauging rounds, groundwater levels fell significantly in wells in the north and central area of site (potentially north of Claxheugh Fault), with groundwater level decreases at MW102 (1.72m), MW105 (at least 1.43m, well reported to be dry) and MW109 (2.55m). This was considered to potentially reflect drilling water influencing the December monitoring round. In contrast, groundwater levels in MW101 and MW106 only dropped by 0.19m and 0.4m respectively. • Between the February 2020 and two (2) March 2020 gauging rounds, groundwater levels rose in MW102 by approximately 0.22m and in MW109 by between 0.3 and 0.5m. Monitoring well MW105 located on the northern side of the site is represented as a dashed line as the well was identified to contain limited or no groundwater during the last three (3) gauging rounds and may not be indicative of resting water level in the wider aquifer, with limited groundwater observed in MW109 in the February 2020 gauging round too. Based on geological mapping, the Claxheugh Fault potentially runs east to west through the northern part of site, with the bedrock mapped to comprise interbedded sandstone, siltstone and mudstone in the northernmost part of the site and sandstone mapped across the rest of the site. The faulted nature of the bedrock and variances reported in the geology in Table H may affect the variance in groundwater levels observed across the site. Water identified within MW103 and the vapour wells (VP101 to VP103) is considered to be perched in localised more permeable pockets within the clay, with no continuous groundwater body present based on observations of the shallow soil made during drilling. Water was identified in MW108 during drilling, but not in MW102 located adjacent to the north of MW108. During well development, the water within MW103 quickly purged dry and was observed to slowly decrease during low flow groundwater monitoring, indicating that the perched water within the superficial clay has limited recovery.
Hydraulic Conductivity	Rising head tests were carried out at three (3) locations on site (MW101, MW102 and MW109) in December 2019 and at two (2) locations (MW101 and MW102) in February 2020 which are screened in the Pennine Middle Coal Measures Formation. The average hydraulic conductivities for MW101 and MW102 were calculated at 2.98 metres per day (m/d) and 0.17m/d, respectively, which are similar to estimated literature hydraulic conductivities for medium grained sandstone. The average hydraulic conductivity for MW109 was calculated at 0.06m/d which is lower than the literature value and possibly associated with the more fine-grained sandstone as described in the borehole log. Hydraulic conductivity data is presented in **Appendix D**.

3.4 Analytical Schedules & QA/QC

Table I – Analytical Information

Analytical Laboratory	Soil, groundwater, potable water and vapour samples were analysed by ALS Life Sciences Ltd. The results are discussed in **Section 4** and presented in **Appendix E.** Copies of the Chain of Custodies (COCs) and laboratory certificates are presented in **Appendix F.** Geotechnical soil samples were analysed by Professional Soils Laboratory. Copies of the Chain of Custodies (COCs) and laboratory certificates are presented in **Appendix G**.
Analytical Schedule	The following schedule of analysis was completed, excluding QAQC samples. The COPC in bold are those identified by Shell as potential risk drivers from retail petroleum sites. The results and analytical methodology are presented in **Appendix F**.

Analysis	Number of Soil Samples	Number of Groundwater Samples	Number of Potable Water Samples	Number of Vapour Samples
Total Petroleum Hydrocarbons (TPH) Health risk fractions including **C8-C12**	17	10	2	-
Benzene, Toluene, Ethylbenzene, **Xylenes** (BTEX) compounds	17	10	2	-
Fuel Oxygenates (methyl tertiary butyl ether (MTBE), tert-butyl ethyl ether (ETBE), di-isopropyl ether (DIPE), tert butanol (TBA), tert-amyl methyl ether (TAME), Ethanol)	17	10	2	-
Polycyclic Aromatic Hydrocarbons (PAH) 16 Speciated including naphthalene	17	10	2	-
Metals (arsenic, boron, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, tin and zinc)	14	10	2	-
2-methylnaphthalene	17	10	2	3
n-hexane	17	10	2	3
Volatile Organic Compounds (VOC) and TPH (C6-12) including **BTEX**	-	-	-	3
Particle Size Distribution	3	-	-	-
Asbestos	7	-	-	-
Atterberg Limits	3	-	-	-
Water Soluble Sulphate, Chloride and PCB 7 Congeners	3	-	-	-
Fraction Organic Carbon (TOC)	8	-	-	-

Table I – Analytical Information	
Field and laboratory quality control sampling	The analytical data have been reviewed for quality assurance and control purposes (QA/QC), the results of which are presented in **Appendix F**. • Laboratory holding times for soil samples were exceeded for PCB analysis undertaken for MW104 (0.5m) and MW105 (0.5m) and some chemicals tested for waste classification in the composite skip sample. Laboratory holding times were exceeded for eleven (11) of the water samples collected during the December groundwater monitoring event, for chemicals including TPH fractions C_{12}-C_{35} and various PAH, with a maximum sampled to analysis screening period of 20 days. However, as these samples were appropriately stored, the exceedance of the screening period is not considered significant. • The surrogate data was generally reported within acceptable limits. GRO Surrogate % for MW105 at 0.5m bgl was reported as 142%) and for MW109 at 2.3m surrogate recovery of Perylene-d12 was 63.7% and Chrysene-d12 (surr.) was 63.3%. The soil at 0.5m in MW105 where over-recovery was reported was sandy and gravelly reworked clay and the soil at 2.3m in MW109 where under-recovery was reported was firmer natural sandy clay. • The relative percentage difference (RPD) between detected concentrations in the groundwater duplicate sample (DUP2) and the parent sample (MW102) collected in December 2019 were slightly above acceptable limits for copper, lead, acenaphthene, fluorene, naphthalene, phenanthrene and >EC7-EC8 Aromatics. The RPD between detected concentrations in the groundwater duplicate sample (DUP) and the parent sample (MW101) collected in February 2020 was slightly above acceptable limits for copper. The results are considered to be acceptable for use, as the reported RPD was within acceptable limits for the key potential risk driving COPC. • The relative percentage difference (RPD) between detected concentrations in the potable water duplicate sample (DUP1) and the parent sample (Active) collected in December 2019 were within acceptable limits. • Concentrations of chromium (III+VI), copper and zinc were detected above the laboratory method of detection limit (MDL) in equipment blank samples collected during groundwater monitoring events completed in December 2019 and February 2020. However, the reported concentrations were within the same order of magnitude as the MDL and are considered to be acceptable. • Ethanol was detected in the laboratory blanks run at the same time as soil samples under laboratory reports SDG 191113-115 and 191115-8). The maximum reported concentration was 0.0645mg/kg, where the laboratory MDL is 0.05mg/kg. As ethanol was not detected in any of the soil samples collected from the site, the results are considered to be acceptable. Hexavalent chromium was detected in the laboratory blank run at the same time as groundwater samples on laboratory report SDG191212-165, where the reported result was 0.99mg/l. This result was queried with the laboratory, who confirmed that this sample was a dilution check standard for instrumentation and that the result was within the dilution check range (+/- 10% of 1mg/l) and therefore acceptable for reporting. • COPC concentrations were not detected in either groundwater trip blank. In general, the data are considered appropriate for reporting.

