

Date: 29th June 2026
Ref: 15-280-L4-3

Barratt & David Wilson Homes North West
303 Bridgewater Place
Birchwood
Warrington
WA3 6XF

GAS CUT-OFF BARRIER SPECIFICATION CHERRYFIELD DRIVE, KIRKBY

1. OVERVIEW

E3P have previously prepared a gas ventilation trench specification for the proposed residential development at the site located south of Cherryfield Drive, Kirkby (Ref: 15-580-L3-1, dated February 2026). The specification was required to address the ground gas risk posed by the off-site historical landfill located along the site's western boundary.

Following consultation with the regulators, the NHBC has expressed a preference not to adopt an active gas-ventilation trench as a form of gas mitigation, due to potential long-term maintenance considerations over the lifespan of the development.

E3P have subsequently been commissioned by Barratt & David Wilson Homes (the Client) to prepare a specification for a gas cut-off barrier, together with a scope for post-remediation and earthworks ground gas monitoring for the proposed residential development.

This letter sets out the proposed design and installation methodology for the gas cut-off barrier, as well as the scope of the post-remediation and earthworks ground gas monitoring regime. The proposed gas cut-off barrier is intended to interrupt potential gas migration pathways laterally within the ground, rather than rely on active ventilation measures to dilute or disperse ground gases. As such, it represents a passive, low-maintenance solution that reduces the potential for long-term performance and maintenance issues.

These proposals will be subject to agreement with the regulators, including Knowsley Metropolitan Borough Council, the Environment Agency, and NHBC, prior to implementation.





2. BACKGROUND

E3P have been provided with previous reports prepared for the site. E3P is of the understanding that the client does not have reliance on these previous reports.

Table 2.1 Previous Reports

AUTHOR	TITLE	REFERENCE	CLIENT	DATE
Clancy Consulting	Preliminary Geoenvironmental Appraisal Report for Phase 2 Site, Cherryfield Drive, Knowsley	Ref: 10/1519/001	Knowsley Metropolitan Borough Council	May 2020
	Geo-Environmental Appraisal Report for Knowsley Community College, Liverpool	Ref: 10/1533/001	Knowsley Metropolitan Borough Council	July 2020
Resource & Environmental Consultants Ltd	Geoenvironmental Site Assessment	Ref: 45759Fp1r0	Knowsley Metropolitan Borough Council	September 2014
ALM Consult Limited	Interpretative Report	Ref: 30090/11	Knowsley Metropolitan Borough Council	September 2015
	Hazardous Gas Risk Assessment	Ref: 30090/11/2	Knowsley Metropolitan Borough Council	December 2015
ESG	Factual Report on Ground Investigation	Ref: F5013-15	2020 Knowsley Limited	February 2016
Ian Farmer Associates	Factual Report on Ground Investigation	Ref: 41989	St Modwen Developments Limited	March 2017
RPS	Due Diligence Information for Land Development	-	St Modwen Developments Limited	June 2017
Atkins	Phase 1 Geo-Environmental Desk Study	Ref: 5145660	St. Modwen (Kirkby 2) Development Ltd	December 2016
Buro Happold	Ground Engineering Site Appraisal	Ref: 021706	-	December 2006
	Geoenvironmental and Geotechnical Interpretative Report: Phase 1 Ground Investigation (GDO 205 Landfill)	Ref: 021706	-	November 2007
Cundall	Geotechnical Due Diligence Brief	Ref: 1028732.SPC.GL.001	Barratt Developments Plc	June 2021

The pertinent points from the above report are summarised in Section 3.5 of the E3P Phase I & II Geoenvironmental Site Assessment (Ref: 15-280-R1-6, dated November 2024).

In addition to the above, E3P has completed the following geoenvironmental assessments for the site:



- ✳ **E3P** – *Phase I & II Geoenvironmental Site Assessment*. Ref: Report 15-280-R1-6, dated November 2024, Prepared for Barratt and David Wilson Homes;
- ✳ **E3P** – *Ground Gas Addendum Report*. Ref: Report 15-280-R3-2, dated November 2025, Prepared for Barratt and David Wilson Homes; and,
- ✳ **E3P** – *Remediation and Enabling Works Strategy*. Ref: Report 15-280-R2-7, dated November 2025, Prepared for Barratt and David Wilson Homes.

The pertinent points from the E3P Ground Gas Addendum Report are summarised in Section 2.4 of the E3P Remediation and Enabling Works Strategy (Ref: 15-280-R2-7, dated November 2025), and are presented in Section 2.1 below.

2.1. GROUND GAS ADDENDUM SUMMARY

Ground gas has been assessed by E3P as part of the E3P Geoenvironmental Site Assessment, with the final assessment detailed within the E3P Ground Gas Addendum Report (Ref: 15-280-R3-2, dated November 2025). The assessment was completed in accordance with the methodology outlined in BS8485, utilising the results of the ground gas monitoring surveys to calculate a tentative gas screening value (GSV). The GSVs for the monitoring positions are summarised in Table 2.2.

This indicates that, based on the peak flow rates, the majority of the monitoring visits are classified as Characteristic Situation (CS)1 – Very Low Gas Risk, with areas of the site characterised as CS2. In addition, a localised area of the site associated with the adjacent landfill and historically deposited materials has been characterised as CS4 due to significant concentrations of methane and carbon dioxide. Data obtained from flooded monitoring wells or during flooded visits has been excluded from the assessment.

Table 2.2 Gas Risk Profile and Location

LOCATION	MAX CH ₄ (% v/v)	GSV (l/hr)	MAX CO ₂ (% v/v)	GSV (l/hr)	CHARACTERISTIC SITUATION
WS101	6.8	0.0068	8.5	0.0085	CS2*
WS102	3.7	0.0037	10.8	0.0108	CS2*
WS105	0.1	0.0001	6.9	0.0069	CS2*
WS106	0.4	0.0004	7.7	0.0077	CS2*
WS108	46.1	0.0461	10.3	0.0103	CS2*
WS110	0.1	0.0001	1.5	0.0015	CS1
WS111	6.2	0.0062	5.3	0.0053	CS2*
WS113	0.1	0.0164	3.1	0.1984	CS2
WS115	0.1	0.0001	0.1	0.0001	CS1
WS117	0.1	0.0001	0.1	0.0001	CS1
WS118	0.1	0.0001	0.3	0.0003	CS1
WS119	0.1	0.0001	0.1	0.0001	CS1
WS120	0.1	0.0001	0.1	0.0001	CS1
WS121	0.1	0.0001	0.1	0.0001	CS1
WS123	0.1	0.0001	0.1	0.0001	CS1



LOCATION	MAX CH ₄ (% v/v)	GSV (l/hr)	MAX CO ₂ (% v/v)	GSV (l/hr)	CHARACTERISTIC SITUATION
WS124	13.7	0.0137	5.4	0.0054	CS2*
WS125	0.1	0.0001	0.1	0.0001	CS1
WS126	0.4	0.0016	3.2	0.0128	CS1
WS128	0.1	0.0001	1.1	0.0011	CS1
WS130	0.1	0.0001	0.1	0.0001	CS1
WS132	0.1	0.0001	1.2	0.0012	CS1
WS133	0.1	0.0001	2.3	0.0023	CS1
WS135	0.1	0.0001	0.1	0.0001	CS1
WS136	0.1	0.0001	0.8	0.0008	CS1
WS137	Flooded				
WS138	0.1	0.0253	0.3	0.0003	CS1
WS140	0.1	0.0001	0.8	0.0008	CS1
WS141	0.1	0.0001	2.4	0.0024	CS1
WS142	0.1	0.0001	1.1	0.0011	CS1
WS144	0.1	0.0001	0.8	0.0008	CS1
WS147	Flooded				
WS149A	0.1	0.0001	0.8	0.0008	CS1
WS151	0.1	0.0001	0.1	0.0001	CS1
WS152	0.8	0.0008	4.8	0.0048	CS1
WS153A	0.1	0.0001	0.8	0.0008	CS1
WS157	0.1	0.0001	0.2	0.0002	CS1
WS161	0.1	0.0001	0.1	0.0001	CS1
WS169	0.1	0.0001	0.1	0.0001	CS1
WS171	0.1	0.0001	0.1	0.0001	CS1
CP/RB101	0.1	0.0001	0.1	0.0001	CS1
CP/RB102	0.1	0.0001	0.1	0.0001	CS1
CP/RB103	0.1	0.0001	0.1	0.0001	CS1
WS201	74.5	4.5612	26.5	1.5372	CS4 (methane)
WS202	Flooded				
WS204	0.1	0.0019	1.0	0.0114	CS1
WS206	0.1	0.002	0.6	0.006	CS1

* Classified as precautionary CS2 based on high concentrations observed. GSV however noted to fall under CS2 threshold.



E3P has assessed the previous variables and has made the following conclusions based on the ground gas monitoring programme:

- ✳ Ground gas monitoring has been split into sections based on observed or theorised ground gas sources, with the key sources identified as the adjacent landfill, the historically deposited landfill materials across the site, and the former petrol filling station.
- ✳ The key source of ground gas identified within the Conceptual Site Model is the adjacent landfill at Bewley Road (Ref: EAHLD06985), which is noted to include household waste and was active from the 1950s to circa 1974.
- ✳ In addition, deep Made Ground has been encountered across the site, with the deepest deposits noted in the central region, associated with historical upfilling with landfill materials, as delineated in the Buro Happold report (Ref: 021706, dated November 2007).
- ✳ To the north of the site, in the area of the former petrol filling station and in the supplementary investigation to the northwest, volatile hydrocarbon contamination has been encountered. The area will be fully remediated, with the tanks removed and validated to ensure there is no unacceptable risk to future end users or the wider environment. None of the wells in the location of the former filling station indicated elevated concentrations of carbon dioxide or methane.
- ✳ The highest concentrations of ground gas observed were in monitoring wells WS201 and WS108, both located adjacent to the Bewley Road Landfill site.
- ✳ In WS201, methane was recorded at a maximum concentration of 72.8 % v/v and GSV reading of 4.56 l/hr, with consistently high concentrations recorded throughout all visits. WS201 also indicates high levels of CO₂ with a maximum concentration recorded as 26.5 % v/v and GSV of 1.54 l/hr. Concentrations above the limit of detection of hydrogen sulphide (H₂S) were also identified within WS201. Hydrogen sulphide can be a corrosive gas, and it is therefore essential that if plots are to be built in this area, the manufacturer of the gas-resistant membrane on any plot must be consulted to ensure that it is suitable for the levels of sulphide observed.
- ✳ The GSV for methane is currently within a CS4 classification in WS201. This borehole is located adjacent to the north of the off-site landfill. In addition, Made Ground with a hydrocarbon odour and decaying timber was noted.
- ✳ Monitoring well WS108 is situated in the southern central region of the site, directly adjacent to the Bewley Road Landfill site. It has recorded a maximum methane concentration of 46.1 % v/v and a carbon dioxide concentration of 10.8 % v/v. Despite high concentrations recorded, minimal flow has been recorded in this location, and it is therefore considered to fall within the CS2 category, alongside all other plots adjacent to the landfill.
- ✳ The increased flow rate observed in WS113 during visit 1 (6.4 l/hr) is likely associated with the known landfill located directly adjacent to the western boundary, however, across a total of 30 visits completed, only one visit noted any indication of gas flow, with the majority of visits encountering carbon dioxide and methane at the limit of detection.
- ✳ Several monitoring wells across the site have identified elevated concentrations of methane and/or carbon dioxide, however with GSV thresholds noted to be below the CS2 criteria. These wells include: WS101, WS102, WS105, WS106, WS108, WS111 and WS124. In general, all of the above noted locations can be associated with the infilling of ground in the central parts of the site and adjacent to the known landfill. It is considered by E3P that precautionary CS2 membranes should be placed in these areas.
- ✳ Regarding potential ground gas pathways across the site, it has been noted that the majority of wells are predominantly underlain by both granular SANDS and cohesive CLAY at depths of 0.10 m bgl to 6.10 m bgl, and it is, therefore, unlikely to fully restrict the migration of ground gases.
- ✳ Ground gas migration pathways are likely to alter during the development, drainage could introduce preferential pathways for gas migration into buildings.