Table I – Analytical Information	
Waste Classification	All material proposed for off-site disposal must be given a proper description and waste classification in accordance with the Environmental Protection (Duty of Care) Regulations 1991, and Hazardous Waste (England and Wales) Regulations 2011. To determine the likely waste classification of the soils beneath the site, the chemical analysis results for soil samples were assessed using the staged process set out in Interpretation of the definition and classification of hazardous waste, Environment Agency, Technical Guidance WM3 (First Edition). Waste Acceptance Criteria (WAC) results alongside the WM3 waste classification were used to determine the appropriate route for the dispose of the soil cuttings generated by the intrusive investigation. Based on the analytical results obtained during the recent AECOM investigation, the concentrations of substances in the soil at the site indicate that it was classified as non-hazardous. WAC results are presented in the laboratory certificates, **Appendix F**. The waste transfer note for the waste generated during the investigation is presented in **Appendix H**.

4. HUMAN HEALTH STAGE 2 GENERIC QUANTITATIVE RISK ASSESSMENT

4.1 Methodology

The methodology adopted in this report is primarily based upon the UK Defra and EA "best practice" in regard to the assessment of contaminated land. The approach taken reflects that promoted in CLR11 (Ref. 7), CL:RM (Ref. 8) and R&D Publication 66 (Ref. 9) and the supporting guidance referenced within them. Soil, groundwater and soil vapour data have been screened against generic assessment criteria (GAC) protective of potential human health receptors.

The derivation of the GACs for organic compounds includes an element of receptor identification and vapour pathway assessment. The vapour pathways assume a distance of 0.5m, 0.65m and 1m from the source to the receptor respectively for soil vapour, soil and groundwater.

Notwithstanding the adopted methodology, for the assessment of potential receptors for petroleum vapour intrusion, assessment has also been completed in line with more recent guidance from the USEPA (USEPA, 2015. Ref. 3). Where receptors are Petroleum Vapour Intrusion (PVI) screened in for further assessment, the GAC are appropriate. Where receptors are PVI screened out, the contribution to risk from the vapour pathways assessed by the GAC can be disregarded.

However, where the USEPA guidance is not valid based on the presence of precluding factors (see Table B), receptors have been selected using distances to receptors set out in USEPA 2015 (Ref. 10). The GAC are appropriate.

The site shop has been included within the assessment, although it is recognised that risks to petrol filling station workers from petroleum products are controlled primarily through health and safety systems.

Ground Gas risk assessment has been carried out following guidance in B8485 (Ref. 11) which sets out an empirical semi-quantitative approach for deriving Gas Screening Values based on gas monitoring measurements to select a Characteristic Situation which informs the scope of gas protection measures that could be required, if any.

4.2 Generic Assessment Criteria (GAC) – Soil, Groundwater and Vapours

The Stage 2 Generic Assessment Criteria (GAC) for soil, groundwater and vapours were derived using the LQM/CIEH S4UL methodology (Ref. 12), protective of:

- On-site workers (including Shell shop staff and site users) using a continued petroleum use (CPU) end use scenario.
- On-site general public and visiting staff (such as contractors, including those conducting excavation works).

Off-site workers and visitors in commercial properties immediately south west of site (nearest building 24m south west) have been PVI screened out, but for completeness Commercial/Industrial GAC have been included in the tables.

For potable water GAC have been based upon the UK Drinking Water Standard (DWS), or where not available EU drinking water standards or World Health Organisation (WHO) drinking water standards. In addition, for compounds where published DWS are not available, additional criteria have been considered, as discussed in **Section 5.1.1.**

Assumptions within the derivation of the GAC and their applicability to the site are set out in Table J. Comparison of soil, soil vapour, groundwater, and potable water analytical results to Stage 2 GAC is provided in **Appendix E** and GAC exceedances are summarised in Table K.

Table J – Assumptions within the GAC and applicability to the site

	GAC	Assumption	Applicable at site	Likely to over or under simulate risks
Active Pathways	CPU	Only vapour pathways are viable. No exposure to soils via direct contact pathways including dermal contact and dust inhalation/ingestion as the site is fully covered in hardstanding/building footprint and/or managed landscape	The site surface in the operational area is covered in 95% hardstanding. The site areas outside of the main operational area to the north, south and west are covered by grass.	GAC applicable to site shop.
Model Parameters all CLEA defaults except those listed below	All land uses - Soil and groundwater	0.58% total organic carbon (TOC)	Representative site TOC value for strata through which vapours pass is 1.4 % TOC	GAC may overestimate risks due to higher TOC.
		Soil separating the source and the receptor is physically similar to the CLEA Sand soil type.	Shallow site soils typically comprise sandy gravelly clay or sandy clay, underlain by sandstone or interbedded siltstone, mudstone and sandstone.	GAC may overestimate risks due to fines content of site soils
	All land uses - Soil and vapour	Vertical distance between soil source and receptor for vapour pathways is approximately 0.5m and receptor building directly overlies source	No soil impact observed during drilling. No exceedances of human health GAC.	GAC may overestimate risks
	All land uses - Groundwater	Vertical distance between source and receptor for vapour pathways is approximately 1.0m and receptor building directly overlies source	Hydrocarbon odour observed at MW102 and MW106, impacted groundwater below 1m bgl.	GAC may overestimate risks
	All land uses - Vapour	'Soil vapour to indoor air' factor for volatile compounds set to zero	Soil vapour data collected from wells with top of screen at 0.5m bgl.	GAC are applicable
	All land uses -Soil, groundwater and vapour	For volatile compounds it is assumed that vapour ingress is via a 2mm crack between concrete floor slab and walls.	Site shop likely to have a ground bearing slab.	GAC applicable for site shop
	CPU - Soil, groundwater and vapour	Building size set to 14m x 6.5m x 2.4m high representative of a small site shop.	Site shop is approximately the size of that used to derive.	GAC are applicable

Based on assumptions listed above and site characteristics, it is considered CPU GAC may overestimate risks at this site.

Table K – GAC Exceedances

Receptor Type	Screening Criteria	Media	Benzene / TPH Aromatic C_5-C_7	TEX / TPH Aromatic C_7-C_{10}	Other Aromatic TPH	Aliphatic TPH	MTBE	Other Oxygenates	n-hexane	TPH Hazard Index	Other VOCs (vapour)	Naphthalene	Benzo(a)pyrene	Other PAHs (incl. 2-methyl	Metals
Human Health	CPU	Soil	×	×	×	×	×	×	×	×	n/a	×	×	×	n/a
		Groundwater	×	×	×	×	×	×	×	×	n/a	×	×	×	n/a
		Soil Vapour	×	×	×	×	×	×	×	n/a	×	×	n/a	×	n/a
	COMM	Soil	×	×	×	×	×	×	×	×	n/a	×	×	×	×
		Groundwater	×	×	×	×	×	×	×	×	n/a	×	×	×	n/a
		Soil Vapour	×	×	×	×	×	×	×	n/a	×	×	n/a	×	n/a
	DWS	Potable Water	×	×	×	×	×	×	×	n/a	n/a	×	×	×	×

Notes: CPU = Continued Petroleum Use

COMM = Commercial Use

✓= Measured in excess of GAC

× = Not measured in excess of GAC

n/a = not applicable

4.3 Discussion of Key Exceedances of Human Health GAC

4.3.1 Human Health – CPU and Commercial

Potential chronic and acute risks to health of site workers on petrol filling stations are controlled primarily under health and safety legislation; however, an assessment of potential chronic risks has been completed in line with the UK regulatory framework for assessing risks from contaminated land to set potential risks into context.

No COPC concentrations exceeded assessment criteria for soil, soil vapour or groundwater human health (CPU or Commercial scenario) and COPC concentrations are therefore not considered to present an unacceptable risk and have not been further assessed.

4.3.2 Human Health – Asbestos in Soil

No asbestos fibres were detected within any of the seven (7) samples tested from shallow Made Ground. Non-asbestos fibre was detected at location MW104 at a depth of 0.5m bgl within the Made Ground. Potential risks to visiting contractors undertaking intrusive works should be managed by appropriate PPE, risk assessment and method statements. Risks to visiting contractors excavating the ground have therefore not been further assessed.

4.3.3 Human Health - DWS

COPC in potable water samples did not exceed DWS and have therefore not been further assessed.

4.4 Ground Gas

Ground gas monitoring results collected from VP101 to VP103 are presented in **Table 4 in Appendix C**, and post purge results are summarised as follows:

Table L – Ground Gas Results

	Units	Minimum	Maximum	Comment
Methane	% v/v	<0.1	<0.1	-
Carbon dioxide	% v/v	0.1	0.5	Maximum result recorded in VP101
Oxygen	% v/v	19.7	19.9	-
Total ground gas flow rates	litres per hour (l/hr)	0.7	2.5	Maximum flow recorded in VP102
Atmospheric pressure	millibar (mBar)	992	990	-
List any wells where waters level was above well screens		Perched water in VP103 was close to the top of the well screen		

*Peak readings were similar to post purge results and have therefore not been separately assessed.

Calculated worst case hazardous gas flow rates based on the maximum recorded flow and concentrations were 0.0025 litres per hour (l/hr) of methane and 0.0035 l/hr of carbon dioxide. The characteristic gas situation is classified as 1 for the site, with a risk classification of Very Low (i.e. less than 0.07 l/hr).

Guidance provided within BS8485 (Ref. 11) suggests that where concentrations of methane and carbon dioxide exceed 1% v/v and 5% v/v respectively then an increase to Characteristic Situation 2 should be considered, but this trigger has not been exceeded.

The characteristic gas situation is classified as 1 for the site, with a risk classification of Very Low. Ground gases have therefore not been considered further in the risk assessment for the site.

4.5 Summary

Based on the Stage 2 human health risk assessment, no COPC concentrations have been further assessed at Stage 3.

5. CONTROLLED WATERS STAGE 2 GENERIC QUANTITATIVE RISK ASSESSMENT

5.1 Generic Assessment Criteria

The risk based methodology adopted in this report is primarily based upon the UK Defra and EA "best practice" in regard to the assessment of contaminated land. The approach taken reflects that promoted in CLR11 (Ref 7), LC:RM (Ref. 8) and R&D Publication 66 (Ref 9) and the supporting guidance referenced within them.

Analytical results for soil and groundwater samples recovered are tabulated in **Appendix E** and have been compared against Stage 2 Generic Assessment Criteria (GAC), protective of:

- Groundwater within the Pennine Middle Coal Measures Formation (Secondary A Aquifer).
- Surface water (surface water drain situated 68m west which possibly extends 30m north west, Monkton Burn 280m south east and ponds 155m south west and 300m north east).

The AECOM controlled waters soil GAC were derived assuming that unsaturated soils beneath the site typically contained 1% TOC. Other assumptions used in the derivation of AECOM controlled waters GAC were 30% total porosity, 7.5% water filled porosity, and 1.86g/cm3 bulk density. The TOC of 1% is considered appropriate to derive GAC based on leaching of COPC from the unsaturated zone. The average TOC measured in unsaturated soil samples collected by AECOM was 1.4% which is more than that used in the derivation of the GAC. Consequently, the controlled waters soil GAC may over estimate risks, and organic COPC which exceed the soil GAC by factors of 1 or less are unlikely to represent an unacceptable risk.

5.1.1 Drinking Water Standard (DWS)

For assessment of groundwater resource potential GAC have been based upon the UK Drinking Water Standard (DWS), or where not available EU drinking water standards or World Health Organisation (WHO) drinking water standards. In addition, for compounds where published DWS are not available, additional criteria have been considered, although it is recognised that these are not published standards, such as

- published taste or odour data have been used for a number of oxygenates (MTBE, ETBE, TAME, DIPE) which are known to have taste and odour thresholds which are significantly lower than toxicity based criteria,
- WHO (2008) proposals for drinking water guidelines which are based on the TPHCWG approach for TPH fractions,
- Risk-based screening levels derived by GSI (2014) for Shell downstream sites, derived to be protective of groundwater ingestion using published toxicity data (for naphthalene, other PAHs, and n-hexane), and derived by AECOM (for TBA).