- ✳ High groundwater levels have been observed across the site, therefore the soils are largely saturated. The proposed development will result in a change in the hydrogeology, and this has the potential to change the anaerobic and aerobic environment, which may result in the increased generation of CH₄ and CO₂.
- ✳ Migration of ground gas from the adjacent landfill has been identified and this has the potential to act as a significant ongoing source of ground gas. The ternary plot indicates that the concentrations of methane and carbon dioxide in WS101, WS111 and WS124 are indicative of landfill gas migration. In addition, elevated flow rates and GSVs were recorded in WS201 and WS113 located to the north of the adjacent landfill. Ground gas is considered to be actively migrating along the infilled channel through the central sector of the site.
- ✳ The flux box tests and surface emissions survey identified elevated concentrations of methane and carbon dioxide in the vicinity of WS201. Given the observed gas concentrations within the adjacent landfill, a gas ventilation trench is considered to be required along the boundary with the landfill to act as a pressure relief pathway and reduce the ground gas concentrations in this area of the site. The gas ventilation trench will need to be designed and installed by a suitably qualified specialist and validated through a programme of post remediation monitoring.
- ✳ Made Ground deposits within the vicinity of WS201 will require excavation to their full depth and all deleterious and putrescible materials removed for off-site disposal.
- ✳ Further post remediation assessment will be required in the location of WS201 to confirm the ground gas classification, given this location is currently classified as CS4 due to significantly elevated concentrations of methane and carbon dioxide. Post remediation monitoring will be required following the installation of the gas ventilation trench and remedial excavation works in order to confirm the reduction of recorded ground gas concentrations.
- ✳ With due consideration of the Conceptual Site Model, it is considered that following the installation of the gas ventilation trench, CS2 gas protection measures will likely be required for all plots where monitoring has identified a CS2 classification within the vicinity of the adjacent landfill and in the area of the on-site infilled channel in the central sector. It is considered that plots located in the north, east and southeast of the site can be classified as CS1 and gas protection measures are not considered to be required in these locations.

Based on the above conclusions, a detailed ground gas zoning plan has been created and is presented as Drawing 15-280-020 (appended to this letter) to indicate the plots that will require ground gas mitigation to ensure no risk to future end users. A snapshot of the ground gas zoning plan is presented as Figure 2.1.



Figure 2.1 Ground Gas Zoning Plan





3. GAS CUT-OFF BARRIER DESIGN

3.1. DESIGN RATIONALE AND PERFORMANCE OBJECTIVES

As stated in Section 1, the NHBC have expressed a preference not to adopt an active gas ventilation trench as a form of gas mitigation, due to potential long-term maintenance considerations over the lifespan of the development.

Given that the off-site landfill is considered to represent a declining source of ground gases over time, it is E3P's recommendation that a precautionary physical barrier is installed between the off-site landfill and the proposed development to interrupt any potential preferential ground gas migration pathways.

The proposed gas cut-off barrier has been designed to provide a robust, passive ground gas mitigation measure along the western boundary of the site, adjacent to the Bewley Road landfill. The cut-off barrier is intended to function as a pathway interception system, reducing lateral migration of landfill gas into the site and lowering ground gas concentrations beneath proposed residential plots. Furthermore, no long-term maintenance of the cut-off barrier is deemed necessary, given that it will be developed and constructed as part of the remedial earthworks.

The design has been developed by E3P on behalf of Barratt & David Wilson Homes, with due regard to the Conceptual Site Model, the findings of the ground gas monitoring programme, and the guidance set out within BS8485 and CIRIA C665.

The cut-off barrier and remedial earthworks will address the variability in gas concentrations, flow regimes, and migration pathways identified across the site.

3.2. CONCEPTUAL BASIS FOR CUT-OFF BARRIER DESIGN

Ground gas monitoring has demonstrated that the ground gas risk along the western boundary is influenced by active migration from the adjacent Bewley Road landfill, variability in gas flow rates with locally high concentrations but generally low to moderate flow in some areas, a combination of granular and cohesive strata that may partially restrict vertical gas migration while allowing lateral movement through Made Ground horizons, and elevated groundwater levels which may suppress vertical gas migration and promote lateral movement along preferential pathways.

In response to these conditions, a cut-off barrier and remedial earthworks arrangement have been selected to ensure effective gas interception under both low-flow/high-concentration and higher-flow conditions.

3.3. CUT-OFF BARRIER – FUNCTION AND JUSTIFICATION

The gas cut-off barrier has been designed to act as a passive impermeable barrier, with its primary functions of intercepting laterally migrating ground gas originating from the adjacent landfill and infilled channel deposits, providing a low-resistance preferential pathway for vertical gas movement towards the surface outside the proposed development boundary, and reducing gas pressure build-up at shallow depth, particularly beneath areas of Made Ground and proposed infrastructure.

The cut-off barrier element is particularly important given that several monitoring locations adjacent to the landfill recorded high methane and carbon dioxide concentrations with limited associated flow, indicating a diffusion-dominated gas regime.



3.4. CURRENT GROUND CONDITIONS

The depth and composition of the Made Ground deposits located along the site's northern and western boundaries has been investigated as part of the on-going remediation and enabling works. The findings of the landfill boundary ground investigation are presented in the letter report 18-528-L1-1, dated June 2026, with a summary presented below.

3.4.1. SUMMARY OF GROUND CONDITIONS

The landfill boundary ground investigation identifies the strata set out in Table 3.1.

Table 3.1 Summary of Strata

HOLE	DEPTH TO STRATUM (m bgl)			
	MADE GROUND	LANDFILL MATERIAL	SAND	CLAY
NORTHERN BOUNDARY (FROM WEST TO EAST)				
SHDP/WS601	0.00–1.80	1.80–>5.45	–	–
TP601	0.00–1.20	1.20–5.20	5.20–>5.80	–
TP602	0.00–1.80	1.80–4.80	4.80–>5.20	–
TP603	0.00–1.30	1.30–4.10	4.10–>4.30	–
SHDP/WS604	0.00–2.10	2.10–>3.41	–	–
TP604	0.00–1.10	1.10–3.90	3.90–>4.40	–
TP605	0.00–1.10	1.10–3.90	3.90–>4.30	–
TP606	0.00–1.10	1.10–3.10	3.10–>3.60	–
TP607	0.00–1.10	1.10–3.00	3.00–>3.30	–
TP608	0.00–2.10	–	3.30–>3.60	2.10–3.30
TP609	0.00–1.60	–	3.30–>3.80	1.60–3.30
TP610	0.00–1.10	–	3.10–>3.40	1.10–3.10
TP611	0.00–0.70	–	–	0.70–>2.80
TP612	0.00–0.60	–	–	0.60–>2.20
TP613	0.00–0.90	–	–	0.90–>2.10
TP614	0.00–0.80	0.80–1.90	–	1.90–>2.70
WESTERN BOUNDARY (FROM NORTH TO SOUTH)				
TP329	0.00–2.70	–	2.70–>3.50	–
SHDP/WS331	0.00–2.40	–	2.40–>4.44	–
TP330	0.00–>4.50	–	–	–
TP331	0.00–>4.30	–	–	–
TP301	0.00–6.30	–	–	6.30–>6.60
SHDP/WS626	0.00–>5.45	–	–	–
TP302	0.00–3.50	–	–	3.50–>3.80
TP314	0.00–3.10	–	–	3.10–>3.40
TP615	0.00–2.20	–	–	2.20–>2.60
TP616	0.00–2.00	–	–	2.00–>2.30
TP617	0.00–3.10	–	–	3.10–>3.40
TP618	0.00–1.80	–	–	1.80–>2.30
TP619	0.00–1.70	–	–	1.70–>2.00
TP620	0.00–1.30	–	1.30–>1.80	–
TP621	0.00–1.60	–	1.60–>2.00	–
TP622	0.00–1.60	–	1.60–>1.90	–
TP623	0.00–1.70	–	1.70–>2.10	–
TP624	0.00–1.80	–	1.80–>2.10	–
TP625	0.00–0.50	–	0.50–>1.20	–



3.4.2. MADE GROUND

Northern Boundary

Made Ground was encountered within all exploratory hole locations to a maximum recorded depth of 5.45 m bgl (SHDP/WS601), situated in the far western corner along the northern boundary. It was noted that Made Ground deposits shallowed towards the east, where it was encountered to 3.00 m bgl in TP607.

The uppermost Made Ground consisted of a reworked topsoil, which was encountered to between 0.20 and 0.30 m bgl, and comprised of a dark brown slightly sandy, slightly gravelly clay with frequent rootlets and a varying gravel of mudstone, brick, concrete, asphalt, ceramic, plastic, and glass.

Underlying the reworked topsoil, a reworked clay was encountered within SHDP/WS601, SHDP/WS604 and TP601 to TP610 to between 1.10 – 1.80 m bgl, and comprised of a brown slightly sandy slightly gravelly clay with rare cobbles. The gravel constituents comprised of brick, concrete, timber, ceramic, metal, rebar, polystyrene, and plastic, with cobbles comprising of concrete, brick, and timber.

Within SHDP/WS601, SHDP/WS604, and TP608 to TP614, Made Ground deposits were encountered to between 0.60 – 2.10 m bgl, and comprised of a black to brown clayey slightly gravelly sand with rare cobbles. The gravel constituents comprised of brick, concrete, timber, ceramic, plastic, fabric, and asphalt, with cobbles comprising of timber, concrete, and whole brick.

Within TP601 to TP607, and TP614, Landfill Material was encountered to a depth of between 3.00 – >5.45 m bgl, and comprised of black gravelly fine to coarse sand with occasional to frequent cobbles. The gravel constituents composed of brick, concrete, asphalt, polystyrene, paper, plastic, rubber, metal, fabric, ceramic, timber, slate, and glass, with cobbles comprising of whole brick, glass bottles, concrete, timber, and fragments of metal drums.

It is noted that E3P have used the terms “Made Ground” and “Landfill Material” in order to differentiate between materials containing a high content of deleterious materials. In reality, the materials are broadly the same in that they predominantly comprised of ash deposited to create level platforms across the site. The deleterious materials identified within the materials along the northern boundary will require segregation and removal.

Western Boundary

Made Ground was encountered within all exploratory hole locations to a maximum recorded depth of 6.30 m bgl (TP301), situated within the vicinity of an infilled channel towards the northern part of the western boundary. It was noted that Made Ground deposits shallowed out towards the south, where it was encountered to 0.50 m bgl in TP625.

The uppermost Made Ground consisted of a reworked topsoil, which was encountered between 0.20 and 0.50 m bgl, and comprised a dark brown, slightly sandy, slightly gravelly clay with frequent rootlets and a varying gravel of mudstone, brick, fabric, plastic, ceramic, and glass.

Underlying the reworked topsoil, a reworked clay was encountered within TP301, SHDP/WS626, TP302 and TP615 to between 0.80 – 1.30 m bgl, and comprised a reddish to orangish brown, slightly sandy, slightly gravelly clay. The gravel constituents comprised of brick, ceramic, timber, concrete, coal, glass, fabric, and metal.



Within all exploratory hole locations, except for TP625, Made Ground Ash deposits were encountered to between 1.30 – 6.30 m bgl, and composed of a black to dark brown sandy gravel/gravelly sand with frequent cobbles. The gravel constituents comprised of brick, ash, clinker, glass, metal, plastic, timber, fabric, ceramic, polystyrene, slate, and paper, with cobbles comprising of whole brick, glass bottles, and concrete.

No “Landfill Material” was encountered along the western boundary.

3.4.3. SUPERFICIAL DEPOSITS

Northern Boundary

Underlying the Landfill Material along the northern boundary within TP601 to TP607, a reddish brown clayey slightly gravelly fine to medium SAND with gravel constituents of mudstone was encountered from between 3.00 m – 4.80 m bgl.

Underlying the Made Ground deposits along the northern boundary a friable brown sandy gravelly CLAY with gravel constituents of mudstone was encountered within TP611 to TP613 between 0.60 m bgl and 2.30 m bgl. Within TP611 to TP614, a friable very stiff, high strength reddish brown mottled light grey sandy gravelly CLAY with gravel constituents of mudstone was encountered between 1.50 m bgl and in excess of 2.80 m bgl.

Within TP608 and TP609, a silty sandy gravelly CLAY with gravel constituents of mudstone was encountered between 1.60 m bgl and 3.30 m bgl, whilst in TP610, a very stiff sandy gravelly CLAY with gravel constituents of mudstone was encountered between 1.10 m bgl and 3.10 m bgl

Underlying the cohesive stratum within trial pits TP608 to TP610, a reddish brown clayey gravelly fine to medium SAND with gravel constituents of mudstone was encountered between 3.10 m bgl and in excess of 3.80 m bgl.

Natural strata was not encountered within the two window sample probeholes advanced along the northern boundary.

Western Boundary

Underlying the Made Ground Ash deposits along the western boundary, both granular and cohesive deposits were encountered.

The natural cohesive strata was encountered within TP301 to TP619 and comprised of a very stiff reddish brown sandy gravelly CLAY, with gravel constituents of mudstone from between 1.70 m – 6.30 m bgl.

The natural granular strata was encountered within TP329 and TP620 to TP625 and comprised of a reddish brown clayey gravelly fine to medium SAND, with gravel constituents of mudstone from between 0.50 m – 2.70 m bgl.

Natural strata was not encountered within the two window sample probeholes advanced along the western boundary.

3.4.4. BEDROCK GEOLOGY

The solid bedrock geology was not encountered during this phase of ground investigation.



3.5. CROSS SECTIONS

A series of cross sections are to illustrate the depth of Made Ground deposits / Landfill Material are presented in Drawings 18-528-019 (Cross Section Location Plan), 18-528-019A (Northern Boundary) and 18-528-019B (Western Boundary), and are appended to this letter, with snapshots presented in Figure 3.1 and Figure 3.2.

Figure 3.1 Cross Section – Northern Boundary

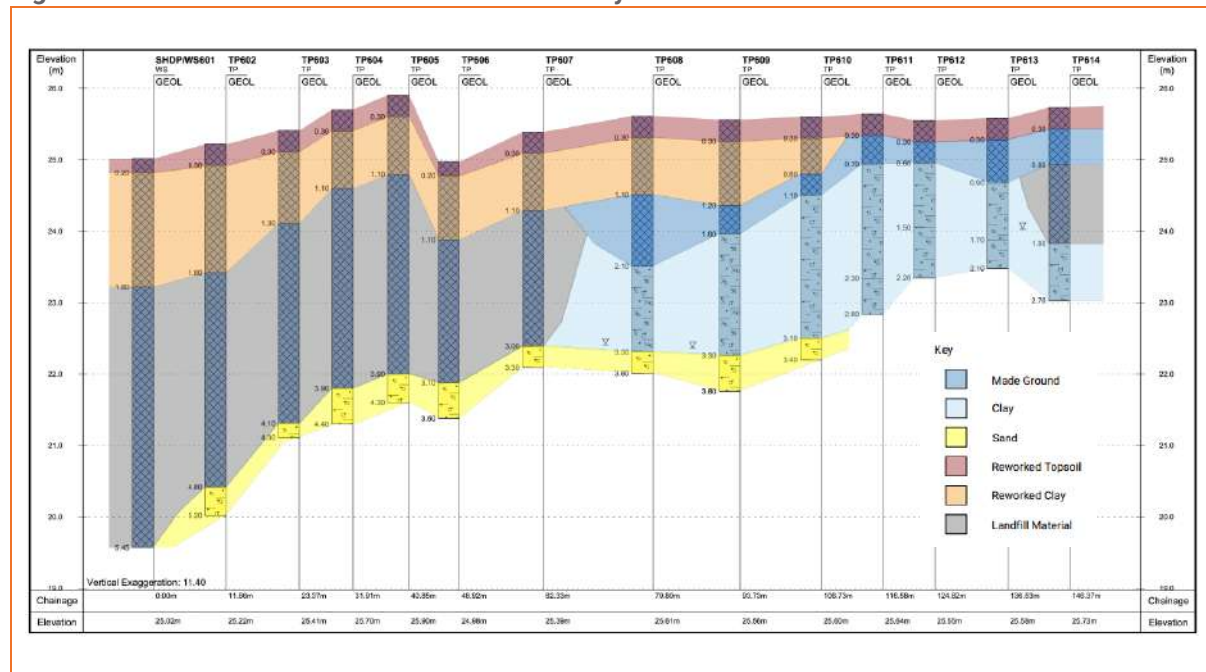
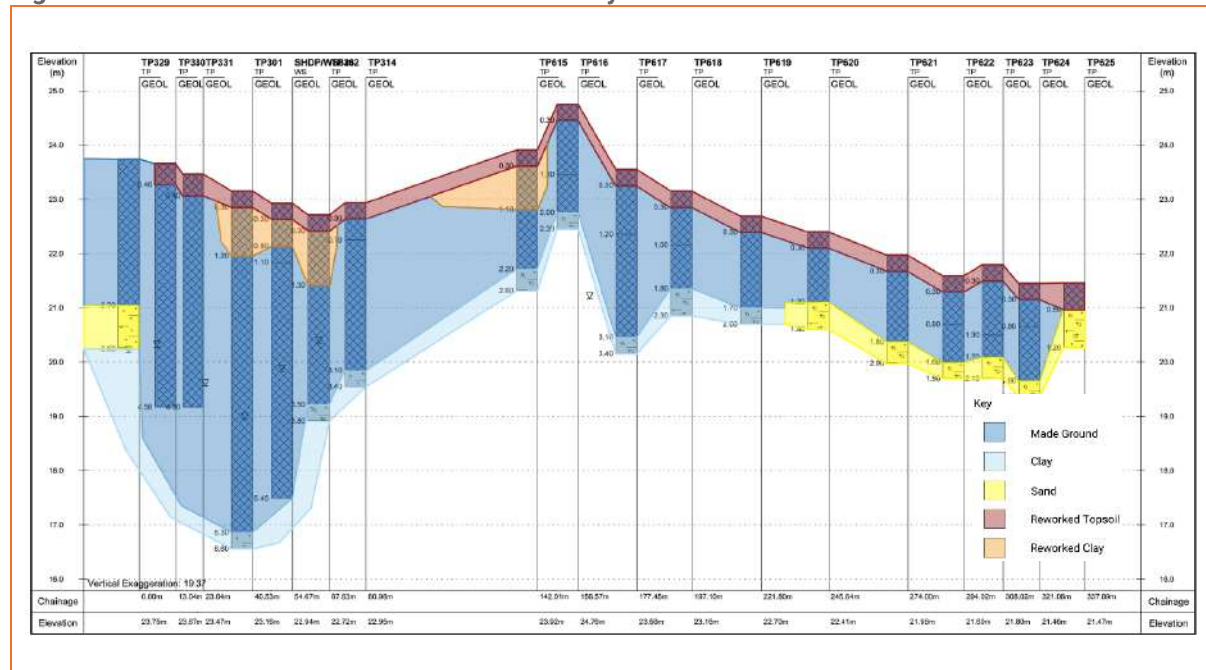


Figure 3.2 Cross Section – Western Boundary





3.6. INTERACTION WITH REMEDIAL EXCAVATION WORKS

The gas cut-off barrier design has been developed in parallel with the proposed remedial excavation works.

Along the northern boundary of the off-site landfill, it is proposed to excavate all Made Ground deposits and remove deleterious materials down to the natural stratum within approximately 25 m of the site boundary, including materials within the vicinity of WS201 which previously recorded elevated methane concentrations.

Along the western boundary of the off-site landfill, it is proposed to excavate a 2.00 m wide cut-off trench, and remove all Made Ground deposits and deleterious materials down to the natural stratum. Within the vicinity of the on-site infilled channel in the central sector, where Made Ground deposits have been recorded to a maximum depth of 6.30 m bgl, the cut-off trench will be stepped in along an area of POS to accommodate a stepped batter.

The resulting excavations / trench will be backfilled with site-won cohesive deposits and compacted in accordance with the E3P Site Earthworks and Compaction Geotechnical Specification (appended to this letter), with materials keyed a minimum of 300 mm into the underlying undisturbed natural stratum. Site-won cohesive deposits will undergo chemical and geotechnical testing in accordance with frequencies outlined within the E3P Remediation and Enabling Works Strategy (Ref: 15-280-R2-7, dated November 2025) to confirm their suitability for re-use, as well as laboratory-based permeability testing at a frequency of 1 per 1000m³. The suitability of the site-won cohesive deposits will also be confirmed by via a visual inspection of the material by a qualified geoenvironmental consultant prior to placement.

During the placement of the site-won cohesive deposits, in-situ permeability testing (falling head tests) will be undertaken every 1.00 m of uphill at a rate of 3 per 25m² along the northern boundary, and 1 every 25 linear meters along the western boundary to confirm the placed site-won cohesive deposits are impermeable (i.e. have a permeability of $<1.00 \times 10^{-9}$). The methodology for the in-situ infiltration testing is appended to this letter.

Furthermore, plots located within the immediate vicinity of the off-site landfill will utilise a driven pile foundation rather than vibro stone column solution, due to the potential for creating a preferential pathway for ground to migrate via the granular columns.

Recovered Made Ground deposits will undergo chemical and geotechnical testing in accordance with frequencies outlined within the E3P Remediation and Enabling Works Strategy (Ref: 15-280-R2-7, dated November 2025) to confirm their suitability for re-use, and subject to these results, may be re-used in areas of low sensitivity (i.e. Public Open Space) or taken off-site for disposal at an appropriately licensed waste management facility.

These works will seek to reduce on-site gas generation potential, remove low-permeability obstructions and preferential pathways, and allow the gas cut-off barrier to interface directly with competent underlying strata, improving gas interception efficiency.

The combined remediation and pathway interruption measures are therefore expected to result in a measurable reduction in ground gas concentrations and gas flux entering the site.

3.7. PERFORMANCE VERIFICATION AND MONITORING

To demonstrate the effectiveness of the gas cut-off barrier, a programme of post-remediation and earthworks ground gas monitoring will be undertaken.

Monitoring wells will be installed on the development side of the cut-off barrier at approximately 25 m intervals in order to confirm that ground gas concentrations and flow rates have been reduced to levels



consistent with the proposed gas protection measures, validate the cut-off barrier installation and construction quality, and support confirmation of the revised ground gas Characteristic Situation in the vicinity of the western boundary.

The results of post-remediation and earthworks monitoring will be reported to Knowsley Metropolitan Borough Council, the Environment Agency, and the NHBC for review and agreement.

3.8. SUMMARY

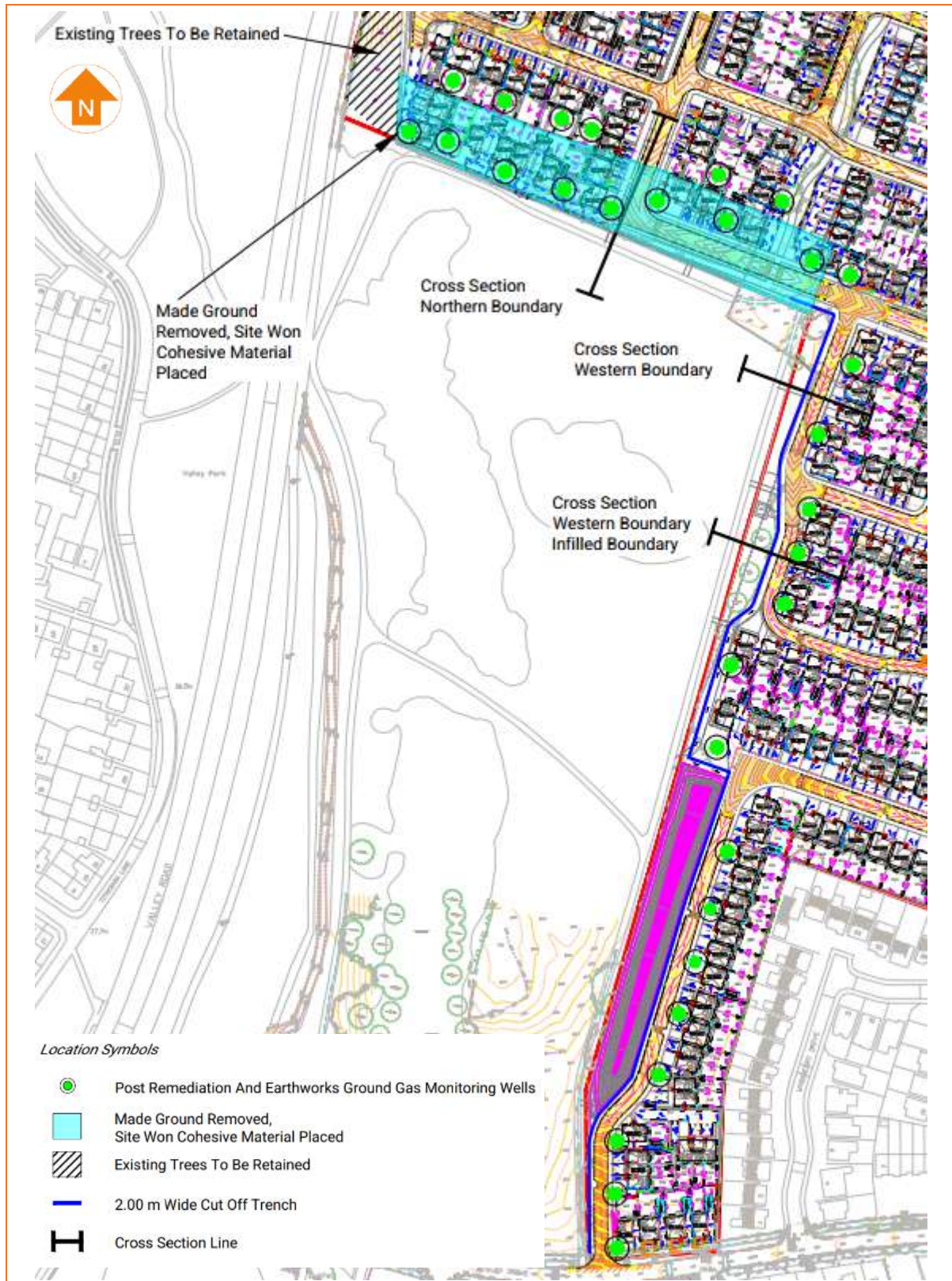
The gas cut-off barrier has been designed to reflect the site-specific ground gas regime and Conceptual Site Model. The system provides a passive, durable and verifiable mitigation measure that reduces lateral and vertical gas migration from the adjacent landfill, supports the proposed ground gas zoning and plot-specific mitigation measures, and protects future residents and the built environment from ground gas risk. Furthermore, no long term maintenance of the cut-off barrier is deemed necessary, given that it will be developed and constructed as part of the remedial earthworks.