The groundwater within the Pennine Middle Coal Measures Formation is considered to be the primary controlled waters receptor.

The groundwater identified within the Pennine Middle Coal Measures beneath the site may be available as a groundwater resource to the wider Secondary A Aquifer. Site data has been compared to DWS GAC, although it is recognised that this assessment may overestimate risks given that there are no abstraction points within 1km of site and that the site is not within a source protection zone. Limited exceedances of the GAC are therefore considered unlikely to represent an unacceptable risk to controlled waters.

Based on hydrogeological information presented in Table H, it is considered likely that water identified within MW103, the vapour wells and in MW108 (during drilling only) is perched and available in localised more permeable pockets within the clay. Groundwater is considered likely to be discontinuous within the superficial Pelaw Clay deposits (Unproductive Strata). This data is included within the GAC tables although it is noted that comparison with DWS is conservative for samples from the unproductive strata.

5.1.2 Environmental Quality Standards (EQS)

For assessment of surface water, GAC have been based upon UK Environmental Quality Standards (EQS) for freshwater, and also EQS from SEPA WAT-SG-53 and PNEC derived for EU REACH registration dossiers/chemical safety reports (via the Fuel Ether REACH Consortium FERC).

A surface water drain is located 68m west of site, which potentially continues 30m from the site boundary to the north west, and is considered to be a secondary controlled waters receptor for EQS along with Monkton Burn 280m south east of site at its closest point and ponds located 155m south west and 300m north east of site.

Due to the reported depth of groundwater within the bedrock on site (4.18m bgl or more and elevation between approximately 40m and 45m AOD), it is considered unlikely to be in connectivity with the surface water drain to the west, which is at a similar elevation to the site. Similarly, the pond located 155m south west of site is at a similar elevation to the site. The pond located 300m north east of site is present within Red Barns Quarry which currently extracts brick shale and therefore may be man-made. Given this, and the distance, the pond is considered unlikely to be a receptor.

Monkton Burn is situated at a lower elevation than the site between approximately 46m AOD to the south east and 41m AOD to the north east and therefore may be in connectivity with the groundwater on site. The burn flows in a north easterly direction and is located approximately 330m east and 400m north east of the site. Given the distance to Monkton Burn, this is considered to be a secondary receptor and exceedances of the EQS GAC will be assessed in this context.

5.2 Analytical Results Screening

Comparison of soil and groundwater analytical results to Stage 2 GAC is provided in **Appendix E** and GAC exceedances are summarised in the table below:

Table M – GAC Exceedances													
Receptor Type	**Screening Criteria**	**Media**	**Benzene / TPH Aromatic C_5-C_7**	**TEX / TPH Aromatic C_7-C_{10}**	**Other Aromatic TPH**	**Aliphatic TPH**	**MTBE**	**Other Oxygenates**	**n-hexane**	**Naphthalene**	**Benzo(a)pyrene**	**Other PAHs (incl. 2-methyl**	**Metals**
Controlled Waters	DWS	Soil	✓	×	×	×	✓	✓	×	×	✓	✓	✓
		Groundwater	✓	✓	✓	✓	✓	✓	×	×	×	×	✓
	EQS	Soil	✓	×	×	×	×	×	×	✓	✓	✓	✓
		Groundwater	✓	✓	×	×	×	×	×	✓	✓	✓	✓

Notes: ✓= Measured in excess of GAC

× = Not measured in excess of GAC

n/a = not applicable

5.3 Discussion of Key Exceedances of DWS GAC

Tables 10 and 11 provide details of each COPC which exceeds DWS GAC. The key exceedances of the DWS GAC are discussed below.

Both soil and groundwater COPC concentrations were found to exceed thresholds for benzene, fuel oxygenates (Diisopropyl Ether and Methyl Tert Butyl Ether) and metals. Groundwater was also found to exceed GAC for ethylbenzene and TPH fractions C_5-C_{12}, with PAH exceedances reported in soil samples:

- Benzene, MTBE and DIPE exceeded the DWS GAC in one soil sample (MW103 at 1.6m bgl). No other soil samples were found to exceed BTEX or fuel oxygenate DWS GAC. MW103 is located in the eastern area of site, with no visual or olfactory evidence of COPC reported during drilling or subsequent groundwater monitoring. Benzene and MTBE were not detected in the perched water samples collected from MW103 in December 2019 and February 2020. DIPE was reported to be marginally above the DWS GAC in the groundwater sample collected in February 2020 (concentration of 1.55µg/l, where the GAC is 0.8µg/l based on a taste and odour threshold). COPC exceedances are considered likely to represent limited localised impact and are considered unlikely to represent an unacceptable risk to controlled waters given that perched groundwater is discontinuous on site.
- Benzene and TPH aromatic fraction C_5-C_7 and ethylbenzene were found to exceed DWS GAC in both groundwater samples collected from MW102 (maximum reported concentration of benzene of 940µg/l) and benzene exceeded the GAC in the sample collected from MW106 in December 2019, by a factor of 8.25. Benzene was reported below the laboratory MDL in the groundwater sample collected in February 2020.
- COPC concentrations in MW102 and MW106 groundwater samples were both reported to exceed TPH C_8-C_{12} aromatic and aliphatic fractions by a maximum factor of 7.6 in MW102.
- MTBE and DIPE exceeded DWS GAC for the groundwater samples collected from MW102 by a maximum factor of 9.34. Results were within the same order of magnitude as the GAC. The DIPE concentration was marginally above the DWS GAC in the groundwater sample collected from MW106 in February 2020 (concentration of 1.75µg/l, where the GAC is 0.8µg/l).

MW102 is located in the eastern area of the site close to the forecourt and underground fuel lines and was reported to have a hydrocarbon odour during both groundwater monitoring events, although no visual or olfactory evidence of COPC was reported for the recovered soil samples. MW106 is located in the west of the site close to the existing tank farm and was reported to have pockets of black staining (possibly hydrocarbon) in soils at 4.95 – 5.0m and 5.7 – 6.6m bgl and a hydrocarbon odour during the GME undertaken in December 2019, with no visual or olfactory evidence observed during groundwater monitoring in February 2020. Concentrations of BTEX, fuel oxygenates, PAH, n-hexane, 2-methylnapthylene and TPH fractions were reported to be below the laboratory MDL in the groundwater samples recovered from MW101, located on the southern boundary of the site and in close proximity to MW106.

- PAH exceedances including benzo(a)pyrene in up to eight (8) soil samples were reported. There were no PAH exceedances of the DWS GAC in any of the groundwater samples collected across the two (2) monitoring events and therefore leaching of PAH from the shallow soil is considered to be limited.
- Metal exceedances for arsenic, chromium trivalent, lead and nickel were reported in fourteen (14) soil samples across all groundwater monitoring well locations. Arsenic was found to exceed DWS GAC at MW106 during both monitoring events by a maximum factor of 2.16, no other metal exceedances were recorded. As such, it is considered that leaching of metals from the shallow soil in to the groundwater is likely to be limited.

5.4 Discussion of Key Exceedances of EQS GAC

Tables 10 and 11 provide details of each COPC which exceeds EQS GAC. The key exceedances of the EQS GAC are discussed below.

In summary, EQS GAC exceedances were reported for benzene, toluene and ethylbenzene, PAH and metals in soil and groundwater samples and TPH aromatic fractions C_5-C_8 were reported to exceed in the groundwater samples recovered from MW102:

- A singular exceedance of benzene in the soil sample collected from MW103 at 1.6m bgl which is not considered to represent an unacceptable risk to controlled waters based on the discussion outlined in Section 5.3.
- Benzene, toluene, ethylbenzene and TPH aromatic fractions C_5-C_8 found to exceed EQS GAC for the groundwater samples collected at location MW102.

- PAHs including benzo(a)pyrene and naphthalene were reported to exceed GAC in ten (10) soil samples taken from all locations with the exception of MW103 and MW106. PAH exceedances were also reported in groundwater samples collected from MW102, MW103, MW106 and MW109 during one or both monitoring events but are not considered to represent an unacceptable risk to the Monkton Burn given the mobility of PAH and the distance to the burn.
- Concentrations of metals in all fourteen (14) soil samples analysed from most locations also exceeded the EQS GAC, with reported exceedances of the GAC in groundwater samples for copper, cobalt, nickel and zinc. However, all groundwater exceedances were within the same order of magnitude of the GAC and as such, it is considered that leaching of metals from the shallow soil in to the groundwater is likely to be limited.

5.5 Discussion of Controlled Waters Risk Assessment

Based on the COPC exceedances discussed in Sections 5.3 and 5.4, the benzene exceedances in the groundwater samples collected from MW102 are considered to be the risk driver for the Pennine Middle Coal Measures Secondary A Aquifer. However, using the current dataset for the site, it has not been possible to quantify parameters for a Stage 3 Detailed Quantitative Risk Assessment for controlled waters for the reasons outlined in the following sections.

5.5.1 Complex Geology

- There is variance in the observed geology encountered across the site which is also observed in nearby BGS borehole logs, with the on-site variance in geology shown in the borehole logs and cross-sections presented in **Appendix B** and the conceptual model (**Figure 7)**:
    - MW101 and MW106 in the south of the site were both reported to predominantly comprise sandstone directly beneath the superficial clay, with thin interbedded bands of siltstone or mudstone. Mudstone was then identified underlying the sandstone at respective depths of 7.3m and 6.6m bgl, with groundwater levels sitting in coarser sandstone bedrock, where little core recovery was achieved during drilling.
    - Boreholes in the central-northern area of the site (MW103, MW105 and MW109) were identified to have interbedded horizons directly beneath the Pelaw clay, with sandstone identified below this in MW105 and MW109 at respective depths of 5.2m and 7.8m bgl.
    - Bedrock in MW102 was reported to comprise sandstone between 2.8m and the maximum drilled depth of 10.0m bgl.
    - The nearest BGS borehole logs extended into the bedrock are NZ36SW133 located approximately 100m west of the nearest on-site monitoring wells and NZ36SW10 located approximately 200m east of the nearest on-site monitoring well. Both are mapped to be present within the interbedded mudstone, sandstone and siltstone, to the north of the Claxheugh Fault. No groundwater information was available for either borehole. NZ36SW133 was reported to be interbedded in the shallow bedrock, with thicker bands of mudstone and sandstone present at depths of 8.59m and 16.23m bgl respectively. Superficial deposits were not reported within borehole NZ36SW10, with a shallow horizon of coal identified. A ~5m thick band of sandstone was then reported to a depth of 6.17m bgl, underlain by interbedded bands of mudstone and coal to 9.75m bgl.
- Based on geological mapping, the Claxheugh Fault may run east to west through the northern part of site, with the bedrock mapped to comprise interbedded sandstone, siltstone and mudstone in the northernmost part of the site and sandstone mapped across the rest of the site. The faulted nature of the bedrock and variances reported in the geology in Table H may affect the variance in groundwater levels observed across the site and it is considered possible that the geological fault actually runs further south across the site, with sandstone encountered above mudstone in both MW101 and MW106.
- The variability described in the on-site borehole logs and the nearby BGS logs highlight the complexity of the geology in the area, with no clear corresponding bands of sandstone, mudstone or siltstone identified across the cross-sections.

5.5.2 Complex Hydrogeology

- Based on the initial groundwater gauging round completed in MW101, MW102 and MW109, it was considered that groundwater flow may be north easterly towards the Monkton Burn at distance (approximately 400m north east of site), with a steep hydraulic gradient across the site. However, the three (3) subsequent groundwater gauging rounds indicate that the initial round may have been impacted by residual drilling water. The groundwater levels in the second, third and fourth groundwater gauging rounds indicated the existing monitoring well network may not be in hydraulic connectivity across the site.
- It has not been possible to infer a groundwater flow direction for groundwater or a groundwater gradient within the Pennine Middle Coal Measures Secondary A Aquifer, with further information outlined in Table H. Groundwater levels have been consistently higher in groundwater monitoring wells MW101 and MW106 located in the south of the site. In addition, groundwater levels dropped significantly in MW102 (east of the site), MW105 and MW109 (north of the site) between December 2019 and February 2020. The faulted nature of the bedrock and variances reported in the geology may affect the variance in groundwater levels observed across the site and it is considered possible that the geological fault may run further south across the site, with groundwater higher to the south of the fault in MW101 and MW106.
- The estimated hydraulic conductivity across the three wells tested ranges by more than an order of magnitude, with 0.17m/d estimated in MW102.
- There is insufficient information to characterise the potential source area of benzene around MW102. The source area cannot be constrained to the north based on the existing dataset. Groundwater samples collected from MW101 located in the south of the site have no reported exceedances of the controlled waters DWS GAC and as such, the source area can be constrained to the south.