Subject to validation and post-remediation and earthworks ground gas monitoring, the proposed design is considered appropriate and proportionate to the identified risks at the site.

E3P have prepared a detailed Gas Cut-Off Barrier Design, which illustrates the proposed layout and design of the cut-off barrier, and locations of the post remediation and earthworks ground gas monitoring wells within Drawing 15-280-046 and 15-280-047 (appended to this report). A snapshot of the proposed layout is presented as Figure 3.1, and snapshots of the proposed design is presented as Figure 3.2, Figure 3.3, and Figure 3.4.



Figure 3.1 Gas Cut-Off Barrier and Post Remediation and Earthworks Monitoring Well Location Plan



Stepped Batter In Area Of Deep Fill

Site Boundary

Post Remediation And Earthworks Ground Gas Monitoring Wells

Plots Currently With CS₂ Mitigation Measures - To Be Reassessed Following Completion Of Post Remediation And Earth Works Ground Gas Monitoring

Gas Pathway

Off-Site Landfill (Made Ground)

Gas Pathway

Depth Varies Between 2.70 mbgl And 6.30 mbgl

Superficial / Bedrock

2.00m

2-3m Turnover Of Made Ground Deposits And Removal Of Deletrious Materials

Vibro Stone Columns

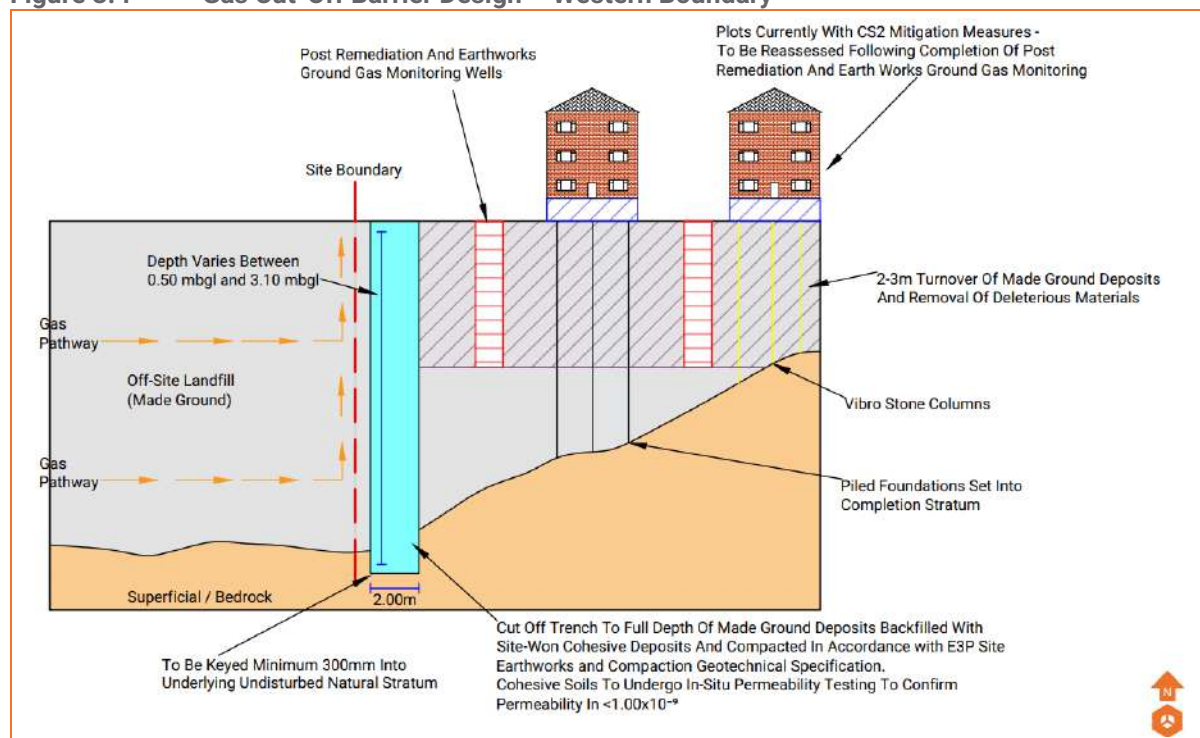
Piled Foundations Set Into Completion Stratum

To Be Keyed Minimum 300mm Into Underlying Undisturbed Natural Stratum

Cut Off Trench To Full Depth Of Made Ground Deposits Backfilled With Site-Won Cohesive Deposits And Compacted In Accordance with E3P Site Earthworks And Compaction Geotechnical Specification. Cohesive Soils To Undergo In-Situ Permeability Testing To Confirm Permeability In $<1.00 \times 10^{-9}$



Figure 3.4 Gas Cut-Off Barrier Design – Western Boundary



4. GAS CUT-OFF BARRIER METHOD STATEMENT

All works to expose and remove deleterious and putrescible materials from within the Made Ground along the northern and western boundaries, including within the vicinity of WS201, and to install the new gas cut-off barrier will be completed under the supervision of a suitable qualified geoenvironmental engineer to ensure no unacceptable environmental risk and to demonstrate that all works have been completed to the highest standard with appropriate validation testing.

A proposed sequence of operations is presented in Table 4.1.

Table 4.1 Sequence of Operations

SEQUENCE	OPERATION
1	Prior to the commencement of any works on-site, the area will be fenced to ensure no unauthorised personnel enter the area of work. It is recommended that a gas analyser is utilised throughout the works and in particular if personnel enter any excavations (suitably battered or trench box utilised) to ensure any works are stopped if any gas concentrations are encountered to mitigate against any potential for asphyxiation or explosion. All detailed risk assessments including working with a confined space will be completed prior to the commencement of any works. Smoking shall be strictly prohibited within 50 m of the landfill at all times.
2	It will be necessary to identify the location of the proposed location of the gas cut-off barrier in a controlled manner to allow full inspection of the Made Ground deposits to be removed.



SEQUENCE	OPERATION
	The location of the new gas cut-off barrier will be marked out on the site at the beginning of the works.
3	Recent intrusive ground investigations have identified Made Ground deposits along the site's boundary with the adjacent landfill to be at proven depths of between 2.20 m bgl, and a maximum recorded depth of 6.30 m bgl. Due to the variable depths of Made Ground deposits along the site's boundary with the adjacent landfill, excavations will be required to be completed down to the natural superficial deposits. Made Ground deposits within 25 m of the northern boundary (including those within the vicinity of WS201), and within the footprint of the 2.00 m wide cut-off trench along the western boundary will be carefully removed in a controlled manner using excavation plant down to the underlying natural superficial deposits. Deleterious and putrescible materials within the Made Ground deposits will require removal in their entirety for off-site disposal, with a confirmation inspection by a qualified geoenvironmental consultant. A stepped batter will be required in order to remove all deleterious and putrescible materials at extensive depths (>4.00 m bgl). A trench box will be utilised to ensure stability of all excavations along the western boundary. All removed materials will be stockpiled on-site on an impermeable membrane. Materials will be removed from site by a licensed waste management company to a suitable facility. Chemical analysis and, if applicable, WAC analysis and WM3 classification, will be required of materials to be exported off-site. Recovered Made Ground deposits will require chemical and geotechnical testing to confirm their suitability for re-use, and subject to these results, may be re-used in areas of low sensitivity (i.e., Public Open Space) or taken off-site for disposal at an appropriately licensed waste management facility.
4	In order to segregate the infill remaining outside of the development area, and following the removal of all Made Ground deposits, the resulting excavations / trench will be backfilled with site-won cohesive deposits and compacted in accordance with the E3P Site Earthworks and Compaction Geotechnical Specification (appended to this letter), with materials keyed a minimum of 300 mm into the underlying undisturbed natural stratum. Site-won cohesive deposits will undergo chemical and geotechnical testing in accordance with frequencies outlined within the E3P Remediation and Enabling Works Strategy (Ref: 15-280-R2-7, dated November 2025) to confirm their suitability for re-use, as well as laboratory-based permeability testing at a frequency of 1 per 1000m³. The suitability of the site-won cohesive deposits will also be confirmed by via a visual inspection of the material by a qualified geoenvironmental consultant prior to placement. During the placement of the site-won cohesive deposits, in-situ permeability testing (falling head tests) will be undertaken every 1.00 m of upfill at a rate of 3 per 25m² along the northern boundary, and 1 every 25 linear meters along the western boundary to confirm the placed site-won cohesive deposits are impermeable (i.e., permeability of <1.00 x10⁻⁹). The methodology for the in-situ infiltration testing is appended to this letter.



SEQUENCE	OPERATION
5	Following the installation of the gas cut-off barrier, a series of post remediation and earthworks ground gas monitoring wells will be installed on the proposed development side of the newly installed cut-off barrier at approximately 25 m intervals in order to demonstrate effective construction and mitigation/protection to the proposed dwellings to the north and east of the adjacent landfill. Monitoring well response zones will be installed within engineered upfill material. A monitoring programme, comprising either interval monitoring (6 visits over 6 weeks) or continuous monitoring (over a period of 3 weeks), should be completed and agreed with the regulators.
6	Following the completion of the post remediation and earthworks ground gas monitoring programme, a post remediation and earthworks ground gas addendum report will be completed and submitted to regulators for approval. Following approval of the post remediation and earthworks ground gas addendum report by the regulators, the monitoring wells will be decommissioned, with pipework removed and holes backfilled with bentonite pellets.

Approval of this specification by the regulators will be sought prior to any works commencing.

We trust this information is satisfactory to your requirements, and should we be able to be of any further assistance, please do not hesitate to contact us.

Yours sincerely,

For and on behalf of E3P Ltd





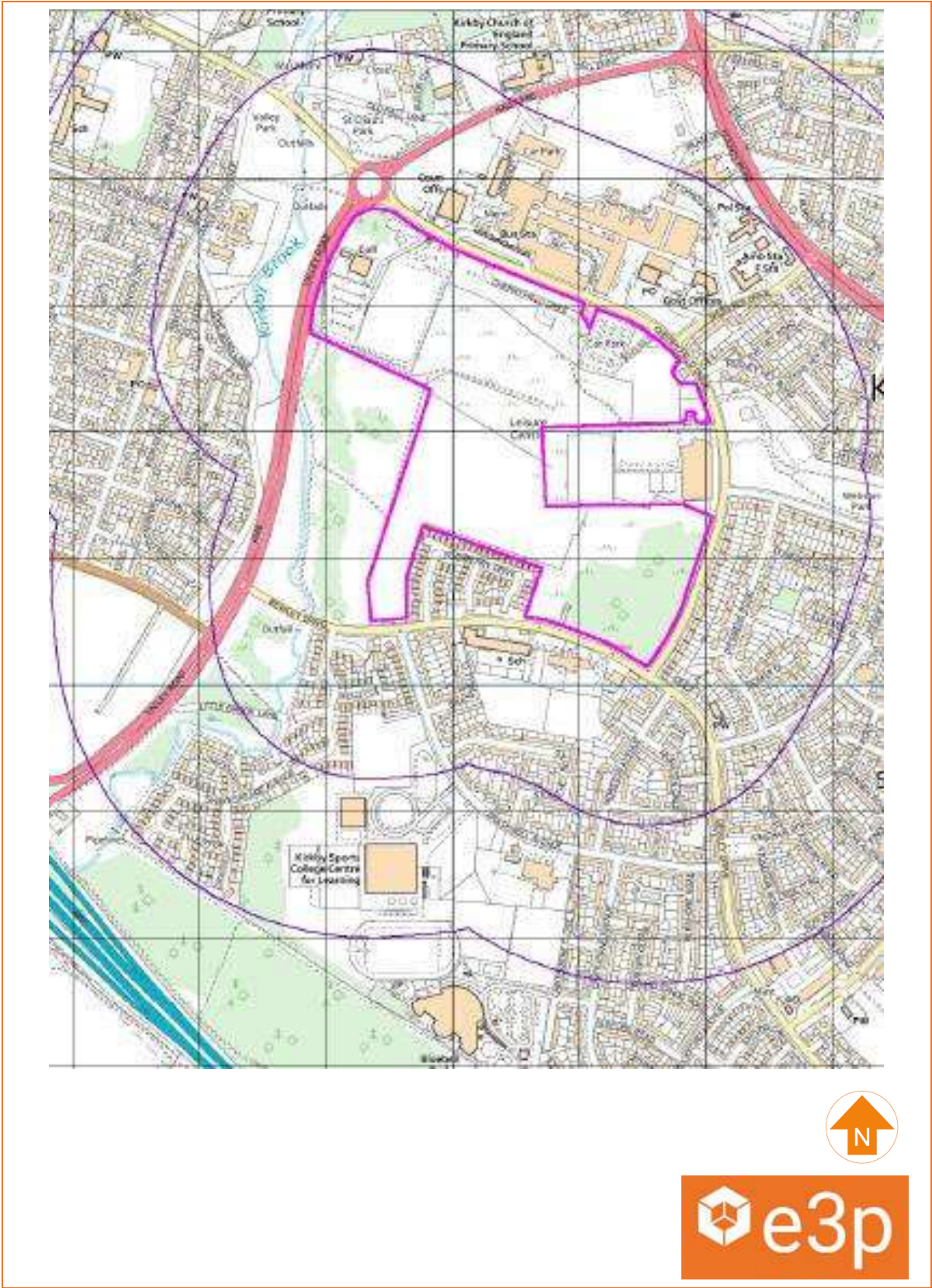
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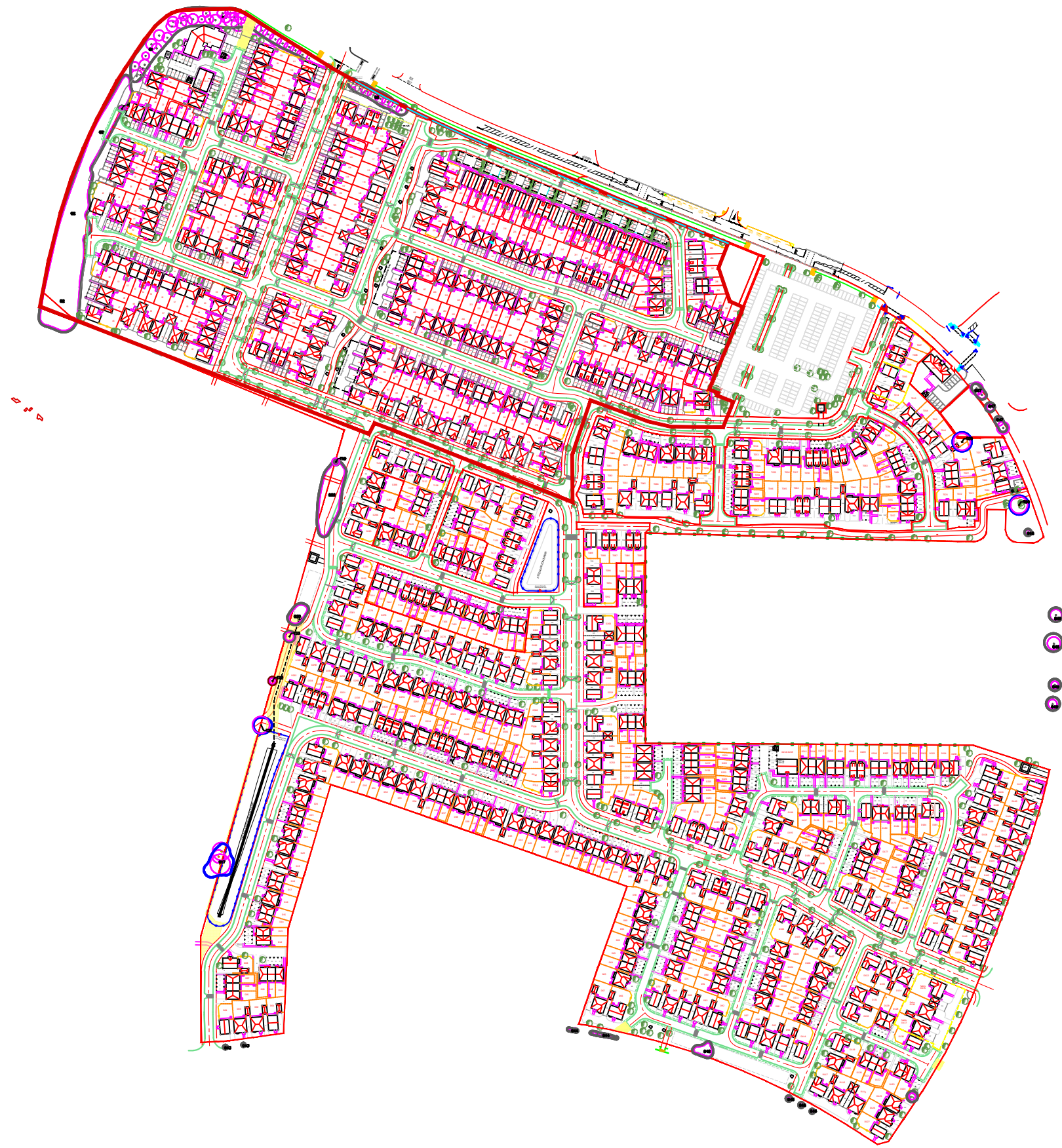
Drawing 15-280-001 – Site Location Plan
Drawing 15-280-002 – Proposed Development Plan
Drawing 15-280-020 – Ground Gas Zoning Plan
Drawing 18-528-006 – Exploratory Hole Location Plan - Landfill Boundary Ground Investigation
Drawing 18-528-019 – Cross Section Location Plan - Landfill Boundary Ground Investigation
Drawing 18-528-019A – Cross Section – Northern Boundary
Drawing 18-528-019B – Cross Section – Western Boundary
Drawing 15-280-046 – Gas Cut-Off Barrier Layout Plan
Drawing 15-280-047 – Gas Cut-Off Barrier Designs – Northern Boundary, Western Boundary (Infilled Channel), Western Boundary

Site Earthworks and Compaction Geotechnical Specification

In-Situ Infiltration Testing Methodology

DRAWING 15-280-001 – SITE LOCATION PLAN





Notes:				
P1	REVE	05.03.2025	CB	NS
P1	REVD	28.02.2025	TG	BH
P1	REVC	03.05.2024	OW	BH
P1	REVB	04.12.2022	LM	BH
P1	REVA	20.04.2022	LM	BH
Phase	Issue	Date	Drawn	Checked

Client:	
DWH	
Job Title:	
Cherryfield Drive, Kirkby	

Job No:	15-280	Date:	05.03.2025
Drawing No:	002	Scale:	NTS
Drawing Title:		Proposed Development Plan	



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To Be Confirmed Following
Post Remediation
Assessment - Currently CS4

Location Symbols

- Window Sample with Monitoring Well
- Approximate Cable Percussive/Rotary Borehole Location With Install

Key

- Plots Classified As CS1 - No Protection Measures Required
- Plots Require CS2 Protection Measures
- Location Classified As CS1
- Location Classified As CS2
- Location Classified As CS4

Notes:					
P1	REVC	07.04.2025	TG	NS	
P1	REVB	11.03.2025	TG	NS	
P1	REVA	05.03.2025	CB	NS	
Phase	Issue	Date	Drawn	Checked	

Client:

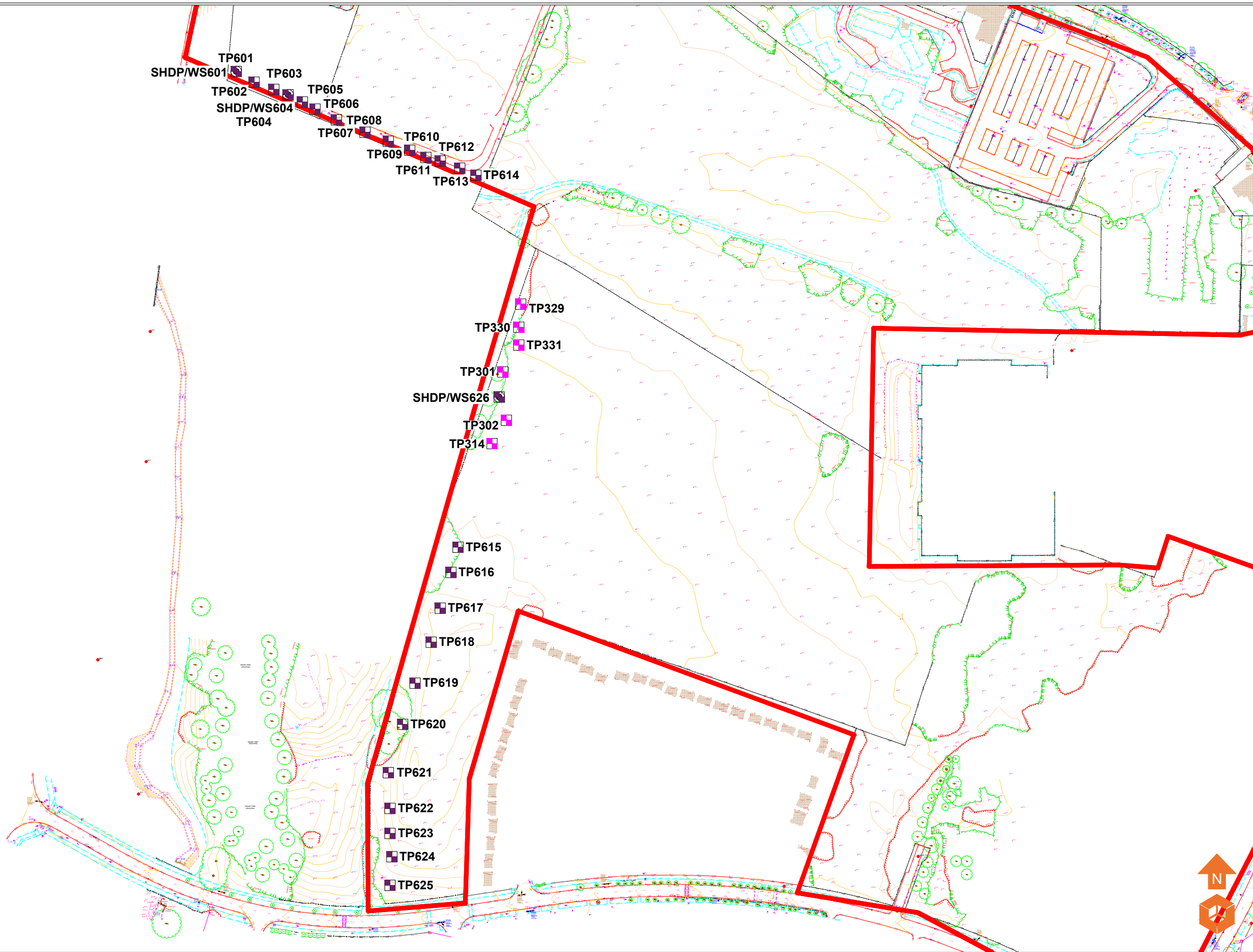
DWH

Cherryfield Drive, Kirkby

Job No:	15-280	Date:	07.04.2025
Drawing No:	020	Scale:	NTS
Job Title:	Cherryfield Drive, Kirkby		
Drawing Title:	Gas Zoning Plan		

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- Location Symbols
- Approximate Trial Pit Location
 - Approximate Super Heavy Dynamic Probehole / Window Sample Probehole Location
 - Approximate Trial Pit Location

Notes:					
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Phase	Issue	Date	Drawn	Checked	PM