5.5.3 Conclusion

Based on the available information, BTEX exceedances in the groundwater at MW102 could represent an unacceptable risk to the Secondary A Aquifer. However, groundwater in this area may not be in hydraulic connectivity with the rest of the monitoring well network (based on variances in groundwater levels) and therefore the wider aquifer. It has not been possible to complete a DQRA based on the current dataset, but it is noted that the hydraulic conductivity is low and any migration of COPC may be sufficiently attenuated to not exceed GAC at the compliance point.

6. CONCEPTUAL MODEL

The Conceptual Model (CM) presented here is based on the information provided in the historic reports prepared for the site, on observations made during the AECOM ESA and subsequent GVME, and on the subsequent AECOM risk assessments.

6.1 Potential Sources

The site is an active petrol filling station, and as such there is the potential of COPC to be present from accidental releases to ground from infrastructure. The ESA has indicated that the COPC listed in **Sections 4** and **5** are present in the areas of the site which were investigated.

These potential sources have been assessed in **Tables N** and **O** below.

6.2 Potential Pathways, and Receptors

The potential pathways and receptors identified for assessment at Stage 2 and/or Stage 3 are listed in **Tables N and O** below.

6.3 Review of Potential Source-Pathway-Receptor Linkages

The following pollutant linkages were evaluated at Stage 2 given continued oil use. These are also detailed on **Figure 7**.

Table N – Human Health CSM

Source	Pathway	Receptor	Likelihood of Pollutant Linkage Presenting an Unacceptable Risk
Impacted soils / groundwater	Lateral and vertical vapour migration and subsequent inhalation.	On-site shop staff, visiting staff and general public.	Unlikely: Based on Stage 2 assessment.
		Off-site workers and visitors in adjacent commercial properties (nearest building 24m south west).	Unlikely: Based on USEPA vapour screening assessment and Stage 2 assessment
	Particulate - Ingestion, inhalation, dermal contact with soil particulates.	On-site shop staff, visiting staff and general public.	Unlikely: Based on Stage 2 assessment.
		Visiting on-site contractors excavating ground.	**Possible***
	Permeation – Migration of hydrocarbon substances through plastic potable water supply pipes.	On-site shop staff (ingestion of drinking water on-site).	Unlikely: COPC were reported at concentrations below the drinking water standards in potable water samples recovered from the shop.

* Potential risks to visiting contractors undertaking intrusive works should be managed by appropriate PPE, risk assessment and method statements. Risks to visiting contractors excavating the ground were therefore not assessed within the scope of the DQRA.

Table O – Controlled Waters CSM			
Source	**Pathway**	**Receptor**	**Likelihood of Pollutant Linkage Presenting an Unacceptable Risk**
Impacted soils / groundwater.	• Partitioning between soil and pore water. • Leaching of impacted soils into groundwater. • Lateral migration of impacted groundwater.	Pennine Middle Coal Measures Formation (Secondary A Aquifer).	Possible: COPC impact (primarily benzene) has been identified in the groundwater samples collected from MW102 installed in the Pennine Middle Coal Measures Formation. It has not been possible to complete a DQRA based on the current dataset.
		Surface water (Unnamed drain situated 68m west which possibly extends 30m north west of site and ponds located 155m south west and 300m north east of site).	Unlikely: Based on hydrogeological information for the site, it is considered unlikely that groundwater within the Pennine Middle Coal Measures is supplying base flow to the identified surface water features.
		Surface water (Monkton Burn located 280m south east at its closest point and flowing to the east and north east of site).	Possible, although considered unlikely based on Stage 2 assessment given the distance to the burn. In addition, a groundwater flow direction for the site has not been determined.

7. CONCLUSIONS

The geology encountered consisted of Made Ground to a maximum depth of 1.7m bgl, underlain by superficial deposits of Pelaw Clay Member (Unproductive Strata) to a maximum depth of 3.4m bgl, which is further underlain by strata of the Pennine Middle Coal Measures Formation (Secondary A Aquifer), which was encountered to the maximum drilled depth of 15m bgl. Boreholes in the south of the site (MW101 and MW106) were reported to predominantly comprise sandstone beneath the Pelaw Clay, underlain by mudstone proven to a maximum drilled depth of 10m bgl. Boreholes in the central – northern area of the site (MW103, MW105 and MW109 were identified to have interbedded horizons beneath the Pelaw Clay, with sandstone identified below this in MW105 and MW109. Bedrock in MW102 was reported to comprise sandstone between 2.8m and the maximum drilled depth of 10.0m bgl.

Based on four (4) rounds of groundwater gauging, it has not been possible to infer a groundwater flow direction due to observed variances in groundwater depths. Depth to groundwater ranged between 4.18m bgl in MW101 located in the south of the site and 9.25m bgl in MW109 located in the north of the site. The groundwater level in MW101 and MW106 was consistently reported to be higher in the south of the site, than in MW102 located in the east and MW105 and MW109 located in the north of the site. Groundwater is in the bedrock Secondary A Aquifer below the site which is considered to be the primary controlled waters receptor. LNAPL was not identified in any of the wells.

A Stage 2 risk assessment was performed on the data collected during the intrusive works to assess potential risks to human health (on-site workers) and controlled waters (perched water in the superficial deposits, underlying Secondary A Aquifer, a drain located west of site and other surface water features). A Stage 3 risk assessment could not be performed to further assess potential risks to controlled waters (underlying Secondary A Aquifer and Monkton Burn located to the east of site) based on the current dataset, due to the complexity of the on-site geology and groundwater levels.

Asbestos was analysed for in seven Made Ground samples but was not identified.

The principal conclusions were as follows:

- Concentrations of COPC measured at the site were considered unlikely to represent an unacceptable risk to human health receptors.
- Potentially unacceptable risks to the groundwater may be present from reported groundwater concentrations of BTEX in one monitoring well located in the east of the site.
- It is noted that groundwater may be in hydraulic connectivity with Monkton Burn located to the east of the site (280m south east at its closest point); however, given the distance it is considered unlikely that concentrations of COPC would represent a potentially unacceptable risk to the surface water.

8. REFERENCES

Ref. 1 AECOM Preliminary Phase I Investigation Report, Ref GB-10019383-20190821-SA-1; 21 August 2019.

Ref. 2 GeoDelft, Tier 2 Environmental Survey, report ref. C1443.SG356, dated September 1999.

Ref. 3 USEPA. Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites. EPA 510-R-15-001. June 2015

Ref. 4 RSK, Soil Verification Report, report ref. 310714- R1(01), dated April 2009.