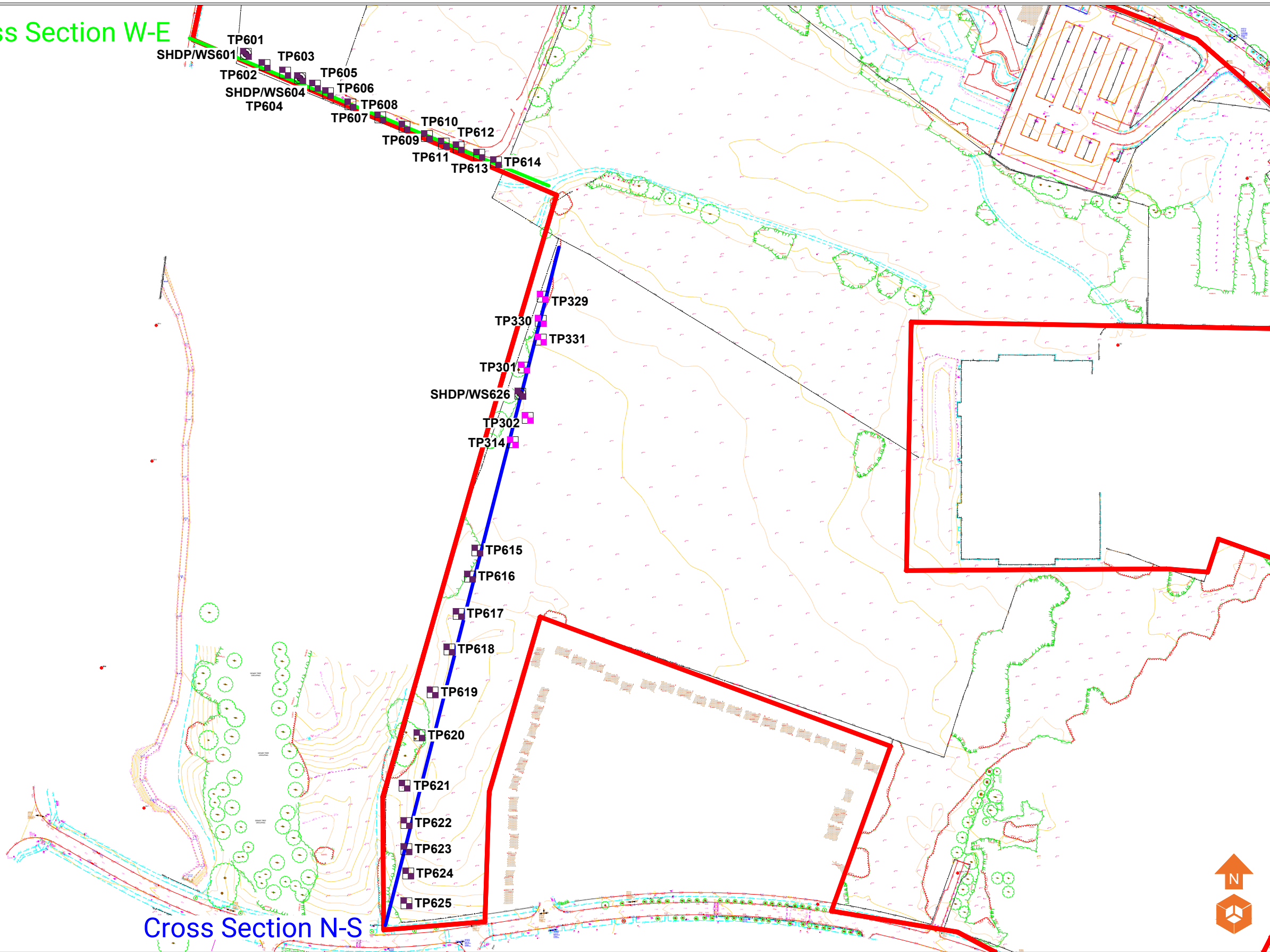
Client:	Westshield
Job Title:	Cherryfield Drive, Kirkby

Job No:	18-528	Date:	18.06.2026
Drawing No:	006	Scale:	NTS
Drawing Title:			
Exploratory Hole Location Plan - Landfill Boundary Ground Investigation			

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Cross Section W-E



Cross Section N-S

- Location Symbols
- Approximate Trial Pit Location
 - Approximate Super Heavy Dynamic Probehole / Window Sample Probehole Location
 - Approximate Trial Pit Location

Notes:

Client:

Westshield

Job No:
18-528
Drawing No:
019
Date:
18.06.2026
Scale:
NTS

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P1	REVA	18.06.2026	TG	MW	MW
Phase	Issue	Date	Drawn	Checked	PM

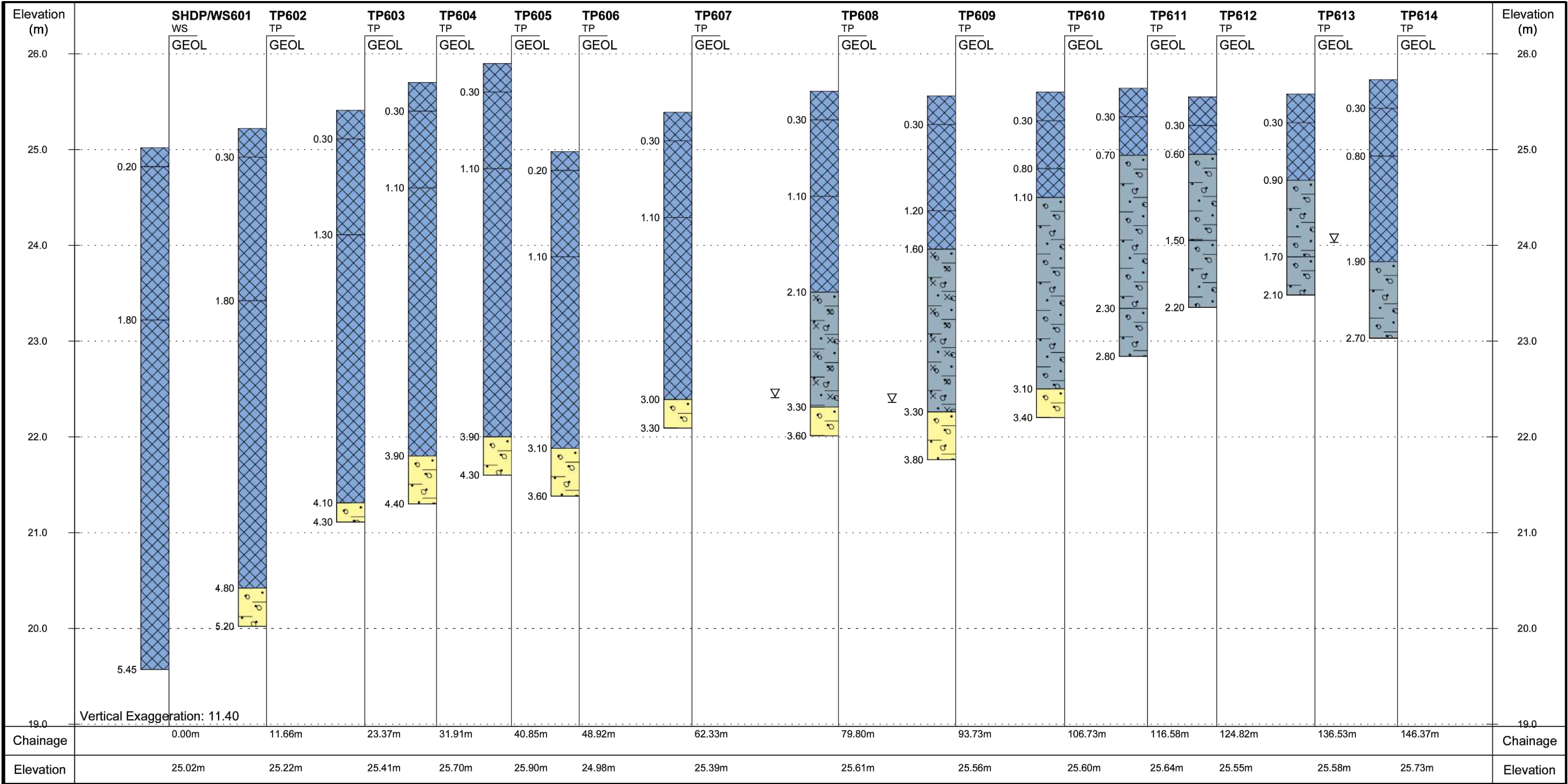
Job Title:

Cherryfield Drive, Kirkby

Drawing Title:

Cross Section Location Plan

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- Key
- Made Ground
 - Clay
 - Sand
 - Reworked Topsoil
 - Reworked Clay
 - Landfill Material

Notes:					
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Phase	Issue	Date	Drawn	Checked	PM

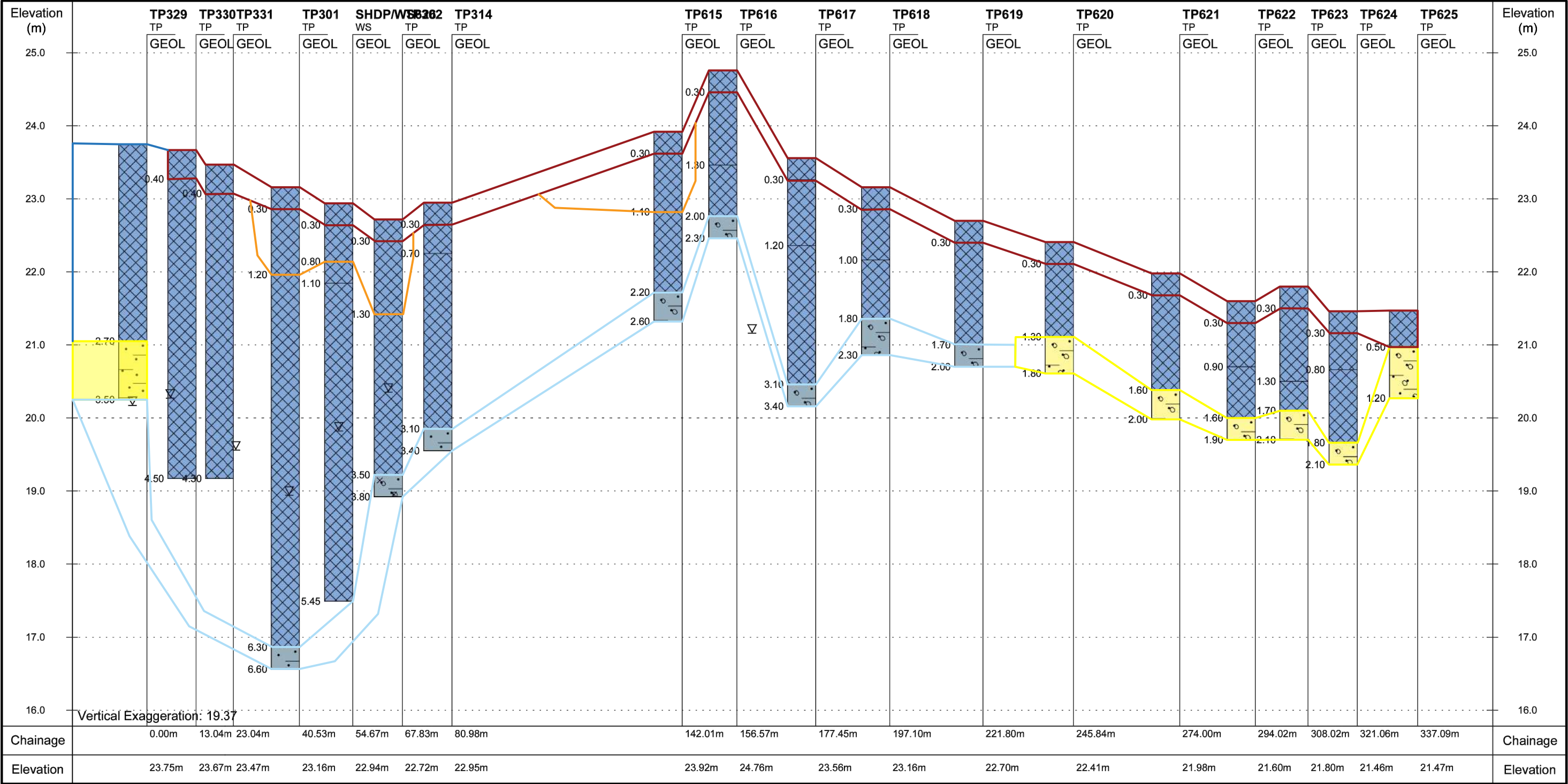
Client:
Westshield
Job Title:
Cherryfield Drive, Kirkby

Job No:	18-528	Date:	18.06.2026
Drawing No:	019A	Scale:	NTS
Drawing Title:		Cross Section - Northern Boundary	



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Key

- Made Ground
- Clay
- Sand
- Reworked Topsoil
- Reworked Clay

Notes:

Client:

Westshield

Job No:

18-528

Date:

18.06.2026

Drawing No:

019B

Scale:

NTS



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Job Title:

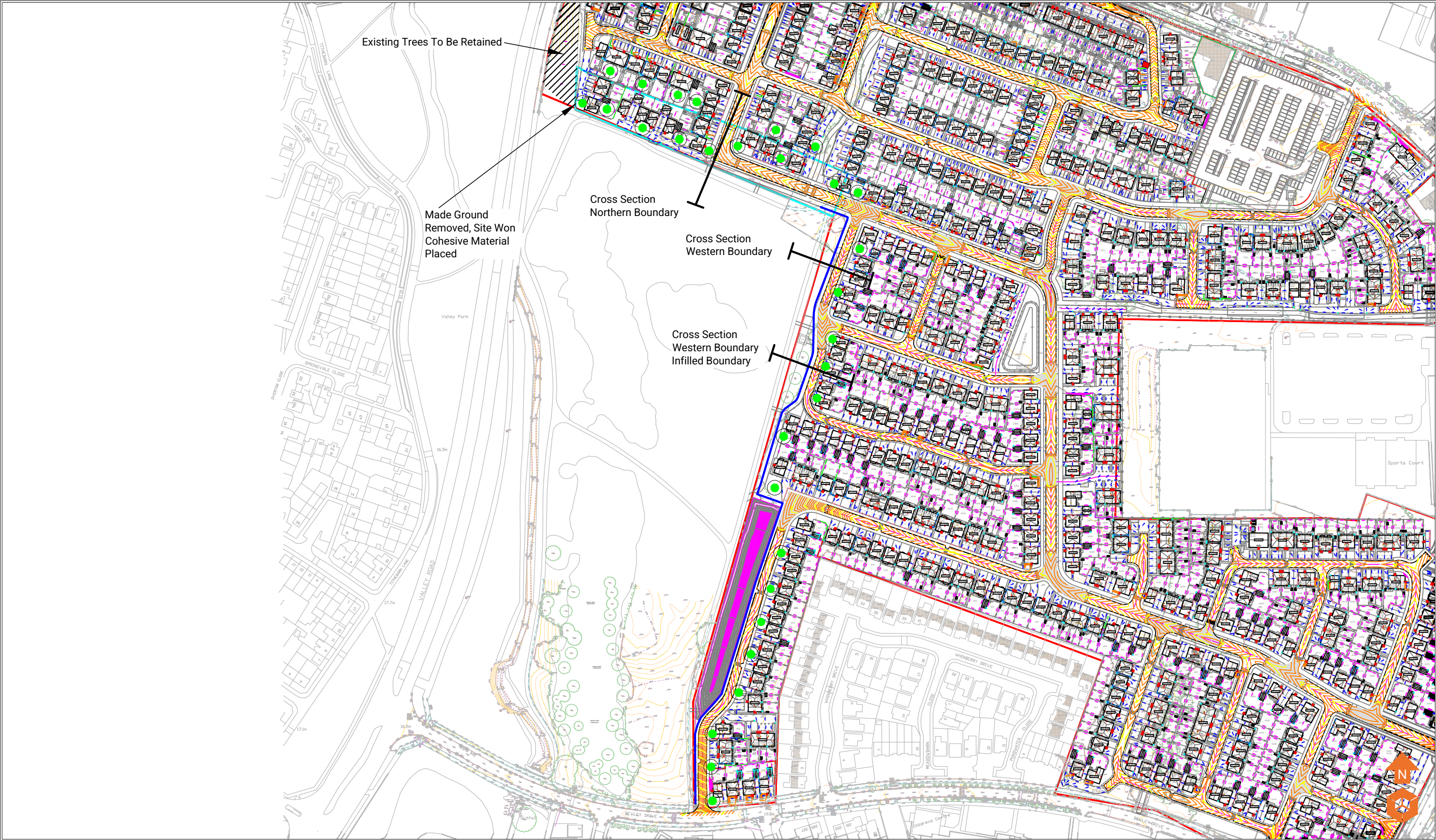
Cherryfield Drive, Kirkby

Drawing Title:

Cross Section - Western
Boundary

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P1	REVA	18.06.2026	TG	MW	MW
Phase	Issue	Date	Drawn	Checked	PM



- Location Symbols
- Post Remediation And Earthworks Ground Gas Monitoring Wells
 - Made Ground Removed, Site Won Cohesive Material Placed
 - ▨ Existing Trees To Be Retained
 - 2.0m Wide Cut Off Trench
 - ⊥ Cross Section Line

Notes:

Post Remediation And Earthworks Ground Gas Monitoring Wells To Be Decommissioned And Removed Following The Completion Of The Monitoring Programme And Acceptance Of The Post Remediation And Earthworks Ground Gas Addendum By The Regulators.

P1	REVA	18.06.2026	TG	MW	MW
Phase	Issue	Date	Drawn	Checked	PM

Client:

DWH

Job Title:

Cherryfield Drive, Kirkby

Job No:	15-280	Date:	18.06.2026
Drawing No:	046	Scale:	NTS

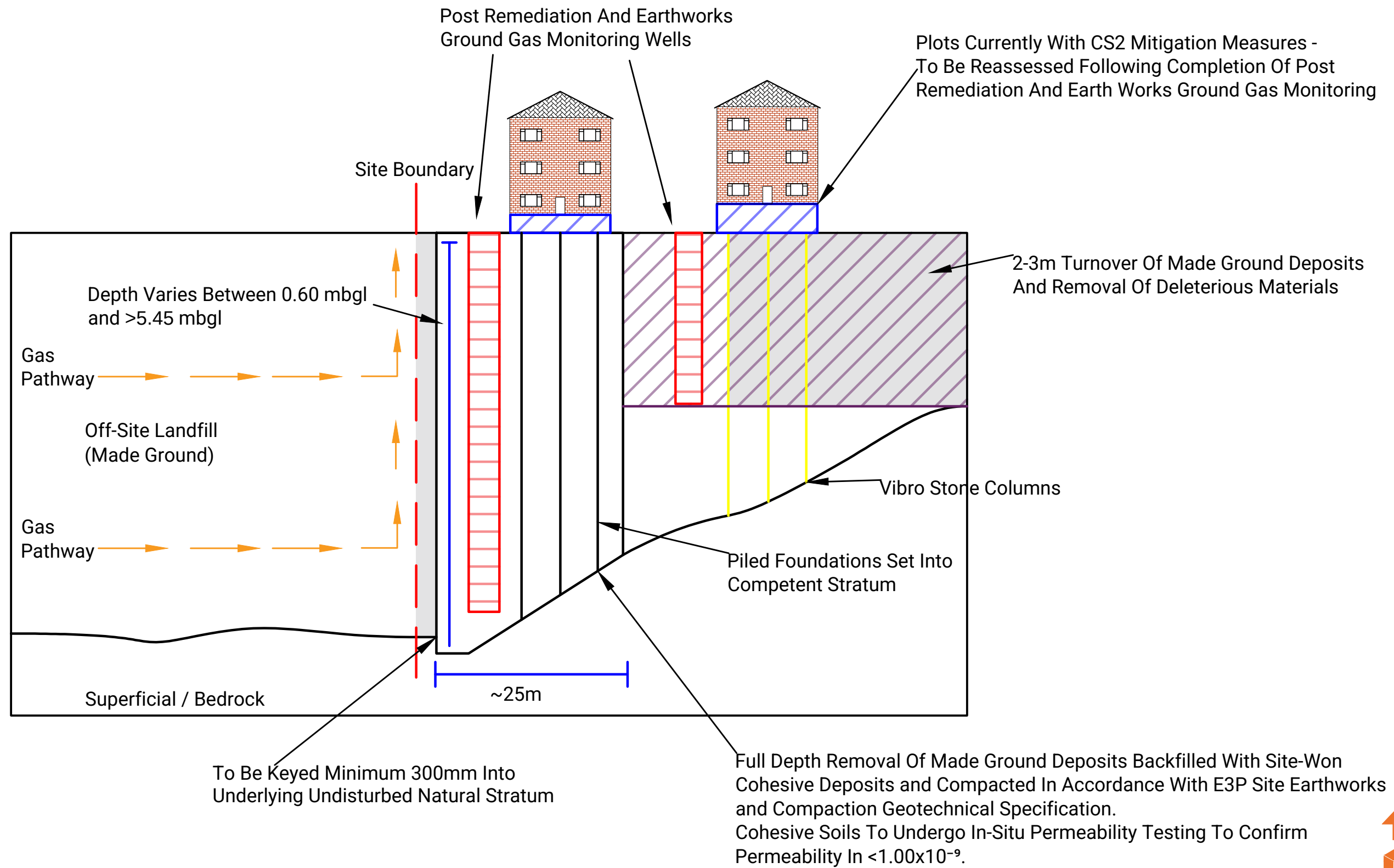
Drawing Title:

Gas Cut Off Barrier Layout Plan



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- Location Symbols
- Made Ground
 - Off-Site Landfill
 - Superficial / Bedrock
 - Ground Gas Monitoring Wells
 - 2-3m Turnover Of Made Ground Deposits

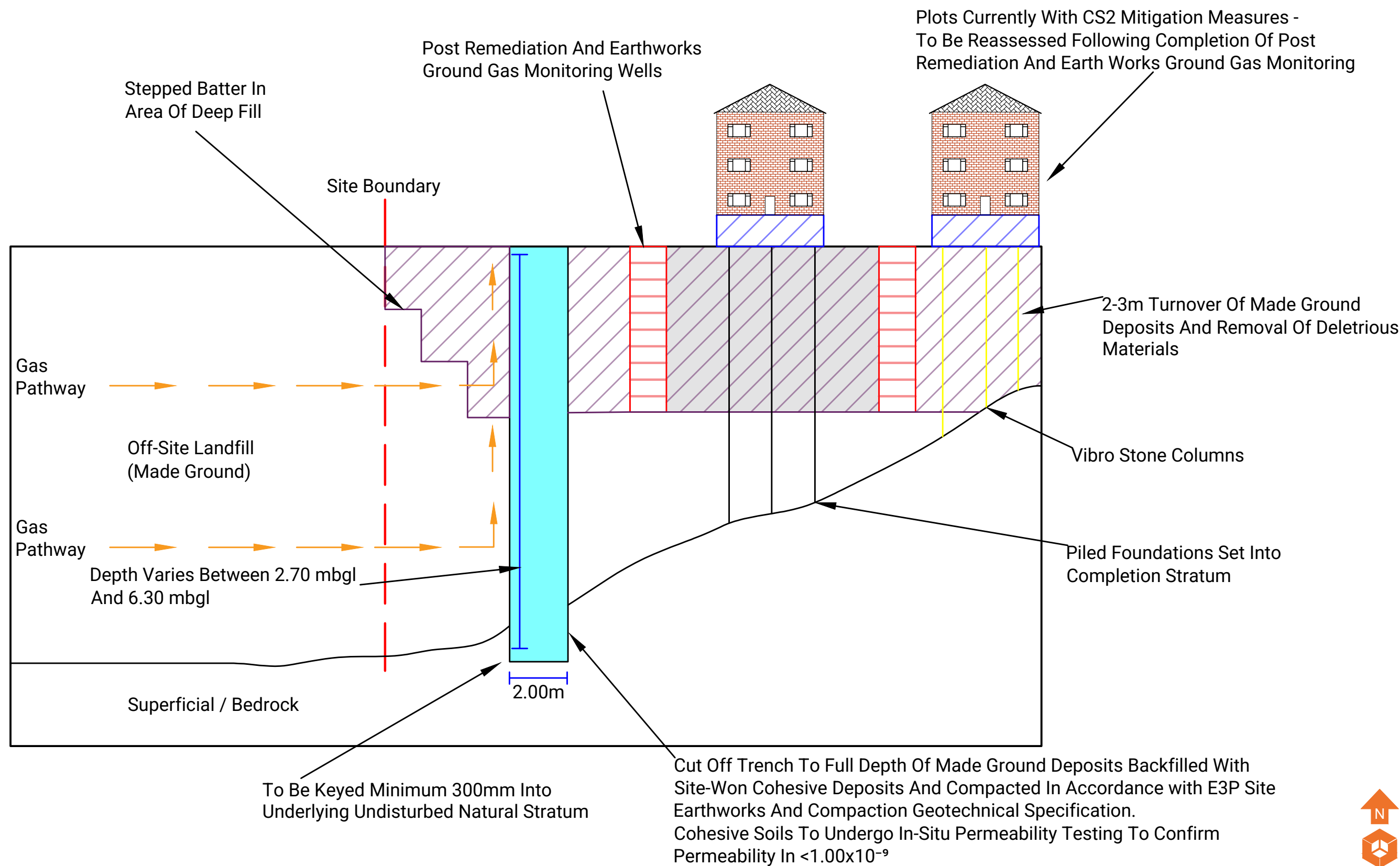
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Client:					
DWH					
Job Title:					
Cherryfield Drive, Kirkby					
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Phase	Issue	Date	Drawn	Checked	PM

<i>Client:</i>	
DWH	
<i>Job Title:</i>	
Cherryfield Drive, Kirkby	

<i>Job No:</i>	<i>Date:</i>
15-280	18.06.2026
<i>Drawing No:</i>	<i>Scale:</i>
047	NTS
<i>Drawing Title:</i>	
Gas Cut Off Barrier Design - Northern Boundary	

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- Location Symbols
- Made Ground
 - Off-Site Landfill
 - Superficial / Bedrock
 - Ground Gas Monitoring Wells
 - 2-3m Turnover Of Made Ground Deposits

Notes:					
Client:					
DWH					
Job Title:					
Cherryfield Drive, Kirkby					
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Phase	Issue	Date	Drawn	Checked	PM