Ref. 5 GeoDelft, Tier 1 Soil Gas Survey, report ref. C928.SG356.8975, dated April 1998

Ref. 6 AECOM Geophysical Investigation Report, October 2019

Ref. 7 CLR11, Model Procedures for the Management of Land Contamination

Ref. 8 Land Contamination: Risk Management, Environment Agency Guidance, June 2019.

Ref. 9 Guidance for the Safe Development of Housing on Land Affected by Contamination, R&D Publication 66: 2008 (Volume 1), NHBC and the Environment Agency 2008.

Ref. 10 USEPA. OSWER Technical Guide For Assessing And Mitigating The Vapor Intrusion Pathway From Subsurface Vapor Sources To Indoor Air, Office of Solid Waste and Emergency Response, June 2015

Ref. 11 British Standard Institute. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings. BS8485:2015. June 2015.LQM/CIEH S4UL methodology

Ref. 12 LQM/CIEH S4UL methodology.

FIGURES



Based upon an Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office. Crown copyright reserved. Licence No. AL 100017812

Title	SITE LOCATION MAP
Location	SHELL WHITEMARE POOL, LEAM LANE, GATESHEAD. NE10 8YB
Client	SHELL UK OIL PRODUCTS LTD

AECOM

App'd:	Drawn:	Date:
SD	RH	APRIL 2020
		Ref: GB/RH/MCH
Scale: AS SHOWN		Job No: 60608750
Drg. Size: A4		**FIGURE 1**

DO NOT SCALE

KEY

- P — FUEL LINE – PETROL
- D — FUEL LINE – DIESEL
- E — ELECTRICITY CABLE
- EH — HIGH VOLTAGE ELECTRICITY CABLE
- G — TANK GAUGE LINE OR COMMS CABLE
- OF — OFF–SET FILL
- V — VENT PIPE
- OIL — OIL PIPE
- CLOSE CIRCUIT TV
- BT — BT CABLE
- CATV — CABLE TELEVISION
- GAS — GAS
- W — WATER SUPPLY PIPE
- F — FOUL WATER DRAIN
- S — SURFACE WATER DRAIN
- MD — MULTI DUCT
- U — UNIDENTIFIED – SEE NOTES
- END OF TRACE
- HISTORICAL DATA(REMOVED/ABANDONED)
- BUILDING
- CANOPY OUTLINE
- MH — MANHOLE
- PILLAR
- AS BUILT FUEL, VENT AND OFFSET LINES.
- DO NOT DRILL
- CRITICAL AREA
- UNABLE TO SURVEY
- SCAR — SCAR OUTLINE
- * T — TANK P=PETROL D=DIESEL
- MW LOCATION
- SURVEY BOUNDARY

- Concrete
- Hedge
- Channel
- Kerb
- Drop kerb
- Wall
- Verge

NOTES

CANOPY HEIGHT IS 4.2 MTS.

FUEL LINES

UNABLE TO LOCATE FUEL, VENT AND OFFSETS - PLASTIC LINES

TAKEN FROM RECORDS

WATER

PLASTIC WATER UNABLE TO LOCATE FROM METER.

ALL UTILITIES LOCATED IN FOOTPATH HAVE BEEN TAKEN FROM RECORDS.

INTERCEPTOR DETAILS

Type	Condition	Size	Material	Depth
INTERCEPTOR	OK	–	PLASTIC	1.66M

TANK DETAILS

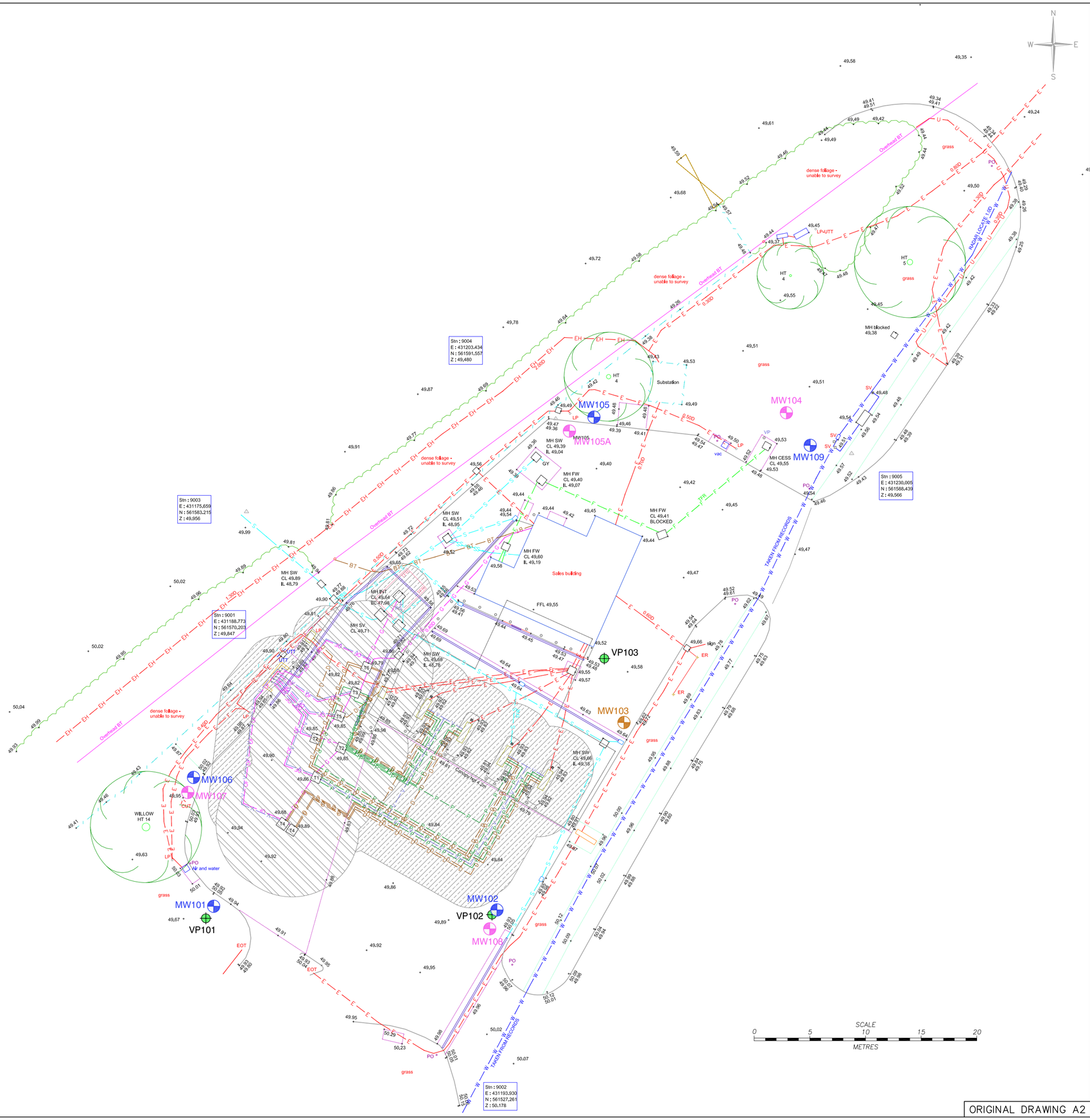
Tank No.	Fuel Type	Capacity	Feed To Pumps
T1	UNLEADED	34,580	1–4
T2	UNLEADED	21,660	5–8
T3	UNLEADED	12,920	1–8
T4	DIESEL	24,700	1–8
T5	DIESEL	21,660	9–10
T1	DIESEL	12,920	1–8