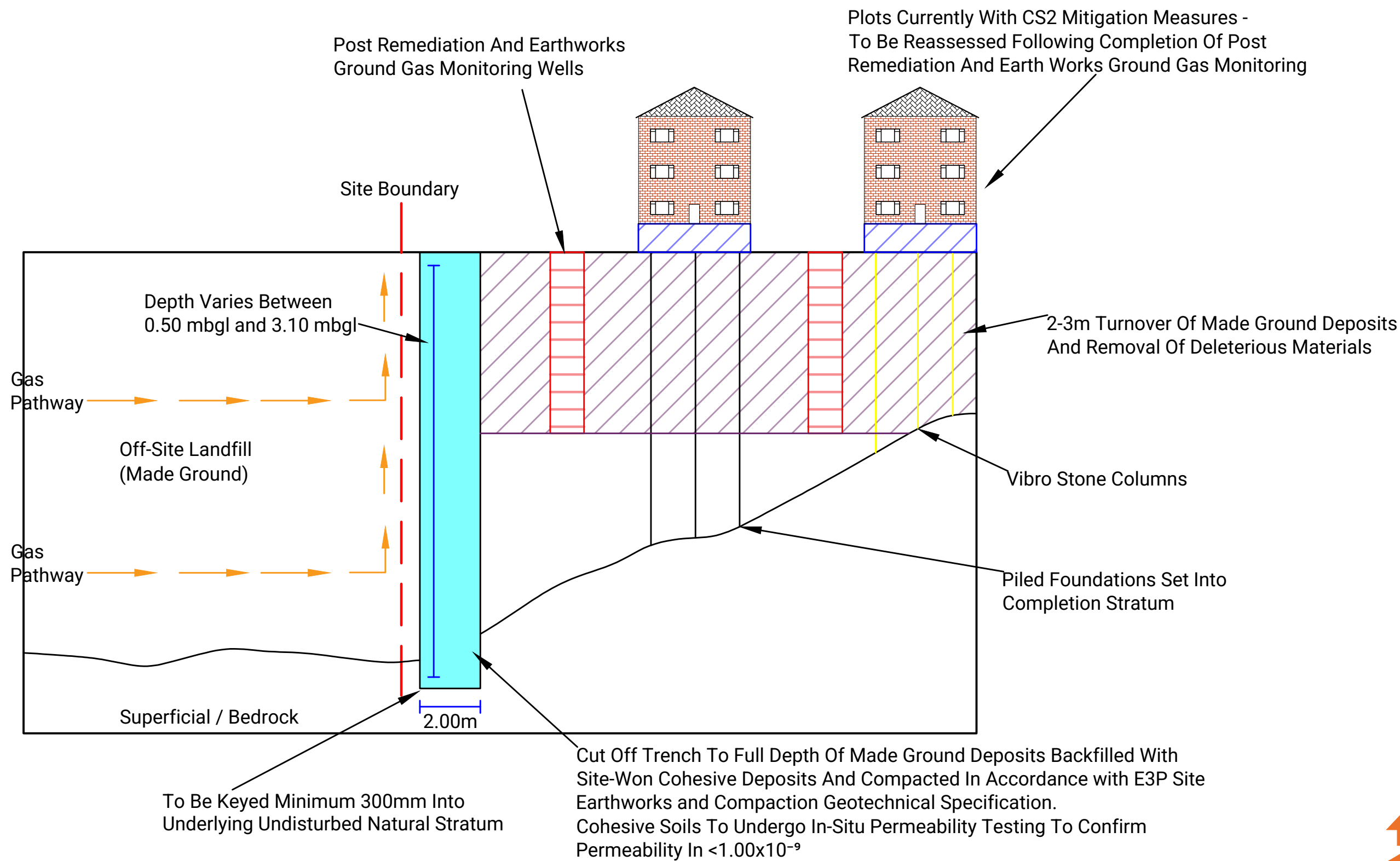
Client:	
DWH	
Job Title:	
Cherryfield Drive, Kirkby	

Job No:	15-280
Date:	23.03.2026
Drawing No:	047
Scale:	NTS
Drawing Title:	
Gas Cut Off Barrier Design - Western Boundary (Infilled Channel)	

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- Location Symbols
- Made Ground
 - Off-Site Landfill
 - Superficial / Bedrock
 - Ground Gas Monitoring Wells
 - 2-3m Turnover Of Made Ground Deposits

Notes:					
Client: DWH					
Job No: 15-280					
Date: 18.06.2026					
Drawing No: 047					
Scale: NTS					
Job Title: Cherryfield Drive, Kirkby					
Drawing Title: Gas Cut Off Barrier Design - Western Boundary					
P1	REVA	18.06.2026	TG	MW	MW
Phase	Issue	Date	Drawn	Checked	PM



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E3P SITE EARTHWORKS AND COMPACTION GEOTECHNICAL SPECIFICATION

Earthworks Pre-Commencement and Performance Specification

CONSTRUCTION DETAIL	MATERIAL	TEST TYPE	FREQUENCY	PERFORMANCE REQUIREMENT
Method Compaction Engineered Up-Fill (To be completed prior to upfilling)	All bulk fill – Class 2 – natural clay materials.	Particle Size Distribution (PSD) and Natural Moisture Content	1 per 1000 m ³	Grading to Class 2
		Compaction Tests using 4.5 kg rammer for cohesive (Class 2) – Optimum Moisture Content and Maximum Dry Density	1 per 2000 m ³	Moisture content to be within 3% (+/-) of the laboratory-determined optimum. Minimum 95% of the laboratory maximum dry density. Maximum 5% air voids.
		Falling Head Permeability	1 per 1000 m ³	Infiltration rate <1.00x10 ⁻⁹



E3P Earthworks Geotechnical Compaction Specification

SOIL/MATERIAL TYPE	CLASS	DESCRIPTION	COMPACTION EQUIPMENT	LAYER THICKNESS	ROLLER PASSES
Cohesive Fill (Clay with minor sand and gravel component)	2 A	Wet Clay	> 1000 kg vibrating tamping roller (sheep foot only)	100–225 mm	3
	2 B	Dry Clay	> 5000 kg vibrating roller or 1400 kg tamping (trench roller)	275 mm or 125 mm	4 or 12
	2 C	Gravelly Clay	> 5000 kg vibrating roller or 1400 kg tamping (trench roller)	275 mm or 125 mm	4 or 12
	2 D	Silty/Sandy Clay	> 5000 kg vibrating roller or 1400 kg tamping (trench roller)	300 mm or 175 mm	4 or 12



Compaction/Backfill Requirements

LAND USE		COMPACTION METHOD AND GENERAL PERFORMANCE CRITERIA				
Liquid and plastic limits		BS 1377: Part 2				
Grading		BS 1377: Part 2				
Uniformity coefficient		Calculated from grading curve				
Moisture content Multi-point moisture condition value (MCV) (to assess optimum moisture content).		BS 1377: Part 2				
Organic matter (maximum 2.5% total organic content)		BS 1377: Part 3				
Water soluble sulphate		TRL Report 447 Test No 1				
Total sulphate content		TRL Report 447 Test No 4				
Earthwork in-situ tests After the filling and compaction of the material, a series of in-situ tests shall be undertaken to confirm the success of the compaction process. This testing shall include, but necessarily be limited to the following: <table><tr><th>TEST</th><th>TEST METHOD</th></tr><tr><td>Plate load tests (equivalent CBR of 5%)</td><td>BS 1377: Part 9</td></tr></table>		TEST	TEST METHOD	Plate load tests (equivalent CBR of 5%)	BS 1377: Part 9	Clause 632 (BS 1377: Part 4)
TEST	TEST METHOD					
Plate load tests (equivalent CBR of 5%)	BS 1377: Part 9					
Disposal of materials The contractor shall be responsible for the safe disposal of any excess of unsuitable material found on the site.						
Compaction testing						



E3P specifies as a minimum requirement in-situ verification testing calculated on the overall fill volume being engineered on site. The below table presents the banding. The frequencies within the In-Situ Validation Testing Table below are to be adjusted to an appropriate grid in order to achieve the minimum volume of testing.

End Product Compliance Testing Of Placed Engineered Fill

FILL VOLUME (M ³)	MINIMUM NUMBER OF TESTS REQUIRED
>100,000	2 no. per 1,000m ³
10,000 to 100,000	3 no. per 1,000m ³
<10,000	5 no. per 1,000m ³



In-Situ Validation Testing

CONSTRUCTION DETAIL	MATERIAL	CATEGORY	TEST TYPE	FREQUENCY	PERFORMANCE REQUIREMENT	
Engineered Up- fill	Class 2 – Site generated natural cohesive material	Fill supporting piled foundations (+2.0 m off set)	To be determined by Non-nuclear Density Gauge correlated by Sand Replacement Density (SRD) Testing.	Each layer of fill shall be inspected and approved prior to placement of the next layer, with density testing undertaken at specified frequencies:	Suitability requirements for Class 2 materials to be reviewed prior to placement to ensure:	
				NNDGs – 1 test every 4 th layer of upfill per 625m ²	Moisture Condition between 7 & 15	
				SRD – 1 test per every 625 m ² (2 nd layer)	Plasticity <40%	
		Infrastructure	Frequency of SRD testing to be increased subject to material type, source, and extent of the works.	In-Situ Permeability Tests –3 tests every 1m of upfill per 625m ² (northern boundary) / 1 test every 1 m of upfill per 25 linear meters (western boundary)	The absence of unsuitable materials (organic matter <1-2%, maximum water-soluble sulphate content 300 mg/l, and frozen or perishable matter).	
				NNDGs – 1 test every 4 th layer of upfill per 25 linear meters along road lines.	Minimum 95% of the laboratory maximum dry density.	
		Landscaping			In-Situ Permeability Tests –3 tests every 1 m of upfill per 625m ² (northern boundary) / 1 test every 1 m of upfill per 25 linear meters (western boundary)	Maximum 5% air voids.
					NNDGs – 1 test every 4 th layer of upfill per 625m ²	Moisture content within ±3% of the laboratory determined optimum moisture content (for cohesive fills).
				Minimum undrained shear strength (Cu) of 40 kPa, verified by hand shear vane testing at the exposed formation level following completion of the engineered fill works.		
				Infiltration rate <1.00x10 ⁻⁹		



CONSTRUCTION DETAIL	MATERIAL	CATEGORY	TEST TYPE	FREQUENCY	PERFORMANCE REQUIREMENT
Base of Formation	Granular or Cohesive	Fill supporting piled foundations (+2.0 m off set)	HSV	1 test every 625 m ²	>40Cu
		Infrastructure	Max Deformation & CBR by Plate Load		<10mm settlement 100 kN/m ² Areas to be assessed against relevant design requirements.



METHOD STATEMENT FOR IN-SITU PERMEABILITY TESTING

Scope and Purpose

This method statement defines the procedure for conducting a falling head (or variable head) test to measure the coefficient of permeability (k) for low-permeability soils. This is typically performed to evaluate clay liners for landfills or to assess borehole infiltration for SuDS (Sustainable Drainage Systems).

In-situ permeability testing will be undertaken at locations specified by the site engineer and in accordance within BS 5930:1999. Testing frequencies are as follows:

- Northern Boundary – every 1.00 m of upfill at a rate of 3 per 25m²
- Western Boundary – every 1.00 m of upfill at a rate of 1 per 25 linear meters

Equipment Required

To conduct the test according to standard engineering protocols (BS EN ISO 22282-2:2012), the following equipment will be required:

- Hand Auger (min. 3 inch diameter)
- Graduated standpipe to provide a variable head of water
- Stopwatch / timer
- Tape measure or water level dipper

Procedure

Field testing often involves monitoring the rate at which water drains into a trial pit or a standpipe.

1. **Preparation:** Excavate the test hole using the hand auger to a minimum test depth of 0.50 m into the layer of upfill. Install a standpipe and seal the response zone if necessary.
2. **Pre-soak:** Fill the test hole with water to saturate the surrounding ground and emulate winter moisture conditions.
3. **Test Execution:** Fill the standpipe with water to a maximum predetermined height, then allow the water to infiltrate.
4. **Data Recording:** Record the falling water level (h) at predetermined time intervals (t) until the water level drops significantly or reaches the standing water table.

Calculations

The coefficient of permeability (k) in cm/s or m/s is calculated using Darcy's equation for falling head conditions:



$$k = \frac{2.303 \times a \times L}{A \times t} \log_{10} \left(\frac{h_1}{h_2} \right)$$

Where:

- a = internal cross-sectional area of the standpipe
- A = cross-sectional area of the test hole
- L = length (or thickness) of the response zone
- t = elapsed time for the head to drop from h_1 to h_2
- h_1 = initial water head height
- h_2 = final water head height

Health & Safety

- **PPE:** Hard hat, steel-toe boots, high-visibility vest, and gloves must be worn for field testing.
- **Slips/Trips:** Ensure work areas around test holes are level, cordoned off, and clearly signed.
- **Manual Handling:** Ensure lifting of heavy soil samples or water containers uses safe ergonomic practices.
- **Confined Space:** Trench boxes are to be utilised for the construction of the 2.00 m wide cut-off trench along the western barrier. Test holes undertaken within the trench boxes are to be undertaken by a confined space trained operative.