TRACE CODES

TFS Trace is From Source to destination with visual evidence to confirm
SDC Sources and/or Destination are Concealed
WS Weak Signal / high interference
VA Visual Assessment (line of site perhaps scarring)
LA Logical Assumed(source & destination exist, line added without trace)
TFR Taken From Records
AEE Anything Else Encountered

ABBREVIATIONS

AR	Assumed Route	IC	Inspection Cover	UTR	Unable to Raise
BO	Bollard	LP	Lamp Post	UTS	Unable to Survey
BH	Borehole	MH	Manhole Cover	UTT	Unable to Trace
BTB	British Telecom Box	MW	Monitoring Well	VR	Vapour Recovery
BTIC	British Telecom Cover	OH	Overhead Service	VP	Vent Pipe
BAR	Barrier	OSA	Off Survey Area	WM	Water Meter
CTV	Cable TV	PR	Pipe Riser	UK	Unknown
CP	Catch Pit	PO	Post		
Co	Concrete	RWP	Rain Water Pipe		
CL	Cover Level	RS	Rod stop		
D	Depth Of MH / IC	RE	Rodding Eye		
DP	Down Pipe	S/A	Soakaway		
ER	Earth Rod	ST	Stop Tap		
EIC	Electricity IC	SV	Sluice Valve		
EP	Electricity Pole	SVP	Soil Vent Pipe		
EOT	End of Trace	SVS	Soil Vapour Sample		
FH	Fire Hydrant	TFR	Taken From Records		
GV	Gas Valve	TP	Telegraph Pole		
Gu	Gully	UTL	Unable to Locate		



NOTES

KEY:

- MW103 — Groundwater Well Installation (Superficial Perched Groundwater)
- MW101 — Groundwater Well Installation (Pennine Middle Coal Measures Formation)
- VP101 — Vapour Well Installation
- MW105A — Shallow Borehole to investigate superficial deposits, no installation

REV.	DESCRIPTION	DRAWN	APPROVED	DATE

STATUS

FOR INFORMATION

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SHELL WHITEMARE POOL,
LEAM LANE, GATESHEAD. NE10 8YB

DRAWING TITLE
Figure 2
Borehole Location Plan

DRAWN	TRACED	CHECKED	APPROVED	DATE
RH		SD	SD	APR 2020

SCALE	DRG No.	REV.
1:250	60608750	.

ORIGINAL DRAWING A2

DO NOT SCALE



NOTES

KEY:

- MW103 — Groundwater Well Installation (Superficial Perched Groundwater)
- MW101 — Groundwater Well Installation (Pennine Middle Coal Measures Formation)
- VP101 — Vapour Well Installation
- MW105A — Shallow Borehole to investigate superficial deposits, no installation
- 42.65 — Groundwater elevation (mAOD)
- mAOD — Metres Above Ordnance Datum

REV	DESCRIPTION	DRAWN	APPROVED	DATE

STATUS
FOR INFORMATION

CONSULTING ENGINEERS

AECOM

6th FLOOR, 1 NEW YORK STREET, MANCHESTER, M1 4HD
TEL 0161-601-1700

CLIENT
SHELL UK OIL PRODUCTS LTD

PROJECT
Shell Whitemare Pool,
Leam Lann, Gateshead.
NE10 8YB

DRAWING TITLE
Figure 3
Groundwater Elevation Plot
(December 2019)

DRAWN		CHECKED	APPROVED	DATE
RH		GB	SD	APR 2020

SCALE	DRG No.	REV.
AS SHOWN	60608750	

ORIGINAL DRAWING A3

DO NOT SCALE



NOTES

KEY:

MW103	Groundwater Well Installation (Superficial Perched Groundwater)
MW101	Groundwater Well Installation (Pennine Middle Coal Measures Formation)
VP101	Vapour Well Installation
MW105A	Shallow Borehole to investigate superficial deposits, no installation
42.65	Groundwater elevation (mAOD)
mAOD	Metres Above Ordnance Datum

REV	DESCRIPTION	DRAWN	APPROVED	DATE

STATUS
FOR INFORMATION

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NE10 8YB

DRAWING TITLE
Figure 4
Groundwater Elevation Plot
(February 2020)

DRAWN		CHECKED	APPROVED	DATE
RH		GB	SD	APR 2020

SCALE	DRG No.	REV.
AS SHOWN	60608750	

ORIGINAL DRAWING A3

DO NOT SCALE



NOTES

KEY:

- MW103 — Groundwater Well Installation (Superficial Perched Groundwater)
- MW101 — Groundwater Well Installation (Pennine Middle Coal Measures Formation)
- VP101 — Vapour Well Installation
- MW105A — Shallow Borehole to investigate superficial deposits, no installation
- 42.65 — Groundwater elevation (mAOD)
- mAOD — Metres Above Ordnance Datum

REV	DESCRIPTION	DRAWN	APPROVED	DATE

STATUS
FOR INFORMATION

CONSULTING ENGINEERS

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SHELL UK OIL PRODUCTS LTD

PROJECT
Shell Whitemare Pool,
Leam Lann, Gateshead.
NE10 8YB

DRAWING TITLE
Figure 5
Groundwater Elevation Plot
(March 20th 2020)

DRAWN		CHECKED	APPROVED	DATE
RH		GB	SD	APR 2020

SCALE	DRG No.	REV.
AS SHOWN	60608750	

ORIGINAL DRAWING A3